A Vectorautoregressive Investment Model (VIM) and Monetary Policy Transmission: Panel Evidence from German Firms

Jörg Breitung
(University of Bonn)

Robert S. Chirinko
(Emory University and CESifo)

Ulf von Kalckreuth
(Deutsche Bundesbank)

Discussion paper 06/03
Economic Research Centre
of the Deutsche Bundesbank

March 2003

Deutsche Bundesbank, Wilhelm-Epstein-Strasse 14, 60431 Frankfurt am Main,
Postfach 10 06 02, 60006 Frankfurt am Main

Tel +49 69 95 66-1
Telex within Germany 4 1 227, telex from abroad 4 14 431, fax +49 69 5 60 10 71

Please address all orders in writing to: Deutsche Bundesbank,
Press and Public Relations Division, at the above address or via fax No. +49 69 95 66-30 77

ISBN 3–935821–48–4

Abstract

This paper proposes a new framework for studying the effects of monetary policy on business investment. Important ambiguities with the modeling of investment dynamics and interactions between real and financial decisions suggest modeling investment spending as a VAR. Based on a panel of financial statement data for 6,408 German firms (44,345 datapoints) supplemented with user costs of capital and confidential measures of creditworthiness, we generate GMM estimates of a Vectorautoregressive Investment Model (VIM). It contains investment and cash flow as endogenous variables, and the user costs of capital and sales growth as additional explanatory variables.

We report four substantive findings. First, monetary policy matters, and business investment is responsive to interest rates embedded in the user cost of capital. Second, allowing real and financial decisions to interact raises the impact of monetary policy by one-third relative to simulations of an investment equation in isolation that assumes an exogenous financial policy. Third, the sensitivity of investment to cash flow shocks is raised by two-thirds relative to single equation computations. Fourth, firms with poor credit ratings are ”paralysed" in being unable to react to changing economic conditions as given by relative prices or demand. On the other hand and consistent with binding financing constraints, these endangered firms show a high responsiveness to cash flow shocks.

Apart from these substantive conclusions, this paper demonstrate that the panel VAR approach is useful for modeling firm dynamics and real/financial interactions and for assessing monetary policy transmission.

JEL Codes: E5, C33, E22

Keywords: Monetary Policy Transmission; Panel Data VAR's; Firm-Level Investment; Germany

Zusammenfassung

In diesem Papier wird ein neuer Rahmen für die Untersuchung der Wirkungen von Geldpolitik auf privatwirtschaftliche Investitionen vorgeschlagen. Wegen ungelöster Probleme bei der Modellierung der Investitionsdynamik und der Interaktion zwischen realwirtschaftlicher und der finanzieller Sphäre einer Unternehmung bietet sich die Modellierung der Investitionsentscheidung als VAR an. Auf der Grundlage eines Panels von Jahresabschlüssen für 6,409 deutsche Firmen (44 345 Datenpunkte), erweitert um Kapitalnutzungskosten und vertrauliche Daten über Kreditwürdigkeit, stellen wir GMM-Schätzungen eines vektorautoregressiven Investitionsmodells (VIM) vor. Es enthält die Investition und den Cash Flow als endogene Variablen, und außerdem Kapitalnutzungskosten und Umsatzwachstum als weitere erklärende Variablen

Vier inhaltliche Ergebnisse verdienen es, herausgehoben zu werden. Erstens, Geldpolitik ist wirksam, und privatwirtschaftliche Investitionen reagieren auf Änderungen der in den Kapitalnutzungskosten enthaltenen Zinsen. Zweitens, eine Berücksichtigung der Interaktionen von realwirtschaftlichen und finanziellen Entscheidungen erhöht die geschätzte Wirkung von Geldpolitik um ein Drittel im Vergleich zur Simulation einer isolierten Investitionsgleichung, bei welcher die finanzielle Situation als exogen betrachtet wird. Drittens erhöht sich die Sensitivität der Investition bezüglich Cash Flow-Schocks um rund zwei Drittel, verglichen mit einer Einzelgleichungsschätzung. Viertens, Firmen mit geringer Kreditwürdigkeit wirken "gelähmt" – sie sind nicht in der Lage, sich auf Änderungen der wirtschaftlichen Bedingungen in Gestalt von Relativpreisen oder der Nachfrage einzustellen. Andererseits weisen diese Firmen eine hohe Sensitivität bezüglich Cash Flow-Schocks auf, was konsistent ist mit bindenden Finanzierungsrestriktionen.

Abgesehen von diesen inhaltlichen Ergebnissen zeigt das Papier, dass der Panel VAR-Ansatz für die Modellierung der unternehmerischen Dynamik, der Interaktion von realer und finanzieller Sphäre sowie der monetären Transmission zweckmäßig ist.

JEL Codes: E5, C33, E22
Schlüsselwörter: Monetäre Transmission, Panel VAR's, einzelwirtschaftliche Investitionen, Deutschland

Contents

List of Tables and Figures

Tables

Figures

A Vectorautoregressive Investment Model (VIM) And Monetary Policy Transmission: Panel Evidence From German Firms [*]

1 Introduction

How does monetary policy impact economic activity? One of the most important transmission channels operates on highly volatile business fixed investment. The monetary authorities alter the terms and availability of credit, and impact investment in plant and equipment. While this textbook version of one transmission channel is widely accepted, questions remain about its empirical importance.[1]

A key difficulty facing econometric assessments of this monetary policy channel is unravelling the complex dynamics that characterize business investment. While theoretical frameworks offer precise implications about long-run capital formation, these formal models have proven less useful in formulating dynamic relations describing transitional investment behaviour. The roles of convex adjustment costs, costly reversibilities, and fixed costs, *inter alia*, have been studied extensively, and important new insights have been developed. However, little consensus exists on which factors are most relevant for modelling investment spending. Hence, the movement of investment spending at cyclical frequencies and its response to variations in interest rates are not fully understood.

Partly in response to these gaps, research on finance constraints has been actively pursued over the past 15 years, and has increased understanding of short-run investment behaviour. Asymmetric information and monitoring frictions between borrowers and lenders result in incentive and agency problems that, in turn, create a wedge between the costs of internal and external finance. Perhaps the most important empirical implication is that financial

---

* The authors acknowledge helpful comments from Heinz Herrmann and the Advisory Board of the Bundesbank's Economic Research Centre, and the invaluable contribution of Fred Ramb with respect to the construction of our user cost variable. The views expressed in this paper do not necessarily reflect those of the Deutsche Bundesbank or CESifo. All errors, omissions, and conclusions remain the sole responsibility of the authors. Contact information: Joerg Breitung, Institute of Econometrics, University of Bonn, Adenauerallee 24-42, 53113 Bonn, GERMANY, PH: 49-(0)228-73-9201, FX: 49-(0)228-73-9189, EM: breitung@uni-bonn.de. Robert S. Chirinko, Department of Economics, Emory University, Atlanta, Georgia USA 30322-2240, PH: 404-727-6645, FX: 404-727-4639, EM: rchirin@emory.edu. Ulf von Kalckreuth (Corresponding author), Deutsche Bundesbank, Economic Research Centre, P.O. Box 100602, Wilhelm-Epstein Strasse 14, D-60006 Frankfurt, GERMANY, PH: 49-69-9566-2217, FX: 49-69-9566-4317, EM: ulf.von-kalckreuth @bundesbank.de.

1 See the symposium papers in Mishkin (1995) and the surveys by Blanchard (1990) and Christiano, Eichenbaum, and Evans (1999).

variables - usually cash flow - properly belong in the investment equation. While the importance of financial factors on business investment decisions has been documented in many studies, whether the coefficients on these variables signify finance constraints is an open question. For example, Chirinko (1997) and Gomes (2001) show that, in formal optimising models, the effects of finance constraints can be capitalized into fundamentals, thus altering the interpretation and role of financial variables in investment equations. In Abel and Eberly (2002), investment spending by an optimising firm faced with uncertainty and imperfect competition depends on cash flow even though the firm does not face any finance constraints. While one can accept the economic importance of finance constraints and the existence of a premium on external finance, doubts exist concerning precisely how these financial factors enter formal theoretical models and affect the specification of an econometric investment equation.

A further implication of finance constraints for firm behaviour is that real and financial decisions are intertwined. An important property of the separation theorem of Modigliani and Miller (1958) is that the supply of finance is infinitely elastic at the prevailing interest rate, and thus real investment decisions can be considered in isolation from financial decisions. Asymmetric information and monitoring cost frictions disrupt this separation theorem, and require that real and financial decisions be analysed in tandem. Benito and Young (2002) take an important first step in that direction, but they stop short of modelling the dynamic consequences of simultaneity.

These real/financial interactions, coupled with important ambiguities concerning the modelling of investment dynamics, suggest taking a new approach to understanding the investment process and its responses to monetary policy. We adopt a VAR methodology, and approximate the complicated and incompletely understood relations among investment and its determinants as a VAR with minimal restrictions.

We begin our analysis in Section 1 by considering specification issues for our Vectorautoregressive Investment Model (VIM). The neoclassical investment model developed by Jorgenson (1963) guides the specification of the basic determinants of investment spending. In this framework, sales is the quantity variable, and the user cost of capital is the price variable. (The user cost variable contains an interest rate, and is key to evaluating the effects of monetary policy on investment spending.) We assume that firms operate in competitive markets and minimize cost; thus, price and quantity variables are exogenous. Recent research on finance constraints has demonstrated that cash flow is an important determinant of investment spending, and we include cash flow as our financial variable. That research has also shown that financial decisions affect and are affected by real investment decisions and, hence, both investment and cash flow are endogenous. Furthermore, current cash flow shocks affect current investment but, owing to gestation and time-to-build lags, investment does not impact cash flow contemporaneously.

Econometric issues are considered in Section 2. We estimate VIM with an equation-by-equation GMM procedure that is asymptotically efficient for our recursive system of dynamic simultaneous equations.[2] Lag lengths are determined with two specification tests. As with any VAR, the individual VIM coefficients are not meaningful in and of themselves. We calculate dynamic multipliers, impulse responses, and error bands associated with the exogenous and endogenous variables, respectively.

Estimates of our VIM are based on three unique datasets for German firms discussed in Section 3. First, as part of its rediscount lending operation, the Bundesbank collected a vast amount of detailed financial statement data. After accounting for lags, outliers, and missing observations, we have an unbalanced panel of 44,345 datapoints for 6,408 firms for the period 1988-1997. Second, we compute user costs of capital along the lines presented in King and Fullerton (1984), adapting important prior work by Harhoff and Ramb (2001) and Ramb (forthcoming) for the purposes of this study. Third, in discharging its credit evaluation obligation, the Bundesbank routinely determined overall creditworthiness through a detailed discriminant analysis.[3] These confidential credit ratings are a precise indicator of those firms facing a substantial external finance premium, and will be important in examining the differential responses by financial constrained and unconstrained firms. In combination, these three datasets provide an exceptional opportunity to analyse the response of investment spending to changes in user costs and shocks to cash flow.

Sections 4 and 5 simulate VIM's estimated on different sub-samples. Section 4 provides benchmark results with the full sample, and draws comparison between a single equation investment model in which financial variables are exogenous and VIM in which both real and financial variables are endogenous. Dynamic multipliers computed for changes in the two exogenous variables - user cost and sales - and impulse response computed for shocks to the two endogenous variables – investment and cash flow – are larger in VIM than in a single equation model. Endogenizing financial decisions leads to more substantial reactions by firms and a more potent monetary policy transmission channel. A 25 basis point increase in short-term rates reduces investment by a substantial 3.1% in two years.

---

2 Our econometric model differs from that used in the pioneering study of Holtz-Eakin, Newey and Rosen (1988). They estimated a VAR model excluding any contemporaneous variables, whereas we have a recursive system of dynamic simultaneous equations.

3 Since the implementation of the Monetary Union on January 1, 1999, the Bundesbank continues to assess creditworthiness in the course of the Eurosystem monetary policy operations, but it no longer rediscounts trade bills.

The roles of heterogeneity and finance constraints are explored in Section 5. Firms facing relatively costly external finance are identified with our confidential Bundesbank creditworthiness data. The sensitivity of these firms to changes in the exogenous variables and shocks to the endogenous variables are compared to firms that have a much lower external finance premium. Firms with poor credit ratings do not react to changing economic conditions as given by relative prices or demand. This "paralysis" might be traceable to their inability to finance investment. On the other hand and consistent with binding financing constraints, these endangered firms show a high responsiveness to cash flow shocks.

Section 6 contains a summary and conclusions.

1. Specifying VIM

1.1. Some Perspective On Modeling Investment Spending

The primary focus of this study is on investment spending, and we begin with a consideration of investment modelling strategies appearing in the literature. In specifying an investment equation, 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 contributions of Jorgenson (1963) and Hall and Jorgenson (1967) relate the price of durable capital to the user cost (or rental price) of capital, defined as a function of interest, tax, and depreciation rates and relative prices. With a readily measurable user cost as a price variable, the long-run demand for capital can be easily analysed.

Complications arise, however, when specifying the demand for the flow of investment. Two sets of “frictions” introduce important and complex factors into the investment equation. The first set of frictions includes dynamic elements such as convex adjustment costs with changing the capital stock, delivery lags, vintage effects, costly reversibility constraints, time-to-build lags, fixed costs, and gestation lags. The interaction between these frictions and durability forces the optimising firm to take a deep look into the future. Consequently, expectations of future variables are an additional dynamic element affecting the investment equation. The second set of frictions is due to asymmetric information and costly monitoring between borrowers and lenders that, in turn, lead to constraints on the availability and cost of external finance. Finance constraints further imply that real and financial decisions are intertwined.

While explicit models have the notable advantages of being based on a choice-theoretic framework and having coefficients in the econometric equation that can be identified with technology and expectation parameters, several problems have arisen. First, their empirical performance has been disappointing, and coefficient estimates appear fragile in many applications. Second, in most cases, they do not provide a framework for assessing the impact of monetary policy on investment spending that is the central concern of the present study. Third, there is a great deal of uncertainty about which of the frictions listed above are important for understanding the investment decision. While additional work with explicit models is likely to yield valuable insights into the investment process, our analysis of monetary policy transmission can best be undertaken with an implicit model given the current state of development of explicit models.

1.2 The Investment Equation

Implicit models are based on a less formal specification of the capital accumulation process. Theory is used to suggest the determinants of investment spending that, in turn, enter into a relatively unrestricted econometric equation.

We assume that the firm operates in competitive markets, and takes output and prices as given. (Since the median firm in our sample has 119 employees, this atomistic assumption seems appropriate.) Cost minimizing behaviour, coupled with a CES production function (Coen, 1969), results in the following specification of the logarithm of the optimal capital stock (k^*),

$$k^*_t = \rho_0 + \rho_1 uc^*_t + \rho_2 s^*_t \tag{1}$$

where uc^*_t is the logarithm of the long-run user cost of capital (described in detail in Section 3.2 and Appendix A), s^*_t is the logarithm of long-run sales, and the ρ's are parameters related to the production technology. In (1), the cost of finance is assumed independent of the amount used by the firm; this assumption will be discussed below.

The challenge facing the applied econometrician is to translate the above demand for a stock of capital into the demand for the flow of investment. To derive a useful econometric specification, we introduce dynamics with three assumptions. First, the adjustment of the capital stock to its optimal level is distributed over time according to the following lag specification,

$$\Delta k_t = I_t/K_{t-1} - \delta = \alpha(L)\, \Delta k^*_t, \tag{2}$$

where Δ is the first-difference operator, the difference in the logarithm of the capital stock equals the investment/capital ratio less depreciation ($I_t/K_{t-1} - \delta$), and $\alpha(L)$ is a polynomial in the lag operator representing technological constraints such as delivery lags and other frictions.

Second, following Jorgenson (1966), we assume that $\alpha(L)$ can be approximated by a rational lag polynomial, $\beta(L)/(1-\gamma(L))$, and rewrite (2) as follows,

$$I_t/K_{t-1} - \delta = \beta(L)/(1-\gamma(L))\, \Delta k^*_t, \tag{3a}$$

$$I_t/K_{t-1} = \beta(L)\, \Delta k^*_t + \gamma(L)\, I_{t-1}/K_{t-2} + \psi, \tag{3b}$$

where $\psi = \delta\,(1-\gamma(1))$. The $\beta(L)$'s, $\gamma(L)$'s, and ψ contain technology parameters.

Third, in preparing their decisions at time t, agents form expectations about the long-run values determining the optimal capital stock in (1). These expectations are based upon current and lagged values of variables determining the optimal capital stock and by lagged values of the dependent variable. Combining the above assumptions, identifying firm-specific variables with an *i* index, and appending an error term ($\zeta_{i,t}$), we obtain the following investment equation,

$$I_{i,t}/K_{i,t-1} = \eta^{UC}(L)\, \Delta uc_{i,t} + \eta^{S}(L)\, \Delta s_{i,t} + \eta^{I/K}(L)\, (I_{i,t-1}/K_{i,t-2}) + \psi_i + \zeta_{i,t}, \tag{4}$$

where the $\eta(L)$'s are coefficients representing a mixture of technology and expectation parameters. Thus, as with all implicit models, this specification is subject to the Lucas Critique. While this objection is undoubtedly correct theoretically, coefficient shifts are unlikely to be important for the small changes in policy analysed in this study. Furthermore, there is some empirical evidence indicating that the Lucas Critique is not quantitatively important.[4]

Equation (5) is based on the assumption that the supply of finance is infinitely elastic at the prevailing interest rate. However, recent research has challenged this view.[5] Owing to fi-

---

4 See Chirinko (1988), Taylor (1989), Chirinko, Fazzari, and Meyer (1999), and Estrella and Fuhrer (forthcoming).

5 The recent renaissance began with Fazzari, Hubbard, and Peterson (1988). See Chatelain (forthcoming), Hubbard (1998), and Schiantarelli (1995) for surveys, Bernanke, Gertler, and Gilchrist (1999, especially equations 3.8 and 3.9) for a formal theoretical model, and Kaplan and Zingales (1997, 2000), Fazzari, Hubbard, and Petersen (2000) for a lively exchange concerning some unresolved issues in the finance constraints literature.

nancial market frictions, the cost of external finance exceeds the cost of internal finance, and investment spending is sensitive to the quantity of internal funds. In this case, the composition of finance affects real decisions. Moreover, these real decisions affect finance. For example, the additional indebtedness for a new investment project may lower cash flow for several years due to interest expenses on the project debt and a higher external finance premium on future borrowings. With financial market frictions, real and financial decisions are intertwined.

To reflect short-term credit constraints, we follow the literature, and include the ratio of cash flow to the capital stock as an additional argument in (5). Finally, we assume that the error term, $\zeta_{i,t}$, contains three components: a firm-specific fixed effect (ϕ_t, which incorporates ψ_i), a time-specific fixed effect (λ_t), and a white noise error ($\varepsilon_{i,t}$). With these additional elements, we obtain the following autoregressive distributed lag (ADL) investment equation,

$$I_{i,t}/K_{i,t-1} \;=\; \pi^{UC}(L)\,\Delta uc_{i,t} \;+\; \pi^{S}(L)\,\Delta s_{i,t} \;+\; \pi^{CF/K}(L)\,(CF_{i,t}/K_{i,t-1}) \tag{5}$$

$$+\; \pi^{I/K}(L)\,(I_{i,t-1}/K_{i,t-2}) \;+\; \phi_i \;+\; \lambda_t \;+\; \varepsilon_{i,t}\,.$$

1.3 The VIM Equation System

Our model of a cost minimizing firm facing finance constraints has several implications for the variables appearing on the right-side of (5) and the specification of the VIM. Since the price and quantity variables are taken as given, $\Delta uc_{i,t}$ and $\Delta s_{i,t}$ are exogenous. By contrast, financing responds to investment, and $(CF_{i,t}/K_{i,t-1})$ is an endogenous variable. Rather than modelling the relations among these variables explicitly, we allow them to interact in a relatively unrestricted manner by estimating the following Vectorautoregressive Investment Model (VIM),

$$A_0\begin{pmatrix}(I/K)_{i,t}\\(CF/K)_{i,t}\end{pmatrix} = A(L)\begin{pmatrix}(I/K)_{i,t-1}\\(CF/K)_{i,t-1}\end{pmatrix} + B(L)\begin{pmatrix}\Delta uc_{i,t}\\ \Delta s_{i,t}\end{pmatrix} + \begin{pmatrix}\phi_i^{I/K}\\ \phi_i^{CF/K}\end{pmatrix} + \begin{pmatrix}\lambda_t^{I/K}\\ \lambda_t^{CF/K}\end{pmatrix} + \begin{pmatrix}u_{i,t}^{I/K}\\ u_{i,t}^{CF/K}\end{pmatrix} \tag{6a}$$

$$A_0\, Y_{i,t} \;=\; A(L)\, Y_{i,t-1} \;+\; B(L)\, X_{i,t} \;+\; \Phi_i \;+\; \Lambda_t \;+\; U_{i,t}, \tag{6b}$$

$$E(U_{i,t}) = 0 \quad \text{and} \quad E(U_{i,t}\, U_{i,t}') = \Sigma_{i,t}\ \text{(diagonal)} \qquad \text{for all } i=1,N \text{ and } t=1,T, \tag{6c}$$

where A_0, A(L), and B(L) contain coefficients for the current endogenous ($Y_{i,t}$), lagged endogenous ($Y_{i,t-1}$), and the current and lagged exogenous variables ($X_{i,t}$), respectively. In (6b), A(L) and B(L) are vectors of lag polynomials, and Φ_i, Λ_t, and $U_{i,t}$, are vectors containing firm-specific fixed effects, time-specific fixed effects, and white noise error terms, respectively. Equation system (6) is a recursive system of dynamic simultaneous equations, and will be the basis for our coefficient estimates and the associated dynamic multipliers and impulse responses with which we assess the sensitivity of investment to monetary policy and other stimuli.

2. Estimating VIM

2.1. Obtaining Coefficient Estimates

This sub-section discusses identification and estimation issues with equation system (6). To identify the coefficients, we assume that the error covariance matrix, $\Sigma_{i,t}$, is diagonal and that the VIM has a recursive structure such that the matrix A_0 is upper triangular,

$$A_0 = \begin{pmatrix} 1 & a \\ 0 & 1 \end{pmatrix} \tag{7}$$

With (7), current cash flow affects current investment through the *a* coefficient but, owing to gestation and time-to-build lags, investment does not impact cash flow contemporaneously.

The coefficients are estimated by GMM. Following Arellano and Bond (1991) and Holtz-Eakin, Newey, and Rosen (1988), we first-difference (6) to eliminate the firm-specific effects and, for notational simplicity, exclude the time-specific fixed effects,

$$A_0\, \Delta Y_{i,t} \;=\; A(L)\, \Delta Y_{i,t-1} \;+\; B(L)\, \Delta X_{i,t} \;+\; \Delta U_{i,t} \qquad i=1,N, \quad t=1,T. \tag{8}$$

Due to the resulting serial correlation in the error term ($\Delta U_{i,t}$), the system is estimated by GMM using the following instruments (whose number increases with *t*),

$$Z_{i,t} \;=\; [X'_{i,t-2}, \ldots X'_{i,1}, Y'_{i,t-2}, \ldots Y'_{i,1}]' \tag{9}$$

and the GMM moment matrix, $E[G_{i,t}(\theta)]$, where

$$G_{i,t}(\theta) \;\equiv\; E[Z_{i,t}\,(A_0\, \Delta Y_{i,t} - A(L)\, \Delta Y_{i,t-1} - B(L)\, \Delta X_{i,t})'] , \tag{10}$$

E[.] is the expectation operator, and the coefficient vector θ comprises the unknown elements in A_0, A(L), and B(L) in (8). The empirical moments are stacked into the column vector $g_i(\theta) = vec[G_{i,p+1} \ldots G_{i,T}]$, where p is the lag order for the polynomials A(L) and B(L). The GMM estimator minimizes the following criterion function,

$$C(\theta) = \left(\sum_{i=1}^{N} g_i(\theta) \right)' W \left(\sum_{i=1}^{N} g_i(\theta) \right) \tag{11 a}$$

where the weighting matrix, W, is given by

$$W = \left[E \left[\sum_{i=1}^{N} g_i(\theta_0) g_i(\theta_0)' \right] \right]^{-1}, \tag{11 b}$$

where θ_0 is the true value of θ that solves $E[G_{i,t}(\theta_0)] = 0$.

Our VIM extends the panel data VAR model considered by Holtz-Eakin, Newey, and Rosen (1988) to a dynamic system of simultaneous equations. In an ordinary VAR system, the coefficients can be estimated efficiently with equation-by-equation least-squares. By contrast, Holtz-Eakin, Newey, and Rosen showed that an efficient GMM estimator for a panel data VAR system must be estimated as a system. However, for the recursive structure employed here, an equation-by-equation GMM procedure is asymptotically as efficient as the system estimator. The reason is that under the assumption that the errors are uncorrelated across equations, the weight matrix *W* is diagonal and, therefore, the equation-by-equation GMM procedure is identical to the system GMM estimator. In finite samples the estimated weighting matrix is not diagonal, in general, and a difference usually exists between the equation-by-equation and system GMM estimators that disappears as *N* tends to infinity (cf. Hayashi, 2000, Section 4.4). In our dataset, N equals 6,408.

2.2 Selecting The Lag Length

We employ two specification tests to select the lag length. With the First-Difference estimator, white noise errors imply that the residuals between periods t and t-2 will be uncorrelated. The Lagrangian Multiplier statistic (LM) proposed by Arellano and Bond (1991) tests for second-order residual serial correlation. A second specification test examines the validity of the overidentifying restrictions with the SH statistic proposed by Sargan (1958) and Hansen (1982). If the model is correctly specified, the residuals between periods t and t-2 will be uncorrelated, and the overidentifying restrictions will be sustained.

Since our primary focus is on investment spending, we focus on the properties of this equation for lag lengths of 2, 3, and 4 periods. The LM statistics have p-values of 0.008, 0.165, and 0.885 for lags 2, 3, and 4, respectively, and the model with only two lags is not acceptable. For the same three models, the p-values for the SH statistic are 0.002, 0.075, and 0.009, respectively. Thus, only the investment model with three lags passes both specification tests, and all of the estimates reported in the tables are based on systems of equations with three lags.[6]

2.3 Computing Dynamic Multipliers, Impulse Responses, And Error Bands

The coefficient estimates from VAR models are difficult to interpret, but they provide useful information for computing dynamic multipliers for changesin the exogenous variables or impulse responses for shocks to the endogenous variables.

To compute dynamic multipliers, the final form of the system has to be determined. Defining $D(L) \equiv A_0 - A(L)$, we can rewrite (6b) as follows,

$$D(L)\, Y_{i,t} \;=\; B(L)\, X_{i,t} \;+\; \Phi_i \;+\; U_{i,t}\,. \tag{12}$$

The final form is obtained by multiplying the system with the inverse of D(L),

$$Y_{i,t} \;=\; M(L)\, X_{i,t} \;+\; D(1)^{-1}\, \Phi_i \;+\; D(L)^{-1}\, U_{i,t} \tag{13}$$

Dynamic multipliers are computed from the elements of the $M(L) = D(L)^{-1}B(L)$ matrix polynomial.

The error bands for the estimated dynamic multipliers are computed from the GMM estimates of θ and its asymptotic covariance matrix. From the asymptotic theory of GMM estimators (e.g., Hansen, 1982), it is known that they have an asymptotic normal limiting distribution. Therefore, the distribution of a function of the estimated coefficients can be simulated by drawing from the normal limiting distribution of the coefficient estimates.[7] Finally, the dynamic multipliers are simulated with the functional relationship between M(L) and θ.

To compute the effects of a shock to the dependent variable, the impulse responses are defined with respect to the shocks in $U_{i,t}$, and are computed from the elements of the $D(L)^{-1}$

6 For the cash flow equation with three lags, the LM and SH tests have p-values of 0.944 and 0.560, respectively.

7 Error bands are based on 1,000 Monte Carlo replications.

matrix in (13). The error bands for the impulse responses are computed in a similar manner to those for the dynamic multipliers.

3. Datasets

3.1. Financial Statements (UBS)

The Bundesbank's financial statement database (*Unternehmensbilanzstatistik*, UBS) constitutes the largest source of accounting data for nonfinancial firms in Germany.[8] These data were collected by the Bundesbank in performing its rediscounting and lending operations. Bills of exchange issued by nonfinancial firms were frequently presented to the Bundesbank by credit institutions (cf. fn. 3). When a bill was presented for discounting, the creditworthiness of the issuing firm and all other firms that have held this bill needed to be determined. In the case of default, liability for payment of the bill fell on any firm that had held the bill. By law, the Bundesbank could only accept bills backed by three parties known to be creditworthy.

About 70,000 annual accounts were collected per year on a strictly confidential basis by the Bundesbank's branch offices. These data were initially subjected to a computer check for logical errors and missing data. Approximately 15,000 accounts had to be excluded because they were incomplete, represented consolidated accounts, or were for firms in sectors (e.g., agriculture) for which no meaningful results could be generated owing to the small amount of available data. Additional checks and corrections for errors were undertaken in the Statistical Department at the Bundesbank's Central Office in Frankfurt before finalizing the UBS database.

The dataset used in estimation is smaller for several reasons. We use data only for firms located in the manufacturing sector of West Germany to avoid any issues of comparability between the western and eastern sections of the country. Sole proprietorships and private partnerships are excluded because their tax treatment depends on personal characteristics that are very difficult to quantify. State dominated corporations are also excluded. The dataset is further reduced by first-differencing, missing values, data cleaning, variable con-

---

8 This discussion draws on the Deutsche Bundesbank (1998) and Stöß (2001), which contain more detailed descriptions of the UBS data.

struction involving lags, and outlier control.[9] The data extend from 1988 to 1997.[10] We thus have available for our preferred econometric specification containing three lags (discussed in Section IV) 44,345 datapoints for 6,408 firms. For 1996, these data represent 42% of the total turnover of the West German manufacturing sector and 61% of the total turnover of incorporated firms in all German manufacturing.

3.2 User Cost (UC)

The user cost of capital (UC) is the variable through which monetary policy through interest rates affects investment spending. In very simple terms, the user cost is comprised of three components,

$$UC = R * P * T, \tag{14}$$

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 ($r = i - \pi$, the nominal discount rate (i) less the expected rate of inflation (π) in the price of investment goods) and the economic rate of depreciation (δ). The P term is the price of investment goods relative to the price of output. Two key taxes entering T are the rate of income taxation (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. The user cost variable used in this study is much more complicated than presented in this sub-section, and important details are discussed in Appendix A.

Table 1 contains summary statistics for the variables that enter VIM defined by equation system (6).

3.3. Creditworthiness Ratio (CWR)

A unique element in this study is the set of creditworthiness ratios (*Gesamtkennzahl*, CWR's) generated by the Bundesbank when it performed its rediscounting and lending op-

---

9 We control for outliers by discarding the upper and lower 1% tails of Δs_t, $(CF_{i,t}/K_{i,t-1})$, and the creditworthiness ratio (introduced in Section 3.3) and the upper 2% tail of $(I_{i,t}/K_{i,t-1})$. See Appendix B for further details about the financial statement data.

10 The beginning year of 1988 is chosen because the definitions of many important financial statement variables were changed in 1986 by the directive harmonizing 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.

erations. The CWR's are determined by a discriminant analysis.[11] The two underlying populations are solvent and insolvent firms, where insolvency is indicated by a legal application for bankruptcy. The sample is constructed by first identifying the relatively scarce insolvent firms, and then adding a solvent firm from the same sector. To enhance the statistical properties of the discriminant function, the sample contains an equal number of solvent and insolvent firms. The following information is used to compute the discriminant function: 1) equity/pension provision ratio (adjusted equity capital and pension provisions as a percentage of total capital employed); 2) return on total capital employed (profit before income taxes and before interest payments as a percentage of total capital employed); 3) return on equity (profit before income taxes as a percentage of adjusted equity income); 4) capital recovery rate (net receipts as a percentage of capital invested); 5) net interest payment ratio (net interest as a percentage of turnover); 6) accounting practice (which affects available valuation methods). The weights assigned to these categories are confidential. These ratios are examined by the Bundesbank's Department of Credit, Foreign Exchange, and Financial Markets for outliers.

The discriminant analysis determines two critical values of the CWR that classifies firms into one of three categories: high degree of creditworthiness (Good), low degree of creditworthiness (Endangered), or Indeterminate. The proportion of distressed firms in the data used in the discriminant analysis appears representative, and compares favourably to the percentage of failed firms in the overall economy (Deutsche Bundesbank, 1998; Stöß, 2001).

4. Simulating VIM - Full Sample

This section reports simulations of VIM to changes in the exogenous user cost and sales variables and shocks to the endogenous cash flow and investment variables. As discussed in Section 2, all coefficients are estimated by GMM with the equations first-differenced to eliminate firm fixed effects. Coefficient estimates and error bands are presented in Appendices C and E, respectively.

4.1. User Cost Change

Monetary policy affects investment spending through the interest rate embedded in the user cost of capital. This variable enters the investment equation, and represents the interest rate

---

11 See Deutsche Bundesbank (1999) for further details about the construction of the CWR's and the credit evaluation process.

channel of monetary policy. In VIM, the user cost also enters the cash flow equation. In turn, cash flow affects investment and vice versa. These real/financial interactions are at the core of the credit channel of monetary policy, and are also captured by VIM.

Table 2a and Figure 1a display the dynamic multipliers for investment and cash flow following from a one unit change in the user cost growth rate.[12] As shown in columns 1 and 4, the responses of both investment and cash flow is substantial in the first two years and, based on the error bands, these multipliers are statistically different from zero. The time profile of responses differ. For investment, 92% of the cumulative response takes place in the first two years. By contrast, only 67% of the reduction in cash flow occurs during the same period.

Relative to single equation evaluations of monetary policy, VIM matters. Columns 2 and 5 contain comparable dynamic multipliers for the ADL investment equation (5) and an analogously specified cash flow equation. The percentage differences between these single equation multipliers and VIM are presented in columns 3 and 6. The cumulative difference for investment is 33.7%. Thus, endogenizing financial decisions and recognizing the feedbacks between investment and cash flow has a substantial impact on the monetary policy transmission channel. For business investment, these feedbacks are one-third as large as the interest rate channel.

To understand the economic significance of monetary policy, we adjust the entries in Table 2a to correspond to the percentage change in investment with respect to a 25 basis point increase in the short-term interest rate. Specifically, the entries in columns 1, 2, 4, and 5 are multiplied by 0.07.[13] During the first two years after this monetary intervention, invest-

---

12 In this experiment, the monetary authorities raise the real rate for an indefinite period. Although this is not a realistic assumption, it allows us to avoid the complications associated with specifying an adjustment path for capital goods prices that returns the real interest rate to its long-run level. Moreover, this assumption has no practical significance for our analysis of investment because the bulk of the response to various stimuli occurs in the first two years.

13 The adjustment proceeds in two steps. First, the entries is Table 2a represent $\Delta I/K$, and are transformed into the percentage change in investment by the following relation: $(\Delta I/I) = (\Delta I/K) / (I/K)$, where (I/K) is the mean value of 0.1813 taken from Table 1, column 1. Second, the entries in Table 2a are for a 100% increase in user cost, and need to be adjusted to the percentage change in the user cost, $\Delta UC/UC$, corresponding to a 25 basis point change. Consider an expanded version of the user cost equation (14), $UC = ((1-\tau)\ i[m]-\pi+\delta) * P * T$, where τ is the corporate tax rate (see equation (A-3) for further details), $i[m]$ is the nominal long-term interest rate that depends on the monetary policy variable (m), π is the expected rate of inflation in the price of investment goods, δ is the economic rate of depreciation, and P and T represent price and tax terms, respectively. Differentiating with respect to m, we obtain $\Delta UC/UC = (\Delta i/\Delta m)\ \Delta m\ (1-\tau) / ((1-\tau)\ i[m]-\pi+\delta)$, where $(\Delta i/\Delta m)$ reflects the impact of the short-term rate controlled by the monetary authorities on the long-term rate entering the user cost and Δm is the basis point change in the short-term rate. We assume that $(\Delta i/\Delta m) = 1$, the net-of-tax real long-term rate is 0.01, $\tau = 0.44$ and δ is 0.10; these numbers are approximate. For $\Delta m = 0.0025$, $\Delta UC/UC = 0.0127$.

ment falls by a substantial 3.1%. However, it is important to realize that this assessment depends critically on the expectation assumptions reflected in the term structure of interest rates.

For the purpose of exposition, we assume that the long term rate changes by the same amount as the short term rate. Depending on how expectations are formed, the sensitivity of the long term rate might be smaller or perhaps even be larger. While our results indicate a statistically significant monetary policy channel that is enhanced by endogenous financing, its economic significance is sensitive to auxiliary assumptions outside the scope of the present study.

4.2. Sales Change

Simulations of a one unit increase in sales growth are presented in Table 2b and Figure 1b. Similar to the results with the user cost, dynamic multipliers based on VIM are approximately 30% larger than those computed from the ADL investment equation in isolation. The multipliers are statistically different from zero at the 5% level for all 10 simulation periods.

To understand the economic significance of these multipliers and the role of demand shifts, assume that exogenous sales rises for all firms by 1.0%[14] In this case, the entries in Table 2b are multiplied by 0.01, and investment rises by 1.9% during the first two years and 3.0% in the long-run (10 years).[15] The well-known investment accelerator is alive and well and, in VIM, enhanced by interactions with financial decisions.

4.3. Cash Flow Shock

The remaining two sets of simulations assess shocks to the equations comprising the econometric system (6). Table 3a and Figure 2a contain impulse responses for a unit shock to cash flow. Relative to single equation calculations, the sensitivity of investment to a cash flow shock is 66% larger when the investment and cash flow equations interact. This dif-

---

(Note that this formulation does not allow the present value of depreciation allowances ("A" in Appendix A) to vary with the interest rate due to computational considerations and a desire to separate fiscal and monetary policy issues.) The entries in Table 2a are thus multiplied by 0.07 = 0.0127 / 0.1813.

14 This perturbation equals a one standard deviation movement in (filtered) GDP for the period 1970-1998. The standard deviation is computed using a band-pass filter, and equals 1.06 (Agresti and Mojon, 2001, Table 1).

15 This change is computed as follows: $(\Delta I/I) = (\Delta I/K)\ 0.01 / (I/K)$, where $(\Delta I/K)$ is taken from Table 2b, column 1 and (I/K) is the mean value of 0.1813 taken from Table 1, column 1. For the first two simulation periods, $(\Delta I/I) = (0.1935+0.1467) * 0.01 / 0.1813 = 1.88\%$.

ference is twice as large as the comparable figures for the user cost and sales multipliers discussed above.

As is standard in VAR analyses, we evaluate the response of investment to a one standard deviation shock, which equals the residual standard error in the cash flow equation. In this case, the entries in Table 3a are multiplied by 0.04, and investment rises by 3.9% in the long-run in response to this cash flow shock.

4.4. Investment Shock

Table 3b and Figure 2b report the impulse responses associated with a unit shock to investment. Apart from the initial shock, the long-run effect on investment and the cumulative difference between the VIM and ADL multipliers are small.

5. Simulating VIM - Sample Sorted By Creditworthiness

Much recent research in macroeconomics has emphasized the importance of firm heterogeneity and the differential impacts of monetary policy on firms facing varying degrees of difficulty obtaining external finance. While the finance constraints literature has been characterized by sharp differences of opinion (see fn. 5), there is rather broad agreement that variations in firm creditworthiness and the resulting wedge between internal and external finance are the key elements in models of finance constraints.[16]

The Bundesbank data on firm creditworthiness allows us to examine the impact of this type of heterogeneity. Firms are classified by a direct measure of the external finance premium, CWR. There are three categories of creditworthiness - Endangered, Good, and Indeterminate - depending on the state in the year before the investment/capital ratio first enters the regression model as a dependent variable. Our large sample permits us to discard the middle group in order to sharpen the evaluation.

Dynamic multipliers and impulse responses for the Endangered and Good classes of firms are presented in Figure 3 (coefficient estimates are in Appendix D). A change in monetary policy (and the associated change in the user cost) has almost no impact on investment by Endangered firms in the first year and a relatively small effect in the second year. The sensitivity of investment to this monetary impulse is much larger for the Good firms. An even

16 For example, Fazzari, Hubbard, and Petersen (1988, p. 183), Kaplan and Zingales (1997, pp. 172-173), and Bernanke and Gertler (1990, pp. 88-89).

more extreme pattern emerges with respect to a change in sales. Firms with poor credit ratings do not react to changing economic conditions. This "paralysis" might be traceable to their inability to finance investment. On the other hand and consistent with binding financing constraints, investment is much more responsive for Endangered firms than for Good firms (bottom panel of Figure 3). The CWR split sample results offer striking confirmation of the importance of firm heterogeneity and finance constraints for understanding the differential effects of monetary policy.

6. Summary And Conclusions

This paper presents a new approach to modelling business investment spending and monetary policy transmission. Ambiguities concerning the modelling of investment dynamics and interactions between real and financial decisions suggest a VAR methodology for drawing relations among investment and its determinants. We specify a Vector Autoregressive Investment model (VIM) containing investment, user cost, sales, and cash flow variables. Estimates are based on a large panel dataset containing 44,345 datapoints for 6,408 German firms supplemented with data for the user cost of capital and firm credit ratings.

We obtain three key results. First, monetary policy matters. The effects of a monetary contraction are statistically significant and very rapid, with 92% of the cumulative response occurring in the first two years. Over this period, a 25 basis point increase in the short-term interest rate lowers investment by 3.1%, though this computation of economic significance is sensitive to auxiliary assumptions outside the scope of this study.

Second, VIM matters. Relative to simulations of a single equation based on exogenous financing, the sensitivity of investment to monetary policy is larger by one-third and to cash flow shocks by two-thirds in VIM. Endogenizing financial decisions and recognizing feedbacks between investment and cash flow has a substantial impact on the monetary policy transmission channel.

Third, financial status matters. Firms with a poor credit rating are "paralysed" in being unable to respond to changes in the user cost and sales. However, they are more responsive to cash flow shocks than firms with a good credit rating.

These initial results indicate that VIM is a feasible approach for analysing firm-level panel data, and can shed new insights into firm behaviour and monetary policy transmission.

References

Abel, Andrew B., and EJanice E. Eberly, “Q Theory without Adjustment Costs and Cash Flow Effects without Finance Constraints," Northwestern and Pennsylvania (February 2002).

Agresti, Anna-Maria, and Benoît Mojon, "Some Stylised Facts on the Euro Area Business Cycle," European Central Bank Working Paper No. 95 (December 2001).

Arellano, Manuel, and Stephen Bond, "Some Tests of Specifications for Panel Data: Monte Carlo Evidence and an Application to Employment Equations", *The Review of Economic Studies* 58 (April 1991), 277-298.

Auerbach, Alan J., "Taxation, Corporate Financial Policy and the Cost of Capital", *Journal of Economic Literature* 21 (September 1983), 905-940.

Benito, Andrew and Garry Young, "Financial pressure and Balance Sheet Adjustment by UK Firms, Bank of England Working Paper No. 168, October 2002.

Bernanke, Ben, and Mark Gertler, “Financial Fragility and Economic Performance,” *The Quarterly Journal of Economics* 105 (February 1990, 87-114.

Bernanke, Ben S., Mark Gertler, and Simon Gilchrist, "The Financial Accelerator in a Quantitative Business Cycle Framework", in John B. Taylor and Michael Woodford (eds.), *Handbook of Macroeconomics*, Vol. 1 (Amsterdam, New York, etc.: North Holland, 1999), Ch. 21, 1341-1393.

Blanchard, Olivier J., “Why Does Money Affect Output?: A Survey,” in Benjamin Friedman and Frank H. Hahn (eds.), *Handbook Of Monetary Economics, Volume 2* (Amsterdam: Elsevier North-Holland, 1990), 779-835.

Chatelain, Jean-Bernard, "Structural Modeling of Financial Constraints on Investment: Where Do We Stand?," in Jan Smets, Catherine Fuss, and Paul Butzen (eds.), *Firms' Investment and Finance Decisions: Theory and Empirical Methodology* (Cheltenham: Edward Elgar, forthcoming).

Chenells, Lucy, and Rachel Griffith, *Taxing Profits in a Changing World* (London: The Institute for Fiscal Studies, 1997).

Chirinko, Robert S., "Business Tax Policy, the Lucas Critique, and Lessons from the 1980s," *American Economic Review* 78 (May 1988), 206-210.

Chirinko, Robert S., "Finance Constraints, Liquidity, and Investment Spending: Theoretical Restrictions and International Evidence," *Journal of the Japanese and International Economies* 11 (June 1997), 185-207.

Chirinko, Robert S., Steven M. Fazzari, and Andrew P. Meyer, "How Responsive is Business Capital Formation to its User Cost? An Exploration with Micro Data," *Journal of Public Economics* 74 (October 1999), 53-80.

Christiano, Lawrence J., Martin Eichenbaum, and Charles L. Evans, “Monetary Policy Shocks: What Have We Learned and to What End?,” in John B. Taylor and Michael Woodford (eds.), *Handbook Of Macroeconomics,* Volume 1A (Amsterdam: Elsevier North-Holland), 1999), 65-148.

Coen, Robert M., "Tax Policy and Investment Behavior: Comment," *American Economic Review* 59 (June 1969), 370-379.

Deutsche Bundesbank, "The Methodological Basis of the Deutsche Bundesbank's Corporate Balance Sheet Statistics," *Monthly Report* 49 (October 1998), 49-64.

Deutsche Bundesbank, “The Bundesbank’s Method of Assessing the Creditworthiness of Business Enterprises,” *Monthly Report* 50 (January 1999), 51-63.

Estrella, Arturo, and Jeffrey C. Fuhrer, "Are 'Deep' Structural Parameters Stable? The Lucas Critique as an Empirical Hypothesis," *The Review of Economics and Statistics* (forthcoming).

Fazzari, Steven M., R. Glenn Hubbard, and Bruce C. Petersen, "Financing Constraints and Corporate Investment", *Brookings Papers on Economic Activity* 1988:1, 141-195.

Fazzari, Steven M., R. Glenn Hubbard, and Bruce C. Petersen, "Investment-Cash Flow Sensitivities Are Useful: A Comment on Kaplan and Zingales", *Quarterly Journal of Economics* 115 (May 2000), 695-705.

Gomes, Joao F., "Financing Investment," *American Economic Review* 91 (December 2001), 1263-1285.

Hall, Robert E., and Dale W. Jorgenson, "Tax Policy and Investment Behavior," *American Economic Review* 57 (June 1967), 391-414.

Hansen, Lars Peter, "Large Sample Properties of Generalized Method of Moments Estimators," *Econometrica* 50 (July 1982), 1029-1054.

Hayashi, Fumio, *Econometrics* (Princeton: Princeton University Press, 2000).

Harhoff, Dietmar, and Fred Ramb, "Investment and Taxation: Evidence from Firm-Level Panel Data", in Deutsche Bundesbank (ed.), *Investing Today for the World of Tomorrow: Studies on the Investment Process in Europe* (Berlin: Springer-Verlag, 2001), 47-73.

Holtz-Eakin, Douglas, Whitney K. Newey, and Harvey S. Rosen, “Estimating Vector Autoregressions with Panel Data,” *Econometrica* 56 (1988), 1371-1395.

Hubbard, R. Glenn, "Capital-Market Imperfections and Investment", *Journal of Economic Literature* 36 (March 1998), 193-225.

Jorgenson, Dale W., "Capital Theory and Investment Behaviour", *American Economic Review* 53 (May 1963), 247-259.

Jorgenson, Dale W., "Rational Distributed Lag Functions," *Econometrica* 34 (January 1966), 135-149.

Kaplan, Steven N., and Luigi Zingales, "Do Investment-Cash Flow Sensitivities Provide Useful Measures of Finance Constraints?", *Quarterly Journal of Economics* 112 (February 1997), 169-215.

Kaplan, Steven N., and Luigi Zingales, "Investment-Cash Flow Sensitivities Are Not Valid Measures of Financing Constraints", *Quarterly Journal of Economics* 115 (May 2000), 707-712.

King, Mervyn A., and Don Fullerton (eds.), *The Taxation of Income from Capital* (Chicago: University of Chicago Press (for the NBER), 1984).

Mishkin, Frederic S., “Symposium on the Monetary Transmission Mechanism,” *Journal Of Economic Perspectives* 9 (Fall 1995), 3-96.

Modigliani, Franco, and Merton H. Miller, "The Cost of Capital, Corporation Finance and the Theory of Investment," *American Economic Review* 48 (June 1958), 261-297.

OECD, *Taxing Profits in a Global Economy. Domestic and International Issues* (Paris: OECD, 1991).

Ramb, Fred, *Steuersystem und Investitionstätigkeit. Eine panelökonometrische Untersuchung für Deutschland {"Taxation and Investment. A Panel Econometric Investigation for Germany"}. In German.* (Baden-Baden: Nomos Verlag, forthcoming).

Sargan, John D., "The Estimation of Economic Relationships Using Instrumental Variables," *Econometrica* 26 (1958), 393-415.

Schiantarelli, Fabio, "Financial Constraints and Investment: A Critical Review of Methodological Issues and International Evidence," in Joe Peek and Eric S. Rosengren (eds.), *Is Bank Lending Important For The Transmission Of Monetary Policy?* (Boston: Federal Reserve Bank Of Boston, 1995), 177-214.

Sinn, Hans-Werner, "Systeme der Kapitaleinkommensbesteuerung: Ein allokationstheorethischer Vergleich {"Systems of Capital Income Taxation. A Comparison with Respect to Allocation"), in Dieter Bös et al. (eds.), *Beiträge zur neueren Steuertheorie* (Berlin, Heidelberg etc.: Springer 1984).

Sinn, Hans-Werner, *Capital Income Taxation and Resource Allocation* (Amsterdam: North-Holland, 1987). (Published in German as *Kapitaleinkommensbesteuerung* (Tübingen: Mohr, 1985).)

Stöß, Elmar, "Deutsche Bundesbank's Corporate Balance Sheet Statistics and Areas of Application," *Schmollers Jahrbuch: Zeitschrift für Wirtschafts- und Sozialwissenschaften* (*Journal of Applied Social Science Studies*) 121 (Spring 2001), 131-137.

Taylor, John B., "Monetary Policy and the Stability of Macroeconomic Relationships," *Journal of Applied Econometrics* 4 (December 1989), S161-S178.

Appendix A: The Construction Of User Costs Of Capital For Germany[17]

The Jorgensonian user cost of capital (see Auerbach (1983) for a derivation) is given by the following formula,

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

where p is the output price level, p^I is the price of investment goods, A is the present value of depreciation allowances, ρ is the nominal discount rate, π^I is the expected rate of investment goods price inflation, δ^e is the economic depreciation rate, and τ is the basic corporate tax rate (the rate of tax paid if no profits are distributed). 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.

Our construction of user costs takes into account multiple assets, multiple sources of funds, and individual taxation following the approach developed by King and Fullerton (1984), extended by the OECD (1991) and Chenells and Griffith (1997), and applied to the German data by Harhoff and Ramb (2001) and Ramb (forthcoming).

If we distinguish as sources of finance between debt finance, new share issues, and retained earnings, the respective discount rates are given by

$$\rho = \begin{cases} i \cdot (1-\tau) & \text{for debt} \\ i/\theta & \text{for new shares} \\ i \cdot \dfrac{1-m}{1-z} & \text{for retained earnings} \end{cases} \qquad \text{(A-2)}$$

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; θ equals the additional dividend shareholders would receive if one unit of post-corporate tax earnings were distributed. Furthermore, i is the nominal interest rate, m is the

17 The user cost of capital for our sample have 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, we have to bear responsibility for the user costs used in this study.

marginal personal tax rate on capital income, and 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. Shareholders who were residents 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. In this case, the expression for the discount rate reduces to

$$\rho = \begin{cases} i \cdot (1-\tau) & \text{for debt} \\ i \cdot (1-\tau) & \text{for new shares} \\ i \cdot (1-m) & \text{for retained earnings} \end{cases} \qquad \text{(A-3)}$$

In the system with full imputation that prevailed in Germany from 1977 to 2000, the two types of outside finance are equivalent (Sinn, 1984 and 1987).

To implement this framework and quantify (A-1), we use sector-specific output price levels ($p_{j,t}$) and depreciation rate ($\delta^e_{j,t}$), where j indexes sectors. Depreciation rates are calculated from a perpetual inventory equation for sectoral capital stocks and investment flows; rates for 1995-1997 are imputed. The price of capital goods (p^I_t) is an economy-wide deflator dated at the beginning of the year, and the expected inflation rate (π^I_t) measures the rate of growth of p^I_t between the beginning and the end of year t. $A_{a,t}$ is the present value of depreciation allowances as a firm-specific asset-weighted average for three different types of assets (indexed by a): building, machinery and equipment. In each case, finance-specific discount rates are used. ($A_{a,t}$ is computed with an optimal switch from accelerated to straight-line depreciation methods.) The rate of interest rate (i_t) is the average yield to maturity of domestic listed debt securities. The tax rate on retained earnings is calculated as a compound tax combining three different taxes of profits: the basic corporate tax on retained earnings (τ^r_t), the local tax (*Gewerbesteuer*, g_t, is deductible for corporate tax purposes), and the "solidarity surcharge" (s_t, which is levied on all corporate and personal tax payments),

$$\tau_t = (1+s_t)\tau_t^r (1-g_t) + g_t, \qquad \text{(A-4)}$$

As in King and Fullerton, we treat local taxes as a normal tax on profits, ignoring some of its special features.[18] As a marginal tax rate for the shareholder, we used the highest marginal income tax m_t^{max}, again inflated by the solidarity surcharge,

$$m_t = (1 + s_t) m_t^{max} . \qquad \text{(A-5)}$$

To combine the different user costs resulting from the three different sources of finance, we use a flow weights defined for the three sources of finance as follows: debt (with total liabilities including the share of borrowed funds in the reserve subject to future taxation), new shares (the first difference of the stock of subscribed capital augmented by share premium or paid-in surplus), and retained earnings (retained earnings with the earned surplus including the share of own funds in the reserves subject to future taxation). For increases of debt, new shares, or retained earnings, the corresponding weight is calculated as a ratio to the sum of *positive* sources of new finance in that year. If a particular weight assumes a negative value, it is set to zero for that year; in each year, the weights sum to unity. For the first year, the respective stock weights are used.

Appendix B: Variable Definitions And Outlier Control

Model 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:

---

18 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. The Gewerbesteuer is raised at the local level. Due to data limitations, however, we have to confine ourselves to the mean Gewerbesteuer rate for the whole sample.

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

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 Section 3.2 and Appendix A.

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

Creditworthiness Ratio (CWR): A discriminant analysis procedure separates firms with 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 creditworthiness ratio (CWR) 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:

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

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

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

Outlier control

Observations with missing values for sales, capital, investment, cash flow or the overall rating ratio were excluded. The presence of CWR serves as a check that the EU harmonization guidelines were being followed. The data set is trimmed by discarding the upper and lower 1% tails of Δs_t, $(CF_{i,t}/K_{i,t-1})$, and CWR and the upper 2% tail of $(I_{i,t}/K_{i,t-1})$.

Appendix C: GMM Coefficient Estimates of Equation System (6)
Full Sample

Explanatory Variable	Investment Equation Dependent Variable: $I_{i,t}/K_{i,t-1}$		Cash Flow Equation Dependent Variable: $CF_{i,t}/K_{i,t-1}$	
	(1)	(2)	(3)	(4)
$\Delta uc_{i,t}$	-0.206**	(0.071)	-0.274**	(0.091)
$\Delta uc_{i,t-1}$	-0.163**	(0.038)	-0.127*	(0.052)
$\Delta uc_{i,t-2}$	-0.014	(0.034)	-0.025	(0.050)
$\Delta uc_{i,t-3}$	0.038	(0.027)	-0.038	(0.034)
$\Delta s_{i,t}$	0.161**	(0.055)	0.465**	(0.075)
$\Delta s_{i,t-1}$	0.095**	(0.014)	0.167**	(0.020)
$\Delta s_{i,t-2}$	0.065**	(0.011)	0.094**	(0.017)
$\Delta s_{i,t-3}$	0.033**	(0.010)	0.035*	(0.014)
$CF_{i,t}/K_{i,t-1}$	0.070*	(0.034)		
$CF_{i,t-1}/K_{i,t-2}$	0.013	(0.014)	0.324**	(0.034)
$CF_{i,t-2}/K_{i,t-3}$	0.005	(0.005)	0.081**	(0.019)
$CF_{i,t-3}/K_{i,t-4}$	0.005	(0.004)	0.006	(0.017)
$I_{i,t-1}/K_{i,t-2}$	0.131**	(0.016)	-0.098**	(0.023)
$I_{i,t-2}/K_{i,t-3}$	-0.002	(0.009)	-0.018	(0.017)
$I_{i,t-3}/K_{i,t-4}$	0.005	(0.007)	0.001	(0.012)
SH p-value	0.075		0.560	
LM p-value	0.165		0.944	
Observations	18,713		18,713	
Firms	6,408		6,408	

Notes to Appendix C:
See the note to Table 1 for variable definitions.** and * indicate statistical significance at the 1% and 5% levels, respectively. Constants (ϕ_i) and year dummies (λ_t) are also included in the regression equation. The instruments are $I_{i,t-m(t)}/K_{t-1-m(t)}$, $\Delta s_{i,t-m(t)}$, $\Delta uc_{i,t-m(t)}$, and $CF_{i,t-m(t)}/K_{i,t-1-m(t)}$ for $m_t \geq 2$, where m_t is as large as possible given data availability and increases over the sample; a constant and λ_t are also in the instrument set. Heteroscedastic-consistent standard errors are in parentheses. Columns 1-2 (3-4) contain the coefficients and standard errors for the investment (cash flow) equation. SH is the p-value for the Sargan-Hansen statistic testing overidentifying restrictions. LM is the p-value for the Lagrange Multiplier statistic testing for second-order autocorrelation. An observation is defined by a “string“ of datapoints needed to form a contiguous relation between the dependent and current and lagged independent and lagged dependent variables.

Appendix D: GMM Coefficient Estimates of Equation System (6)
Sample Split By Firm Creditworthiness.

Explanatory Variable	Investment Equation Dependent Variable: $I_{i,t}/K_{i,t-1}$				Cash Flow Equation Dependent Variable: $CF_{i,t}/K_{i,t-1}$			
	Good		Endangered		Good		Endangered	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta uc_{i,t}$	-0.309**	(0.082)	0.012	(0.131)	-0.199*	(0.098)	-0.052	(0.147)
$\Delta uc_{i,t-1}$	-0.193**	(0.043)	-0.104	(0.079)	-0.083	(0.055)	-0.128	(0.107)
$\Delta uc_{i,t-2}$	-0.050	(0.036)	-0.086	(0.073)	0.015	(0.050)	0.010	(0.100)
$\Delta uc_{i,t-3}$	0.008	(0.030)	0.009	(0.054)	-0.009	(0.036)	-0.032	(0.069)
$\Delta s_{i,t}$	0.220**	(0.065)	0.044	(0.059)	0.543**	(0.085)	0.272**	(0.076)
$\Delta s_{i,t-1}$	0.112**	(0.017)	0.043	(0.022)	0.185**	(0.025)	0.090**	(0.029)
$\Delta s_{i,t-2}$	0.063**	(0.014)	0.021	(0.018)	0.107**	(0.019)	0.036	(0.027)
$\Delta s_{i,t-3}$	0.031**	(0.011)	0.031*	(0.015)	0.028*	(0.015)	0.043*	(0.021)
$CF_{i,t}/K_{i,t-1}$	0.071*	(0.034)	0.142**	(0.030)				
$CF_{i,t-1}/K_{i,t-2}$	0.005	(0.016)	0.018	(0.013)	0.392**	(0.040)	0.043	(0.024)
$CF_{i,t-2}/K_{i,t-3}$	0.005	(0.006)	0.010	(0.008)	0.046*	(0.020)	0.070**	(0.014)
$CF_{i,t-3}/K_{i,t-4}$	0.003	(0.005)	-0.007	(0.005)	-0.002	(0.017)	-0.022	(0.012)
$I_{i,t-1}/K_{i,t-2}$	0.114**	(0.017)	0.103**	(0.031)	-0.099**	(0.028)	-0.042	(0.029)
$I_{i,t-2}/K_{i,t-3}$	-0.011	(0.010)	-0.013	(0.016)	0.012	(0.020)	-0.055**	(0.018)
$I_{i,t-3}/K_{i,t-4}$	0.003	(0.008)	0.010	(0.012)	0.012	(0.015)	-0.006	(0.016)
SH p-value	0.239				0.687			
LM p-value	0.132				0.908			
Observations	16,259				16,259			
Firms	5515				5515			

Notes to Appendix D:

See the note to Table 1 for variable definitions.** and * indicate statistical significance at the 1% and 5% levels, respectively. Constants (ϕ_i) and year dummies (λ_t) are also included in the regression equation. The instruments are $I_{i,t-m(t)}/K_{t-1-m(t)}$, $\Delta s_{i,t-m(t)}$, $\Delta uc_{i,t-m(t)}$, and $CF_{i,t-m(t)}/K_{i,t-1-m(t)}$ for $m_t \geq 2$, where m_t is as large as possible given data availability and increases over the sample; a constant and λ_t are also in the instrument set. Heteroscedastic-consistent standard errors are in parentheses. Columns 1-4 (5-8) contain the coefficients and standard errors for the investment (cash flow) equation. SH is the p-value for the Sargan-Hansen statistic testing overidentifying restrictions. LM is the p-value for the Lagrange Multiplier statistic testing for second-order autocorrelation. An observation is defined by a "string" of datapoints needed to form a contiguous relation between the dependent and current and lagged independent and lagged dependent variables

Appendix E: Error Bands For The Dynamic Multipliers And Impulse Responses For VIM

Panel A: Dynamic Multipliers (DM) – User Cost Change

	I/K			CF/K		
t	**Lower (1)**	**DM (2)**	**Upper (3)**	**Lower (4)**	**DM (5)**	**Upper (6)**
0	-0.3376	-0.2257*	-0.1069	-0.4069	-0.2740*	-0.1199
1	-0.2768	-0.2102*	-0.1430	-0.3089	-0.1937*	-0.0720
2	-0.1066	-0.0514	0.0118	-0.1990	-0.0855	0.0349
3	-0.0263	0.0214	0.0688	-0.1661	-0.0742	0.0164
4	-0.0121	-0.0029	0.0056	-0.0729	-0.0335	0.0059
5	-0.0078	-0.0032	0.0007	-0.0402	-0.0175	0.0036
6	-0.0045	-0.0017	0.0005	-0.0226	-0.0084	0.0020
7	-0.0024	-0.0009	0.0002	-0.0122	-0.0041	0.0010
8	-0.0013	-0.0005	0.0001	-0.0069	-0.0020	0.0005
9	-0.0007	-0.0002	0.0000	-0.0038	-0.0010	0.0002
10	-0.0004	-0.0001	0.0000	-0.0021	-0.0005	0.0001
Sum		**-0.4753**			**-0.6943**	

Panel B: Dynamic Multipliers (DM) – Sales Change

	I/K			CF/K		
t	**Lower (1)**	**DM (2)**	**Upper (3)**	**Lower (4)**	**DM (5)**	**Upper (6)**
0	0.1066	0.1935*	0.2769	0.3396	0.4651*	0.5863
1	0.1225	0.1467*	0.1720	0.2454	0.2983*	0.3535
2	0.0853	0.1050*	0.1244	0.1672	0.2097*	0.2549
3	0.0458	0.0625*	0.0805	0.0823	0.1169*	0.1574
4	0.0108	0.0163*	0.0225	0.0294	0.0487*	0.0746
5	0.0033	0.0066*	0.0107	0.0112	0.0239*	0.0415
6	0.0014	0.0031*	0.0058	0.0037	0.0115*	0.0238
7	0.0005	0.0014*	0.0030	0.0012	0.0055*	0.0136
8	0.0002	0.0007*	0.0016	0.0003	0.0027*	0.0078
9	0.0001	0.0003*	0.0009	0.0001	0.0013*	0.0045
10	0.0000	0.0001*	0.0005	0.0000	0.0006*	0.0026
Sum		**0.5362**			**1.1843**	

Panel C: Impulse Responses (IR) – Cash Flow Shock

	I/K			CF/K		
t	**Lower (1)**	**IR (2)**	**Upper (3)**	**Lower (4)**	**IR (5)**	**Upper (6)**
0	0.0143	0.0701*	0.1246	1.0000	1.0000	1.0000
1	0.0286	0.0442*	0.0614	0.2609	0.3168*	0.3722
2	0.0135	0.0275*	0.0371	0.1278	0.1776*	0.2318
3	0.0073	0.0189*	0.0275	0.0402	0.0858*	0.1414
4	0.0031	0.0092*	0.0144	0.0149	0.0418*	0.0809
5	0.0012	0.0046*	0.0081	0.0039	0.0203*	0.0478
6	0.0004	0.0023*	0.0047	0.0013	0.0099*	0.0282
7	0.0001	0.0011*	0.0027	0.0003	0.0048*	0.0167
8	0.0000	0.0005*	0.0016	0.0001	0.0023*	0.0099
9	0.0000	0.0003*	0.0009	0.0000	0.0011*	0.0058
10	0.0000	0.0001*	0.0005	0.0000	0.0005*	0.0034
Sum		**0.1788**			**1.6611**	

Panel D: Impulse Responses (IR) – Investment Shock

	I/K			CF/K		
t	**Lower (1)**	**IR (2)**	**Upper (3)**	**Lower (4)**	**IR (5)**	**Upper (6)**
0	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000
1	0.0983	0.1242*	0.1504	-0.1358	-0.0984*	-0.0614
2	-0.0082	0.0089	0.0299	-0.1040	-0.0620*	-0.0199
3	-0.0094	0.0029	0.0187	-0.0721	-0.0303	0.0082
4	-0.0051	-0.0013	0.0038	-0.0421	-0.0158	0.0041
5	-0.0034	-0.0013	0.0008	-0.0239	-0.0079	0.0021
6	-0.0021	-0.0008	0.0004	-0.0144	-0.0038	0.0008
7	-0.0013	-0.0004	0.0001	-0.0084	-0.0019	0.0003
8	-0.0008	-0.0002	0.0000	-0.0049	-0.0009	0.0001
9	-0.0005	-0.0001	0.0000	-0.0029	-0.0004	0.0000
10	-0.0003	-0.0001	0.0000	-0.0017	-0.0002	0.0000
Sum		**1.1318**			**-0.2216**	

Notes To Appendix E:* indicates statistical significance at 5% level. Panels A and B contain error bands (Lower and Upper) and dynamic multipliers (DM) for changes in user cost and sales, respectively. Panels C and D contain error bands and impulse responses (IR) for shocks to cash flow and investment, respectively. See Section 2.3 and the Notes to Tables 2 and 3 for details. Error bands are based on 1,000 Monte Carlo replications.

Table 1: Summary Statistics for the Full Sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variable	**Mean**	**Std. Dev.**	**Min.**	**25%**	**Median**	**75%**	**Max.**
I_t / K_{t-1}	0.1813	0.220	0	0.0585	0.1161	0.2157	2.2138
Δuc_t	0.0222	0.0717	-0.3478	-0.0178	0.0094	0.0644	0.4991
UC_t	0.1587	0.0183	0.0857	0.1457	0.1572	0.1697	0.2812
Δs_t	0.0206	0.1597	-0.5959	-0.0654	0.0214	0.1068	0.8308
S_t	173.15	1455.12	0.27	9.94	26.13	71.25	65,900.0
CF_t / K_{t-1}	0.2843	0.4941	-1.9143	0.1091	0.1887	0.3308	9.2678

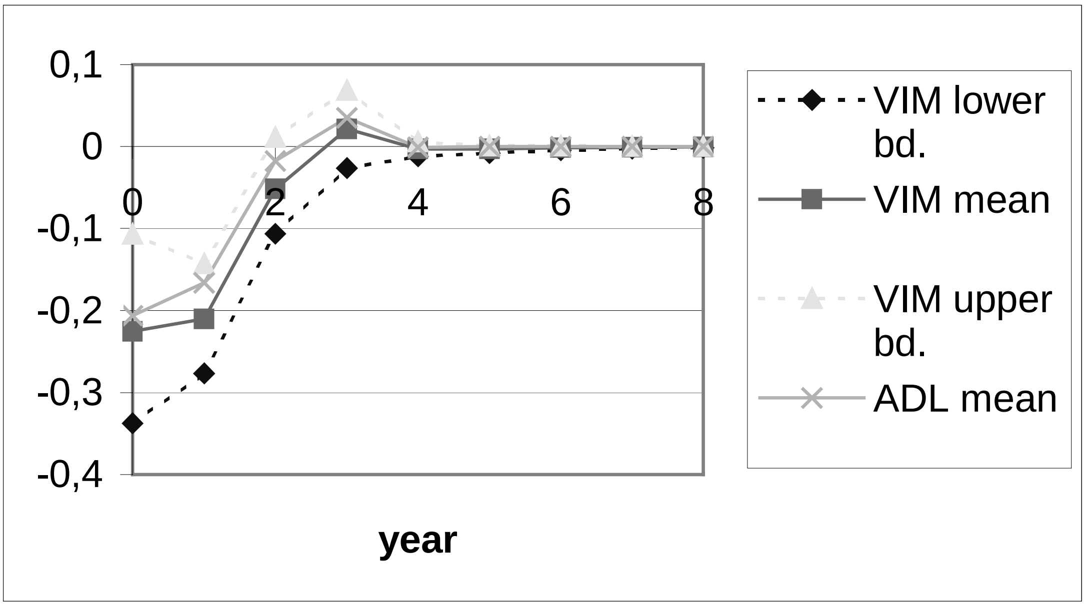
Notes to Table 1:
The sample contains 44,345 datapoints for 6,408 firms for 1988-1997. I_t/K_{t-1} is the investment/capital ratio; Δ is the first-difference operator; uc_t is the logarithm of UC_t; UC_t is the user cost of capital; s_t is the logarithm of S_t; S_t is real sales in millions of Deutschmarks; CF_t/K_{t-1} is the cash flow/capital ratio. See Section 3 and Appendices A and B for more details about the variables.

Table 2a: Dynamic Multipliers – User Cost Change

	I/K			CF/K		
t	**VIM (1)**	**ADL (2)**	**% Diff. (3)**	**VIM (4)**	**ADL (5)**	**% Diff. (6)**
0	-0.2257*	-0.2065	5.40%	-0.2740*	-0.2740	0.00%
1	-0.2102*	-0.1661	12.38%	-0.1937*	-0.2159	-2.82%
2	-0.0514	-0.0176	9.49%	-0.0855	-0.1174	-4.05%
3	0.0214	0.0352	3.88%	-0.0742	-0.0949	-2.64%
4	-0.0029	-0.0007	0.63%	-0.0335	-0.0415	-1.03%
5	-0.0032	0.0000	0.90%	-0.0175	-0.0218	-0.55%
6	-0.0017	0.0002	0.52%	-0.0084	-0.0110	-0.33%
7	-0.0009	0.0000	0.24%	-0.0041	-0.0056	-0.18%
8	-0.0005	0.0000	0.13%	-0.0020	-0.0028	-0.10%
9	-0.0002	0.0000	0.06%	-0.0010	-0.0014	-0.06%
10	-0.0001	0.0000	0.03%	-0.0005	-0.0007	-0.03%
Sum	**-0.4753**	**-0.3556**	**33.66%**	**-0.6943**	**-0.7872**	**-11.80%**

Notes To Table 2a:
Dynamic multipliers computed for a 1 unit change in the user cost; see Section 2.3 for details. * indicates statistical significance at 5% level. When the entries in columns 1, 2, 4, and 5 are multiplied by 0.01, the multipliers correspond to a 25 basis point increase in the short-term rate controlled by the monetary authorities and a 1.0% increase in the user cost of capital; see Section 4 for details. Columns 1-3 (4-6) are for the investment (cash flow) equation in equation system (6). Columns 1 and 4 simulate the complete equation system (6), while columns 2 and 5 simulate their respective equations in isolation. The percentage differences (% Diff.) in columns 3 (6) are computed as the difference between VIM and ADL results divided by the sum of the ADL multipliers in column 2 (5).

Figure 1a: Dynamic Multipliers – User Cost Change



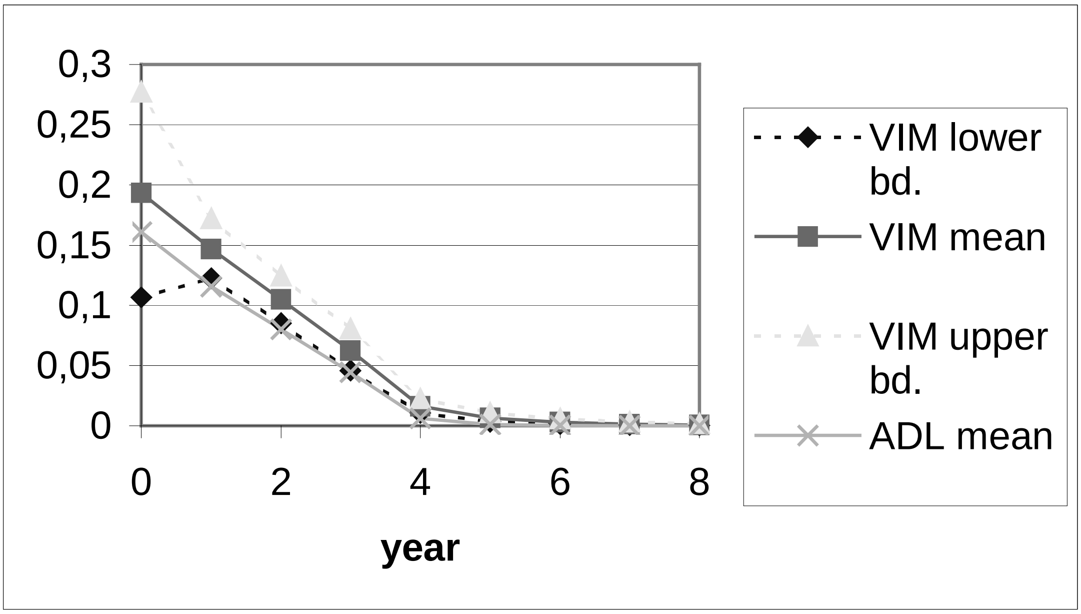
Notes To Figure 1a:
Plot of dynamic multipliers from Table 2a and error bands in Appendix E. Error bands are based on 1,000 Monte Carlo replications.

Table 2b: Dynamic Multipliers – Sales Change

t	I/K			CF/K		
	VIM (1)	**ADL (2)**	**% Diff. (3)**	**VIM (4)**	**ADL (5)**	**% Diff. (6)**
0	0.1935*	0.1609	7.98%	0.4651*	0.4651	0.00%
1	0.1467*	0.1156	7.62%	0.2983*	0.3174	-1.48%
2	0.1050*	0.0800	6.12%	0.2097*	0.2338	-1.87%
3	0.0625*	0.0443	4.45%	0.1169*	0.1391	-1.72%
4	0.0163*	0.0063	2.45%	0.0487*	0.0658	-1.33%
5	0.0066*	0.0012	1.32%	0.0239*	0.0340	-0.79%
6	0.0031*	0.0004	0.67%	0.0115*	0.0172	-0.44%
7	0.0014*	0.0001	0.32%	0.0055*	0.0087	-0.25%
8	0.0007*	0.0000	0.16%	0.0027*	0.0044	-0.13%
9	0.0003*	0.0000	0.08%	0.0013*	0.0022	-0.07%
10	0.0001*	0.0000	0.04%	0.0006*	0.0011	-0.04%
Sum	**0.5362**	**0.4088**	**31.19%**	**1.1843**	**1.2888**	**-8.11%**

Notes To Table 2b:
Dynamic multipliers computed for a 1 unit change in sales. See the notes to Table 2a for further information about the table entries.

Figure 1b: Dynamic Multipliers – Sales Change



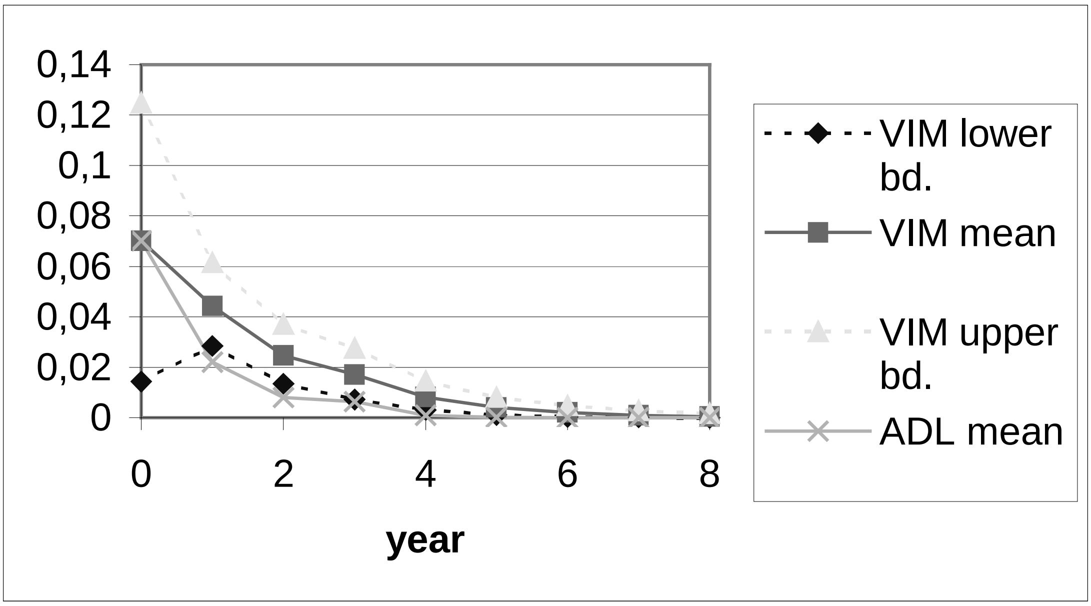
Notes To Figure 1b:
Plot of dynamic multipliers from Table 2b and error bands in Appendix E. Error bands are based on 1,000 Monte Carlo replications.

Table 3a: Impulse Responses – Cash Flow Shock

	I/K			CF/K		
t	**VIM (1)**	**ADL (2)**	**% Diff. (3)**	**VIM (4)**	**ADL (5)**	**% Diff. (6)**
0	0.0701*	0.0701	0.00%	1.0000*	1.0000	0.00%
1	0.0442*	0.0220	20.62%	0.3168*	0.3237	-0.41%
2	0.0275*	0.0081	18.03%	0.1776*	0.1855	-0.46%
3	0.0189*	0.0064	11.58%	0.0858*	0.0924	-0.39%
4	0.0092*	0.0009	7.68%	0.0418*	0.0469	-0.30%
5	0.0046*	0.0002	4.15%	0.0203*	0.0238	-0.20%
6	0.0023*	0.0001	2.08%	0.0099*	0.0121	-0.13%
7	0.0011*	0.0000	1.03%	0.0048*	0.0061	-0.08%
8	0.0005*	0.0000	0.51%	0.0023*	0.0031	-0.05%
9	0.0003*	0.0000	0.25%	0.0011*	0.0016	-0.03%
10	0.0001*	0.0000	0.12%	0.0005*	0.0008	-0.01%
Sum	**0.1788**	**0.1077**	**66.04%**	**1.6611**	**1.6958**	**-2.05%**

Notes To Table 3a:
Impulse responses computed for a 1 unit change in cash flow. See the notes to Table 2a for further information about the table entries.

Figure 2a: Impulse Responses – Cash Flow Shock



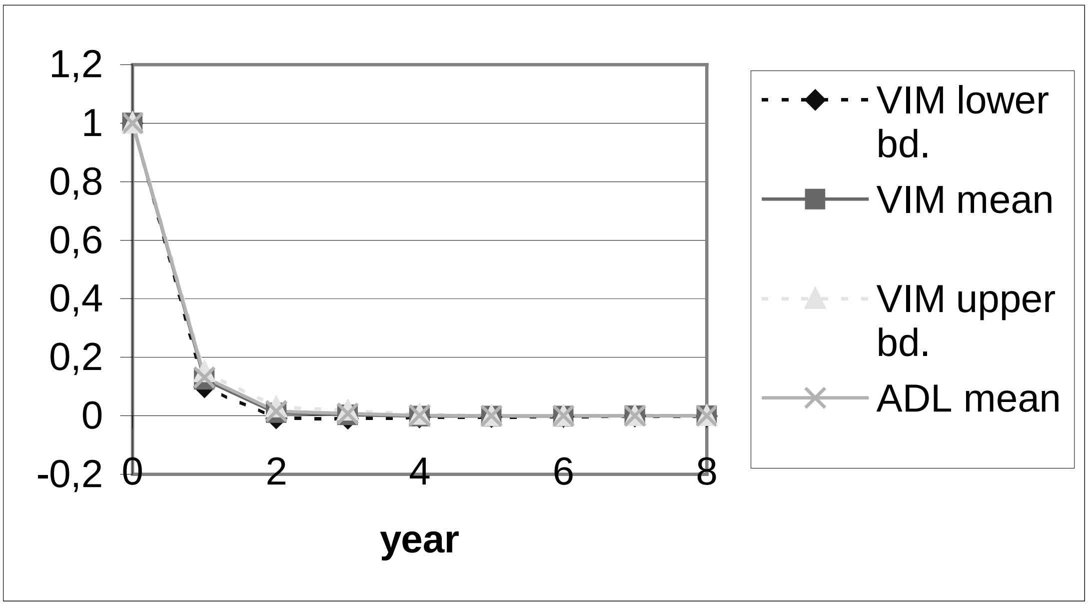
Notes To Figure 2a:
Plot of dynamic multipliers from Table 3a and error bands in Appendix E. Error bands are based on 1,000 Monte Carlo replications.

Table 3b: Impulse Responses – Investment Shock

	I/K			CF/K		
t	**VIM (1)**	**ADL (2)**	**% Diff. (3)**	**VIM (4)**	**ADL (5)**	**% Diff. (6)**
0	1.0000	1.0000	0.00%	0.0000	0.0000	0.00%
1	0.1242*	0.1311	-0.60%	-0.0984*	-0.0984	0.00%
2	0.0089	0.0154	-0.56%	-0.0620*	-0.0498	6.24%
3	0.0029	0.0072	-0.37%	-0.0303	-0.0232	3.60%
4	-0.0013	0.0016	-0.25%	-0.0158	-0.0121	1.85%
5	-0.0013	0.0003	-0.14%	-0.0079	-0.0061	0.89%
6	-0.0008	0.0001	-0.07%	-0.0038	-0.0031	0.38%
7	-0.0004	0.0000	-0.04%	-0.0019	-0.0016	0.15%
8	-0.0002	0.0000	-0.02%	-0.0009	-0.0008	0.06%
9	-0.0001	0.0000	-0.01%	-0.0004	-0.0004	0.02%
10	-0.0001	0.0000	0.00%	-0.0002	-0.0002	0.01%
Sum	**1.1318**	**1.1557**	**-2.06%**	**-0.2216**	**-0.1958**	**13.20%**

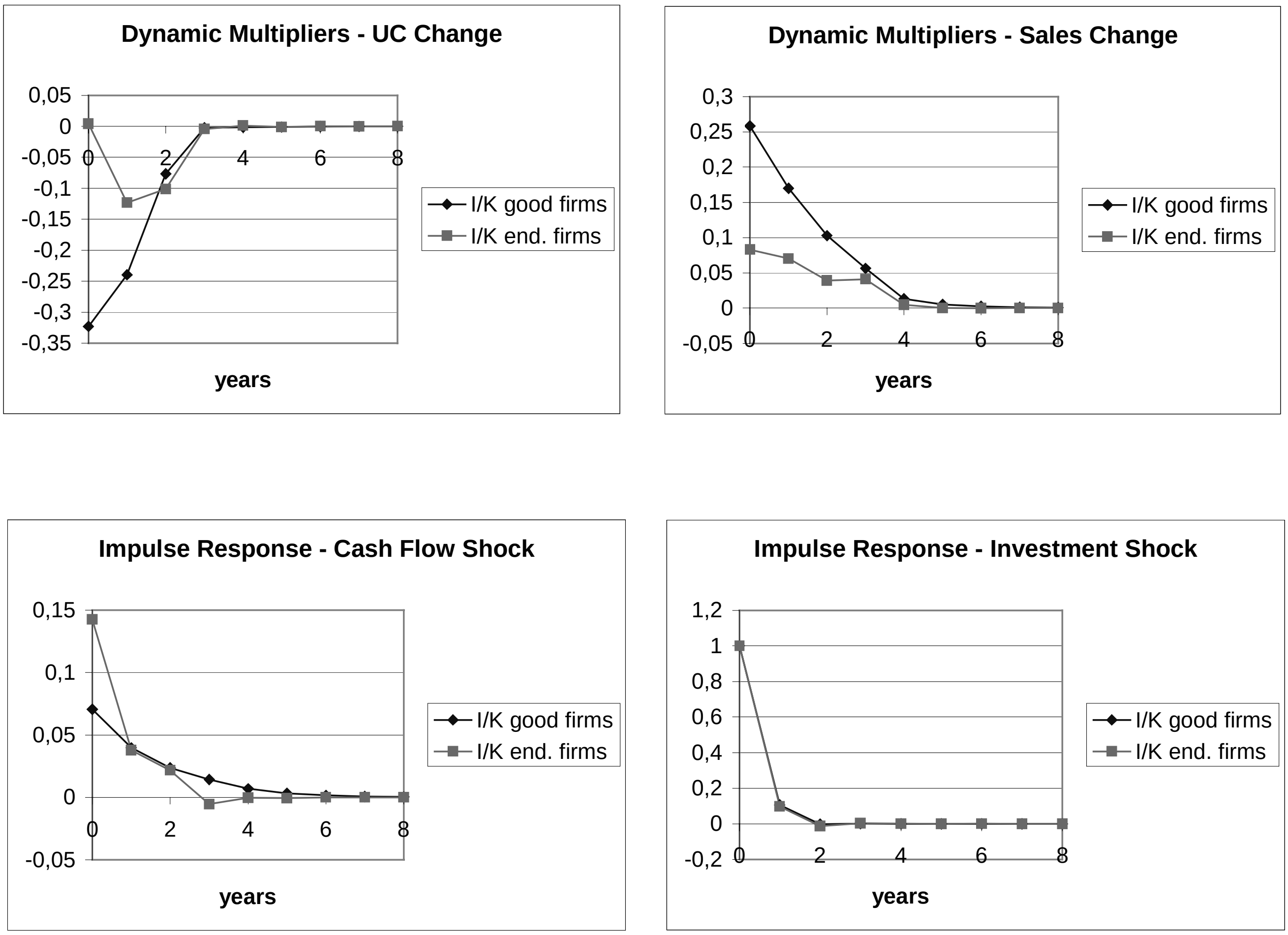
Notes To Table 3b:
Impulse responses computed for a 1 unit change in investment. See the notes to Table 2a for further information about the table entries.

Figure 2b: Impulse Responses – Investment Shock



Notes To Figure 2b:
Plot of dynamic multipliers from Table 3b and error bands in Appendix E. Error bands are based on 1,000 Monte Carlo replications.

Figure 3: Dynamic Multiplier, Impulse Responses, And Firm Creditworthiness



Notes To Figure 3:
The simulation results are for firms with good and endangered creditworthiness. See Section 5 for details. Top panel, dynamic multipliers computed for a 1 unit change in the user cost and sales. Bottom panel, impulse responses computed for a 1 unit change in cash flow and investment. See Section 2.3 for details.

The following papers have been published since 2002:

January	2002	Rent indices for housing in West Germany 1985 to 1998	Johannes Hoffmann Claudia Kurz
January	2002	Short-Term Capital, Economic Transformation, and EU Accession	Claudia M. Buch Lusine Lusinyan
January	2002	Fiscal Foundation of Convergence to European Union in Pre-Accession Transition Countries	László Halpern Judit Neményi
January	2002	Testing for Competition Among German Banks	Hannah S. Hempell
January	2002	The stable long-run CAPM and the cross-section of expected returns	Jeong-Ryeol Kim
February	2002	Pitfalls in the European Enlargement Process – Financial Instability and Real Divergence	Helmut Wagner
February	2002	The Empirical Performance of Option Based Densities of Foreign Exchange	Ben R. Craig Joachim G. Keller
February	2002	Evaluating Density Forecasts with an Application to Stock Market Returns	Gabriela de Raaij Burkhard Raunig
February	2002	Estimating Bilateral Exposures in the German Interbank Market: Is there a Danger of Contagion?	Christian Upper Andreas Worms
February	2002	The long-term sustainability of public finance in Germany – an analysis based on generational accounting	Bernhard Manzke

March	2002	The pass-through from market interest rates to bank lending rates in Germany	Mark A. Weth
April	2002	Dependencies between European stock markets when price changes are unusually large	Sebastian T. Schich
May	2002	Analysing Divisia Aggregates for the Euro Area	Hans-Eggert Reimers
May	2002	Price rigidity, the mark-up and the dynamics of the current account	Giovanni Lombardo
June	2002	An Examination of the Relationship Between Firm Size, Growth, and Liquidity in the Neuer Markt	Julie Ann Elston
June	2002	Monetary Transmission in the New Economy: Accelerated Depreciation, Transmission Channels and the Speed of Adjustment	Ulf von Kalckreuth Jürgen Schröder
June	2002	Central Bank Intervention and Exchange Rate Expectations – Evidence from the Daily DM/US-Dollar Exchange Rate	Stefan Reitz
June	2002	Monetary indicators and policy rules in the P-star model	Karl-Heinz Tödter
July	2002	Real currency appreciation in accession countries: Balassa-Samuelson and investment demand	Christoph Fischer
August	2002	The Eurosystem's Standing Facilities in a General Equilibrium Model of the European Interbank Market	Jens Tapking

August 2002	Imperfect Competition, Monetary Policy and Welfare in a Currency Area	Giovanni Lombardo
August 2002	Monetary and fiscal policy rules in a model with capital accumulation and potentially non-superneutral money	Leopold von Thadden
September 2002	Dynamic Q-investment functions for Germany using panel balance sheet data and a new algorithm for the capital stock at replacement values	Andreas Behr Egon Bellgardt
October 2002	Tail Wags Dog? Time-Varying Information Shares in the Bund Market	Christian Upper Thomas Werner
October 2002	Time Variation in the Tail Behaviour of Bund Futures Returns	Thomas Werner Christian Upper
November 2002	Bootstrapping Autoregressions with Conditional Heteroskedasticity of Unknown Form	Sílvia Gonçalves Lutz Kilian
November 2002	Cost-Push Shocks and Monetary Policy in Open Economies	Alan Sutherland
November 2002	Further Evidence On The Relationship Between Firm Investment And Financial Status	Robert S. Chirinko Ulf von Kalckreuth
November 2002	Genetic Learning as an Explanation of Stylized Facts of Foreign Exchange Markets	Thomas Lux Sascha Schornstein
December 2002	Wechselkurszielzonen, wirtschaftlicher Aufholprozess und endogene Realignmentrisiken *	Karin Radeck

* Available in German only.

December 2002	Optimal factor taxation under wage bargaining – a dynamic perspective	Erkki Koskela Leopold von Thadden
January 2003	Testing mean-variance efficiency in CAPM with possibly non-gaussian errors: an exact simulation-based approach	Marie-Claude Beaulieu Jean-Marie Dufour Lynda Khalaf
January 2003	Finite-sample distributions of self-normalized sums	Jeong-Ryeol Kim
January 2003	The stock return-inflation puzzle and the asymmetric causality in stock returns, inflation and real activity	Jeong-Ryeol Kim
February 2003	Multiple equilibrium overnight rates in a dynamic interbank market game	Jens Tapking
February 2003	A comparison of dynamic panel data estimators: Monte Carlo evidence and an application to the investment function	Andreas Behr
March 2003	A Vectorautoregressive Investment Model (VIM) And Monetary Policy Transmission: Panel Evidence From German Firms	Joerg Breitung Robert S. Chirinko Ulf von Kalckreuth

Visiting researcher at the Deutsche Bundesbank

The Deutsche Bundesbank in Frankfurt is looking for a visiting researcher. Visitors should prepare a research project during their stay at the Bundesbank. Candidates must hold a Ph D and be engaged in the field of either macroeconomics and monetary economics, financial markets or international economics. Proposed research projects should be from these fields. The visiting term will be from 3 to 6 months. Salary is commensurate with experience.

Applicants are requested to send a CV, copies of recent papers, letters of reference and a proposal for a research project to:

Deutsche Bundesbank
Personalabteilung
Wilhelm-Epstein-Str. 14

D - 60431 Frankfurt
GERMANY