Monetary Policy and Investment in Germany

Microeconometric Evidence for a German Credit Channel

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Abstract

This paper investigates monetary policy transmission at the microeconometric level. The credit rationing literature suggests that monetary policy has a larger effects on firms which are credit constrained. I use a large panel of German industrial firms to investigate whether this is empirically true in the German case. Whereas interest rates have only a weak effect on investment, I find strong evidence that monetary policy affects constrained firms more than others. Furthermore, investment is more sensitive to financial structure in periods of tight monetary policy. This contrasts earlier findings by Stöß (1996). The same result applies for periods of monetary tightness. I conclude that the credit channel is dominant in Germany. Given the findings for other countries this result indicates that financial systems in the Euro area are less different than suggested in previous studies.

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JEL classification: E51, C23, E22

It is wrong always, everywhere and for everyone to believe anything upon insufficient evidence.

W. K. Clifford, British philosopher

1 Introduction

Although economists agree that monetary policy has an influence on investment there is an ongoing debate which channels of monetary transmission are most important. This question is also important for Central Bankers who wish to determine the distributional effects of monetary policy. This paper sheds some light on the question giving some empirical evidence for Germany.

The Modigliani & Miller (1958) theorem states that a firm's capital structure is irrelevant to its value. In this setting, a monetary contraction which raises interest rates increases the cost of finance and all firms reduce investment symmetrically. More recently, this so called interest rate channel has been complemented by the notion that external finance and internal finance are only imperfect substitutes. Myers & Majluf (1984) introduced Stiglitz & Weiss's (1981) idea of asymmetric information to investment models, and Stiglitz (1992) considered default risk as an additional reason why external finance may be more costly than internal funds. For both reasons, creditors will charge an external finance premium, which leads to asymmetric effects of monetary policy. A monetary contraction increases default risk and hence the necessity to verify the debtor's financial state. Because a contractionary shock increases the informational cost overproportionately, the price of external finance *relative* to internal finance rises, especially so for bank-dependent borrowers who are unable to resort to credit markets. It may therefore decrease investment not only by raising the opportunity costs of investment but also by raising the extra cost of external finance relative to internal finance (Schiantarelli 1995, p. 202f). Contractionary monetary policy will then hit firms harder with agency or informational problems.

A third reason for asymmetric effects of monetary policy arises from the so-called asset price channel: raised interest rates decrease the value of fixed assets used as collateral and hence, the firm's net value. This in turn raises the cost of credit especially for firms which need fixed assets as collateral.[1]

For the Central Bankers, a larger share of credit constrained firms imply stronger asymmetric effects of monetary policy. First, the interest rate channel is less efficient when more firms are credit constrained, because these firms cannot substitute freely when interest rates rise (Barran, Coudert & Mojon 1996). Second, monetary policy effects will be more asymmetric if some firms are credit constrained, because credit constrained firms react by more than they would just according to the interest rate channel, and the downturn following a monetary contraction will be more pronounced (Gertler & Gilchrist 1994, Bernanke, Gertler & Gilchrist 1996). Higher interest rates then increase default risk in a systematic way. In combination, a large share of credit constrained firms leads to large but asymmetric effects of monetary policy.

While many papers have dealt with the empirical evidence in the US, Europe has received less interest.[2] This paper tries to fill this gap by looking at the empirical evidence for Germany. Only two papers have looked into microeconometric evidence for

[1] Schiantarelli (1995, p. 179) gives an overview on the literature dealing with the asset price channel.

[2] For a survey on the US see Hubbard (1998), other EMU countries are surveyed by Wesche (2000).

the German transmission mechanism.[3] Stöß (1996) uses descriptive methods to show that the credit channel is unimportant in Germany, whereas Ehrmann (2000) applies a SVAR framework on business surveys to argue that the credit channel matters for very small firms in Germany. I use a long panel of large, quoted German firms to investigate which is true. Since the panel I use only consists of quoted firms information problems should not be large, because information about these firms is efficiently transmitted by the stock market. Furthermore, default risk is typically lower for these firms.[4] Hence, according to the previous studies, the credit channel should not matter in this sample.
This paper combines two strands of econometric literature. Several papers (e.g. Gertler & Gilchrist 1993, Gertler & Gilchrist 1994, Oliner & Rudebusch 1996, Bernanke et al. 1996) have used the Quarterly Financial Reports (QFR) to look into the effects of monetary policy on investment. However, the QFR are highly aggregated data, so that constrained firms can only be identified by very rough measures, and across-firm variance is not fully accounted for. In another line of research, contributions working with firm-level data estimate influences on investment decisions (e.g. Whited 1992, Hubbard, Kashyap & Whited 1995). However, monetary policy measures have not been used in these papers. The only paper looking at the effects of monetary policy on a micro level is the article by Kashyap, Lamont & Stein (1994). However, their work lacks a theoretical model, and it focusses on one-year case studies rather than investigating a long time period. In the present paper, I develop a model based on Bond & Meghir (1994) that captures the monetary environment and asymmetric information explicitly, and is able to separate these influences. I derive a set of Euler equations and estimate the influences of monetary policy on investment decisions. To anticipate the main result, I find strong evidence in favour of asymmetric effects of monetary policy and hence, a credit channel in Germany. Most importantly, the credit channel matters for large, stock quoted German firms.
The rest of the paper consists of four parts. In the next section, I derive the empirical model and discuss measures of financial constraint and the stance of monetary policy. Section 3 describes the data and the econometric technique used. Section 4 presents the estimation results and a final part concludes.

2 Theoretical Framework

This section sets out the firm's optimization problem and derives a set of Euler equations, which can be estimated using a panel GMM estimator. A second subsection discusses possibilities to identify constrained firms and suggests a recent approach, which permits firms to switch between constrained and unconstrained states. The last subsection addresses measures for monetary policy in the literature and explains which ones seem most appropriate for the German setting.

[3]More generally, investment decisions by German firms have been investigated by Harhoff & Körting (1998), Winker (1996), Elston (1998) and Funke, Maurer, Siddiqui & Strulik (1998).

[4]However, in this sample over 17% of the firms went bankrupt and another 4% were taken over during the sample period 1960 – 1997. This may indicate that some firms are financially constrained.

2.1 The Investment Problem

Consider an infinitely living firm, the present value of which is given by the sum of expected future dividends

$$V_t(K_t) = D_t + E_t\left[\sum_{i=1}^{\infty}\left(\prod_{j=1}^{i}(1+r_{t+j})^{-1}\right)D_{t+i}\right],$$

where r_t is the discount rate between $t-1$ and t, E_t is expectation conditional upon information in t and D_t are dividends paid to the shareholders at time t.
To simplify the exposition of the problem I abstract from taxes and the possibility of issuing new shares. This does not alter the core of the problem but it will be easier to focus on the problem of debt. As a consequence, I will use capital gains net of taxes in the empirical part. The firm faces the profit function

$$\Pi_t(K_t, L_t, I_t) = p_t\left(Y(K_t, L_t) - G(K_t, I_t)\right) - w_t L_t - p_t^I I_t, \tag{1}$$

where K and L are capital and labor, respectively, I_t is investment building K_t and p is the output price. $Y(\cdot)$ is output, $G(\cdot)$ is the adjustment cost function for new investment, w_t is the wage rate and p_t^I the price of new investment goods. As usual, I assume Y to be concave, G to be convex. Allowing for borrowing from external lenders, dividends do not dependent on profits in t only, but in addition the firm may issue bonds. Hence

$$D_t(K_t, L_t, I_t, B_t) = \Pi_t(K_t, L_t, I_t) + B_t - (1 + i_t - \pi_t^e)B_{t-1}, \tag{2}$$

where B are bonds issued, i is the nominal interest rate in the market and π^e is expected inflation. The firm may issue bonds for one period only. Hence, in t it has to repay the bonds from $t-1$ plus interest accrued. However, the firm is free to re-issue bonds in the next period. Dividends may not be negative so that the present value from equation (1) is maximized subject to

$$D_t \geq 0 \quad \text{and} \tag{3}$$

$$\lim_{T\to\infty}\left(\prod_{j=0}^{T-1}(1+(i-\pi)_{t+j})^{-1}\right)B_T = 0, \forall t \tag{4}$$

so that the firm cannot borrow infinitely to pay out dividends.[5] As usual, the capital stock moves according to

$$K_t = (1-\delta)K_{t-1} + I_{t-1},$$

where δ is the depreciation rate of the capital stock. The firm maximizes utility of the shareholders and hence its present value, so that the Bellman equation is given by

$$V(K_t, L_t, I_t, B_t) = \max D_t(K_t, L_t, I_t, B_t) + E_t\left[(1+r_{t+1})^{-1}V_{t+1}(K_{t+1})\right]$$

[5] Equation (4) is the No-Ponzi-game condition. As in earlier research, it does not enter the estimation procedure. Instead, it is assumed to hold, cf. e.g Whited (1992).

Let λ_t be the Lagrange multipliers associated with the restriction (3). Then the first order conditions are

$$\frac{\partial \Pi_t}{\partial L_t} = \frac{w_t}{p_t} \tag{5}$$

$$\frac{\partial V_t}{\partial I_t} = \frac{\partial D_t}{\partial K_t} + \frac{\partial D_t}{\partial I_t} + E_t\left[(1+r_{t+1})^{-1}\frac{\partial V_{t+1}}{\partial K_{t+1}}\right] \overset{!}{=} 0, \tag{6}$$

$$\frac{\partial V_t}{\partial B_t} = 1 + \lambda_t - \frac{1+i_t-\pi_t^e}{1+r_{t+1}} E_t\left[1+\lambda_{t+1}\right] \overset{!}{=} 0 \quad \text{and} \tag{7}$$

$$\frac{\partial V_t}{\partial K_t} = \frac{\partial D_t}{\partial K_t} + E_t\left[(1+r_{t+1})^{-1}\frac{\partial V_{t+1}}{\partial K_{t+1}}\right]. \tag{8}$$

Equation (5) concentrates labor out of the problem, it is simply remunerated by its marginal product. Using (6) we can rewrite (8) as

$$\frac{\partial V_t}{\partial K_t} = \frac{\partial V_t}{\partial I_t} - \frac{\partial D_t}{\partial I_t} \tag{9}$$

$$= -\frac{\partial D_t}{\partial I_t}. \tag{10}$$

This equation has intuitive appeal. It states that the firm equals marginal revenue from one unit of capital in time t to the marginal cost of installing one unit of capital in t.
Rewriting (7) yields

$$E_t\left[\frac{1+\lambda_{t+1}}{1+\lambda_t}\right] = \frac{E_t[1+r_{t+1}]}{1+i_t-\pi_t^e}. \tag{11}$$

As λ_t can be interpreted as the shadow cost of paying out dividends in t, equation (11) also has an intuitive interpretation. It shows that the firm will equate the shadow value of delaying dividends to the relation of the market real interest rate versus its expected internal discount rate.[6] The left hand side can be interpreted as a measure of distress, which depends on the monetary environment (Oliner & Rudebusch 1996).[7] Formally, if λ is positive dividends are zero in optimum. Larger shadow costs of paying out dividends are a sign for stronger financial constraints, and the firm will delay dividends. Econometrically, we will only be able to discover financial conditions if financial distress *changes* between two periods.
Estimating equation (10), we have the problem that the marginal shadow value of capital, $\partial V_t/\partial K_t$, is unobservable. Two approaches have been followed to recast the theoretical model in econometric form. The first tries to estimate the shadow value of capital from the data, the other eliminates it from the equation instead. Following Tobin's Q-theory, Abel (1980) has shown that assuming linear homogeneity of the production function and the adjustment cost function, perfect competition in all markets and under the condition that the firm's market value represents the sum of expected future dividends (i.e. there are no bubbles in financial markets), average Q is linearly related to marginal q. Furthermore, q is a sufficient statistic for the firm's investment decision. Hence, no other terms should be significant in the estimation. However, these restrictions do not always seem to be warranted. Instead, studies using Q find that

[6] Whited (1992) points out that this is analogous to the consumption literature.
[7] I will turn to the firm-specific financial situation below.

cash flow is a relevant influence over and above Q.[8] This does not only hold for credit constrained firms, which may not be in optimum and for which, as a consequence, financial variables may be influential in addition to Q, but for all firms in the panel (Fazzari, Hubbard & Petersen 1988, Hayashi & Inoue 1991, Blundell, Bond, Devereux & Schiantarelli 1992). Another path along the same lines has been explored by Abel & Blanchard (1986). They develop a VAR forecasting model for the marginal revenue product of capital. However, theory does not provide for forecasting of q, and it is improbable that the researcher will use the same information set as the firm's managers. Hence, the researcher's forecast errors may not be orthogonal to the information set used by the firm and her estimations may be biased.

The alternative approach does not rely on estimations of the shadow value of capital but uses the information that equation (10) will also hold in $t+1$. One can then directly estimate the Euler equations. Using (10) in $t+1$ (8) becomes

$$\frac{\partial V_t}{\partial K_t} = \frac{\partial D_t}{\partial K_t} + (1-\delta)E_t\left[-(1+r_{t+1})^{-1}\frac{\partial D_{t+1}}{\partial I_{t+1}}\right] \tag{12}$$

and inserting (10) again leads to

$$-\frac{\partial D_t}{\partial I_t} = \frac{\partial D_t}{\partial K_t} - (1-\delta)E_t\left[(1+r_{t+1})^{-1}\frac{\partial D_{t+1}}{\partial I_{t+1}}\right], \tag{13}$$

which eliminates the marginal shadow value of capital from the problem. Assuming rational expectations for the real marginal revenue of investment the firm will incur an orthogonal forecasting error: $E_t[(1+r_{t+1})^{-1}\frac{\partial D_{t+1}}{\partial I_{t+1}}] = (1+r_t)^{-1}\frac{\partial D_t}{\partial I_t} + \eta_{t+1}$.[9] Replacing the expectation term by realized marginal revenue of investment plus a forecast error results in

$$\frac{1-\delta}{1+r_{t+1}}\frac{\partial D_{t+1}}{\partial I_{t+1}} = \frac{\partial D_t}{\partial I_t} + \frac{\partial D_t}{\partial K_t} + \epsilon_{t+1}.^{10} \tag{14}$$

This form introduces a stochastic error directly from the model, rather than adding it afterwards like q-model estimations do. Furthermore, it has the major advantage of avoiding the delicate estimation of the marginal value of capital.

To estimate equation (14) one needs to specify a functional form for the adjustment cost and the marginal revenue product of capital to find the derivative of (2) with respect to investment and capital. Assuming quadratic adjustment costs

$$G_t = \frac{b}{2}\left(\frac{I_t}{K_t} - c\right)^2 K_t$$

and a Cobb-Douglas type production function

$$Y(K,L) = (K^\alpha L^{1-\alpha})^{\beta\ 11}$$

[8] Fazzari & Petersen (1993) point out that considering working capital as an investment as well, the impact of cash flow may even be underestimated. In contrast, Gilchrist & Himmelberg (1998) show that mistakes in measurement are the main source for this result. However, also in their sample the relevance of financial variables like cash flow depends on the sample split criteria used. Also Hayashi & Inoue (1991) go a long way to show that cash flow has a weaker influence than generally accepted. However, cash flow is still important in most of their results.

[9] I adopt rational expectations from Whited (1998). If the observation period for the firm differs from the decision period, the errors may follow a low-order AR process.

[10] $\epsilon_t = -(1-\delta)\eta_t$.

[11] Here $0 > \beta > -\infty$ measures a combination of market power and the price elasticity of demand, cf. Böhm, Funke & Siegfried (1999).

we can write an empirical form of (14)

$$E_t\left[\frac{1+\lambda_{t+1}}{1+\lambda_t}\right]\frac{1-\delta}{1+r_{t+1}}\left(p_{t+1}b\frac{I_{t+1}}{K_{t+1}}-p_{t+1}bc+p^I_{t+1}\right) =$$

$$p_t b\frac{I_t}{K_t}-p_t bc+p^I_t-p_t\alpha\beta\frac{Y_t}{K_t}-\frac{p_t b}{2}\frac{I_t^2}{K_t^2}-\frac{p_t bc^2}{2}+\epsilon_{t+1}. \qquad (15)$$

Using (11) to replace the unobservable λs, we have in estimable form

$$\frac{I_{t+1}}{K_{t+1}} = \gamma_1+\frac{1+i_t-\pi^e_t}{1-\delta}\frac{p_t}{p_{t+1}}\left(\frac{I_t}{K_t}+\gamma_2\frac{p^I_t}{p_t}-\gamma_3\frac{Y_t}{K_t}-\gamma_4\frac{I_t^2}{K_t^2}\right)$$
$$-\gamma_5\frac{p^I_{t+1}}{p_{t+1}}+\hat{\epsilon}_{t+1}, \qquad (16)$$

where $\gamma_1 = c\left(1-\frac{p_t}{p_{t+1}}\frac{(1+i_t-\pi^e_t)(1+c/2)}{1-\delta}\right)$, $\gamma_2=\gamma_5=1/b$, $\gamma_3=\alpha\beta/b$, $\gamma_4=1/2$. Since the current marginal product of investment is influenced by the same variables as the expectation of future marginal product of investment in equation (13) the error term in (14) will not be orthogonal to $\partial D_t/\partial I_t$ and a simultaneity bias results. Hence, I estimate the model by GMM.

There are two possibilities to account for the influence of financial variables on the investment decision. The underlying hypothesis for GMM is that a set of instruments is uncorrelated to the error term. Whited (1998, p. 484) suggests that if instead financial variables not captured by the model influence the expectation of future marginal product of investment in equation (13) they will fall into the error term. In this case, also lagged financial variables should be correlated with the error term and a test for the orthogonality of these instruments should reject. A rejection of financial instruments would then be an indicator for financial distress. However, Hubbard et al. (1995) justly point out that an influence of cash flow on investment may also be an indicator for wasteful spending by managers who do not maximize the shareholders' value rather than an indicator of financial distress. Therefore, I account explicitly for the influence of the financial environment by including a term for the difference between the cost of internal and external finance.Extending the profit function (1) by a term $A(\cdot)$ accounting for agency costs we get

$$\Pi_t(K_t,L_t,I_t) = p_t\left(Y(K_t,L_t)-G(K_t,I_t)-A(B_t,K_t)\right)-w_tL_t-p^I_tI_t, \qquad (1')$$

where agency costs are convex (Hubbard 1998). Using a quadratic specification as in Hansen & Lindberg (1997),

$$A(B_t,K_t) = \begin{cases}\frac{\phi}{2}\left(\frac{B_t}{K_t}\right)^2K_t \text{ if } \frac{B_t}{K_t}>0\\ 0 \text{ else}\end{cases}, \qquad (17)$$

gives the additional term $-p_t\left(\phi(B_t/K_t)^2+bc^2/2\right)$ on the right hand side in (15). The shadow value of delaying dividends given in equation (11) changes to

$$E_t\left[\frac{1+\lambda_t}{1+\lambda_{t+1}}\right] = \frac{1+i_t-\pi^e_t}{(1+r_{t+1})p_t\phi\frac{B_t}{K_t}}. \qquad (11')$$

Hence, the empirical specification (16) becomes

$$\frac{I_{t+1}}{K_{t+1}} = \gamma_1+\frac{1+i_t-\pi^e_t}{(1-\delta)p_{t+1}\phi\frac{B_t}{K_t}}\left(\frac{I_t}{K_t}+\gamma_2\frac{p^I_t}{p_t}-\gamma_3\frac{Y_t}{K_t}+-\gamma_4\frac{I_t^2}{K_t^2}-\gamma_6\frac{B_t^2}{K_t^2}\right)$$
$$-\gamma_5\frac{p^I_{t+1}}{p_{t+1}}+\hat{\epsilon}_{t+1}, \qquad (16')$$

where coefficients are as in equation (16) above, except for $\gamma_1 = c\left(1 - \frac{(1+i_t-\pi_t^e)(1+c/2)}{(1-\delta)p_{t+1}\phi B_t/K_t}\right)$ and the new coefficient $\gamma_6 = \phi/b$. Since I would like to compare results to earlier studies (Fazzari et al. 1988, Bond & Meghir 1994, Hansen & Lindberg 1997) I estimate a linearized version of the model. Taylor approximation around the means of the variables and rearranging yields

$$\begin{aligned}\frac{I_{t+1}}{K_{t+1}} &= \tilde{\gamma}_1 + \tilde{\gamma}_2\frac{I_t}{K_t} - \tilde{\gamma}_3\frac{I_t^2}{K_t^2} - \tilde{\gamma}_4\frac{Y_t}{K_t} + \tilde{\gamma}_5\frac{B_t}{K_t} - \tilde{\gamma}_6\frac{B_t^2}{K_t^2} \\ &\quad + \tilde{\gamma}_7\frac{p_t^I}{p_t} - \tilde{\gamma}_8\frac{p_{t+1}^I}{p_{t+1}} + \tilde{\gamma}_9(i-\pi)_t + \tilde{\epsilon}_{t+1}, \qquad (18)\end{aligned}$$

where all $\tilde{\gamma} \geq 0$. Note that the coefficient for monetary policy is positive. Since higher interest rates shift investment from today to tomorrow, investment tomorrow will increase as interest rates rise. To consider the question whether monetary policy has asymmetric effects we will look at the coefficients $\tilde{\gamma}_5$ and $\tilde{\gamma}_6$. Stronger influence of agency problems will show in larger coefficients.

2.2 Sample Splitting

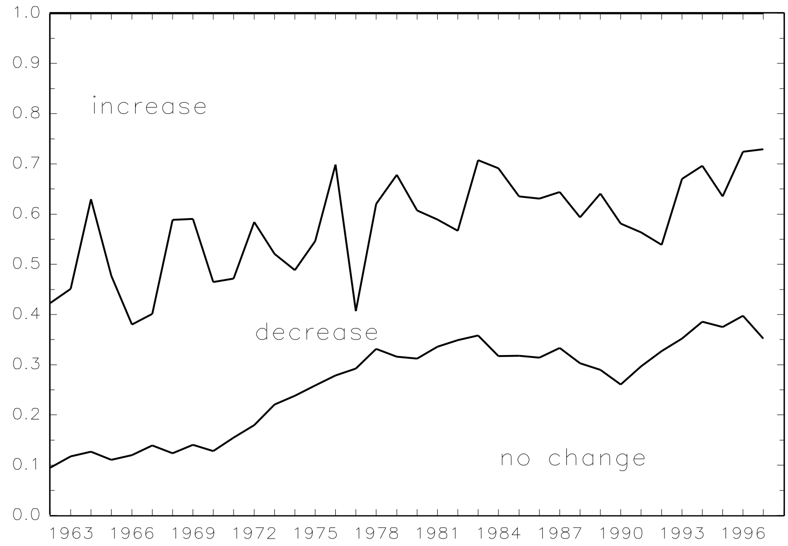
In order to investigate the influence of financial asymmetries, constrained firms in the sample have to be identified. In the literature, firms have been divided by dividend payout ratio (Fazzari, Hubbard & Petersen 1995), the affiliation with industrial groups (Hoshi, Kashyap & Scharfstein 1991), the existance of a bond rating (Whited 1992), ownership structure (Oliner & Rudebusch 1992), size and age (Devereux & Schiantarelli 1990).[12] However, these criteria have several drawbacks: they may not be exogenous, they do not change over time and they are often arbitrary. Of these problems, the exogeneity problem can be solved easiest by lagging the variables used as criteria. With respect to changes over time, Schiantarelli (1995) points out that firms will probably face constraints only in some periods. Accordingly, firms should be allowed to switch states between constrained and unconstrained. Third, classification depends frequently on the researcher's choice. For example, Carpenter, Fazzari & Petersen (1998) call firms with assets of less than \$300 million "small", whereas Stöß (1996) uses sales as the criterion, where less than 50 million DEM is the threshold value for "small".

To be consistent with the model, classification should be derived from the firm's optimization problem. Since the maximand in our model is the present value of dividends, it is straightforward to separate firms by their dividend payout behaviour. Three time-varying criteria will be used here. I will follow Schiantarelli (1995, p. 193) and use a dummy for periods, in which a firm pays non-positive dividends. Second, I will use dividend *cuts* as the indicator of financial constraint as in Cleary (1999). Since *reducing* dividends indicates that the firm has difficulties to serve its shareholders, dividend cuts are an appropriate measure for financial constraint. Figure 1 plots the share of firms in the sample, which increased, decreased, and left unchanged dividend payout ratios. It is obvious that firms change their behaviour with respect to dividend payments over time. Hence, time-varying criteria may indeed yield different insights from a static distinction between constrained and unconstrained firms. As a third measure, I adapt Cleary's (1999) idea to forecast dividend cuts by discriminant analysis. I use equity return, cash flow over assets, debt over assets and dividends to forecast whether

[12] Petersen & Rajan (1994) show for a panel of small firms that the size effect dominates the influence of age.

firms cut back dividends in the next period.[13] I classify firms as constrained for which a dividend cut is forecasted by the analysis. This approach reduces the arbitrariness of ad hoc ratios used in previous studies (e.g. 0.17 dividends paid per income as in Hubbard et al. (1995)).

Figure 1: Changes in dividend payout over time



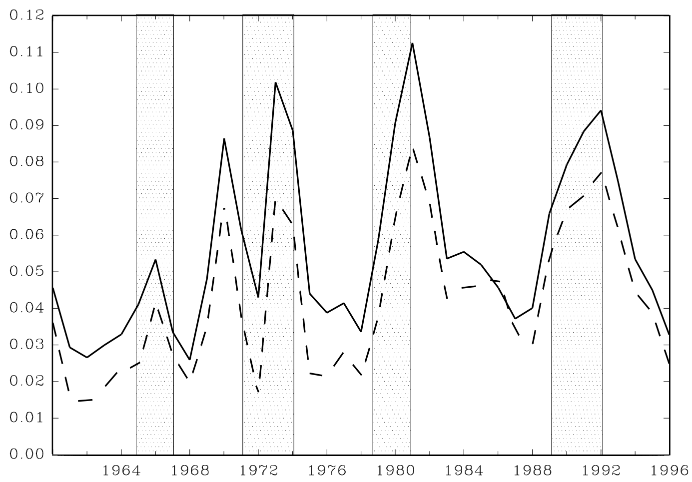
2.3 Monetary Policy Conditions

To measure the stance of monetary policy, three approaches have been followed in the literature: the narrative approach (Romer & Romer 1989), the Federal Funds interest rate (Bernanke & Blinder 1992), and VAR modelling (Gordon & Leeper 1994, Christiano & Eichenbaum 1995). In the seminal paper on the narrative approach, Romer & Romer (1989) read the minutes of the Federal Open Market Committee (FOMC) to determine periods in which the FOMC intended to tighten monetary policy. For Germany, narrative accounts have been applied by Stöß (1996), Tsatsaronis (1995) and Worms (1998). I adapt their results as one measure for the stance of monetary policy. Stöß's (1996, p. 18) reading of the Bundesbank's business reports suggests that tight monetary policy prevailed in 1979 - 81 and in 1989 - 92. However, his sample only runs from 1978 until 1995. Tsatsaronis (1995) identifies five months of restrictive policy by the Bundesbank for the period 1957 - 90, namely 1960:2, 1966:1, 1969:9, 1973:5 and 1981:2. Following this account and the discussion by Worms (1998, pp. 256f), I will regard the years 1965 - 66 1971 - 74, 1979 - 81 and 1989 - 92 as "restrictive".[14] The second approach, suggested by Bernanke & Blinder (1992), uses the Federal Funds interest rate as a measure of monetary policy. However, since the theoretical model predicts an influence of the *real* rate, the overnight rate ought to be deflated. One may assume perfect foresight and use inflation to deflate the overnight rate. Figure 2 shows real and nominal overnight interest rates for Germany. Periods of tight monetary policy

[13]Cleary uses assets over liabilities, debt over assets, gross earnings over interest plus dividend payments, income per sales, sales growth, cash plus short term loans minus investment over K to project the cut in dividends, where income per sales and sales growth have the strongest influence.

[14]Classifying 1969 as a restrictive period enforced the results slghtly.

Figure 2: Nominal and real interest rates in Germany



Note: Nominal (solid) and real (dashed) short-run interest rates. Means were taken from annualised monthly rates.

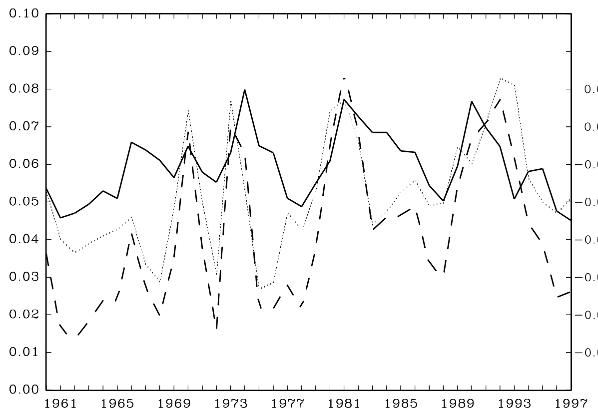
following the narrative approach are represented by shaded areas. It is obvous that real and nominal interest rates in Germany are highly correlated. Hence, deflating the interest rate will not matter much. Figure 2 also demonstrates that periods of tight monetary policy identified by the narrative approach are the same as those, in which interest rates increased sharply. However, since during these periods interest rates were not already high but had a high growth rate, using the narrative approach or the level of the short-run interest rate may lead to different results. Hence, I will run the regressions with both measures to understand whether my results are robust with respect to the measure of monetary policy. Since the firm optimizes given *expected* inflation the use of *ex post* inflation may be misleading. Therefore, Laurent (1988) and Goodfriend (1991) suggest to use a long-run interest rate as a deflator because it includes *expected* inflation. Following this, one may use the spread between short and the long rate. Figure 3 shows the spread, the long-run and the short-run real interest rates. Since the real overnight rate and the spread move rather closely results will be identical for the *ex post* and the *ex ante* inflation rate. Hence, I avoid the Lucas-critique and use the spread rather than the *ex post* real interest rate as a measure of monetary policy.

Finally, since investment may be influenced more strongly by the long than the short term interest rate, I will also use the real long-term interest rate as a measure.[15] For this case, figure 3 makes clear that the deflated long rate reacts sluggishly to changes in the real short rate. Using the real long rate as an indicator for monetary policy may therefore change the picture somewhat.

The idea of using interest rates as measures for monetary policy has been criticized by Gordon & Leeper (1994) and Christiano & Eichenbaum (1995) because it does not separate between endogenous and exogenous changes in the Central Bank's instrument. Instead, they suggest to predict the prime rate by a VAR, and regard the residuals as exogenous changes to monetary policy. Yet, also this approach has come under

[15]For an empirical analysis describing the link between the overnight rate and the long-term rate, cf Nautz & Wolters (1999)

Figure 3: German real interest rates



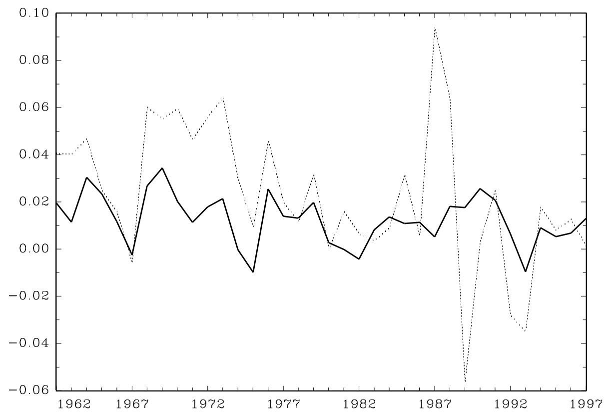
Note: Long-run (solid) and short-run (dashed) *real* interest rates and the spread (dotted, right axis).

criticism, because the VAR mischaracterises the Central Bank's information set since it is based on a very small macro model of the economy. Furthermore, the results are very sensible to the restrictions imposed to extract the structural shocks, which leads to highly unstable coefficient estimates (Rudebusch 1998). Hence, I do not follow this approach but adhere to the narrative and the interest rate approaches.

3 Data and Estimation

Firm level data were collected from the Bonner Stichprobe, a database containing the annual reports of 719 West-German stock quoted firms (Albach et al. 1994). The firms are distributed over all sectors of the economy and the data run from 1960 to 1997 (38 years). I exclude financial firms and holding companies for which single-firm data were available. To avoid dominating outliers, I follow Carpenter et al. (1998) and delete firms for which any variable is in the upper or lower 0.1% of the data set. This leaves me with an unbalanced panel of 395 firms (12043 observations). The remaining panel represents roughly three percent of total value added in Germany. Figure 4 shows that the growth rate of value added in the panel and in Germany are highly correlated. Therefore, I am confident that the sample can be regarded as representative for the German economy. This is an important point since I am interested in measuring influences of monetary policy on the German industry sector as a whole. The only exception to the comovement of value added in the panel and Germany are the years 1986 and 1989, where large changes in the panel are induced by the change in accounting rules in Germany. This change has been smoothed out in the national figure. Leaving aside this hump the two series have a positive correlation of 0.671 (including the hump it is still significantly positive with a correlation of 0.449 and a t-value of 2.78). Figure 5 in the appendix depicts annual means of the data to discover whether accounting rules influence the estimations. It is obvious that the data used in the estimations are not influenced by this change. In constructing these variables, Albach et al. (1994) have obviously taken into account the effects of the law.
To see whether firms in the panel are credit constrained at all we consider bankruptcies that occurred during the sample period. Table 1 shows that no firms go bankrupt

Figure 4: Growth rate of value added in the panel and in Germany



Note: First difference of logged real value added in the panel (dotted) and Germany (solid).

Table 1: Bankruptcies in the panel

period	firms bankrupt
1960 - 65	0
1966 - 70	0
1971 - 75	10
1976 - 80	26
1981 - 85	22
1986 - 90	21
1991 - 97	40
1960 - 97	119

during the first ten years. This is probably a bias due to selecting the largest German stock quoted firms. On the other hand, many firms leave the panel in the periods of tight monetary policy during the late seventies and even more so in the early nineties. This may indicate that financial constraints could play a role even for these large stock quoted firms.

To construct indicators for monetary policy I use the overnight interest rate and the yield on obligations with a maturity of ten years from the Bundesbank database. Since industry data are available only on an annual basis in Germany, I use annual means from monthly interest rates.

3.1 Estimation Technique

To estimate the dynamic panel regression I use the Arellano & Bond (1991) first-difference GMM estimator.[16] The GMM estimator uses equations in first-differences,

[16]It is outside the scope of this paper to give a detailed overview on dynamic panel data estimation issues. The growing interest in panel data modelling reflects the increasing availability of such data and enormous advances in computing technology. The interested reader is referred to the references in Böhm, Funke & Siegfried (1999, p. 19, fn 20) and Blundell & Bond (1998). The GMM estimates and the specification tests I report are computed using DPD98 written in GAUSS (Arellano & Bond 1998).

from which the firm-specific effects are eliminated by the transformation, and for which endogenous variables lagged two or more periods will be valid instruments provided there is no serial correlation in the time-varying component of the error terms. Since the consistency of the estimator relies on this assumption, I report LM-test for the lack of first-order and second-order serial correlation in the residuals. If the residuals are serially uncorrelated the first differences transformation induces first-order serial correlation, but not second-order (See Arellano & Bond 1991, p. 281). In the estimates, I essentially use lags of the variables in the model. As a check for the validity of the selected instruments used, I present Sargan's test of over-identifying restrictions to ensure that the instruments are uncorrelated with the estimated residuals from the model. Table 2 reports results for the one-step and the two-step GMM estimator with t-values and test statistics that are asymptotically robust to general heteroscedasticity. Although the two-step GMM estimates are more efficient, the asymptotic t-values can be an unreliable guide for inference in small samples and should therefore be treated with caution. I therefore report both the one-step and the two-step t-statistics.

4 Estimation Results

Estimating the basic model (18) we get the results presented in table 2. To allow for comparison with earlier results I dropped real investment costs from the regressions. The last panel of figure 5 in the appendix shows that PPI/CPI does not change dramatically over the observation period. Hence, the estimation results should not be influenced heavily.

Considering the estimation results, the signs for the coefficients of the lagged endogenous terms and the debt-asset ratio are as predicted by the model. The influence of the lagged endogenous and the quadratic term are considerably smaller than in Bond & Meghir (1994), but comparable to Hansen & Lindberg (1997). Since I do not decompose gross output the model predicts a negative coefficient, which also results from the regressions. The coefficient's size is also in line with the earlier papers. All coefficients except for the real interest rate are highly significant. The coefficients of the real interest rate is positive but insignificant in all cases. Actually, using the ex post long-term or short-term real interest rates instead of the spread, we find a negative coefficient (not rendered here for brevity). However, the other coefficients are robust to changes in the monetary policy instrument. Column two shows for the baseline model that dropping the interest rate from the regression has no effect on the other results.

Th coefficients of the debt-equity ratio lie in between the results from earlier research (Bond & Meghir 1994, Hansen & Lindberg 1997). These coefficients suggest some influence of asymmetric effects of monetary policy. If financial structure matters it should do so more for periods of tight monetary policy and for financially constrained firms. I look at this question adding the debt-equity ratio terms times a dummy to the regression. Column three demonstrates for periods of tight monetary policy measured by the narrative approach that the debt-equity ratio is more influential. The direct influence of the real interest rate is even weaker than before. In periods of tight monetary policy, raised interest rates affect investment mainly through a relative increase of external finance costs. Hence, the direct influence of the real interest rate on investment is overestimated if one disregards that monetary policy raises the cost of external finance overproportionately.

Column four and five give the results for firms with forecasted dividend cuts, and

with actual dividend cuts in the previous period. Again, financial structure exerts a non-negligible influence on investment. The influence of the rela interst rate is slightly stronger than in the previous cases. Monetary policy works on constrained firms mainly by the relative cost of external finance. Hence, this exewrcise measures more accurately the direct interest rate effect on investment by unconstrained firms.
The results in the last column show the effect for firms with non-positive dividend payments in the previous period. As opposed to dividend *cuts*, the additional effect of financial structure is much weaker. Hence, measuring financial constraint by relative dividend payments may be regarded as more adequate.

Table 2: Estimation Results

	Baseline Model		Tight Monet. Policy	Forecasted Div. Cut	Actual Div. Cut in t–1	Non-Positive Div. in t–1
$(I/K)_{it}$	0.311	0.321	0.311	0.315	0.314	0.309
	[10.73]	[11.27]	[10.78]	[10.78]	[11.14]	(10.71)
	(6.89)	(6.93)	(6.97)	(6.88)	(7.36)	[6.82]
$(I/K)^2_{it}$	-0.054	-0.056	-0.055	-0.053	-0.053	-0.055
	[-11.48]	[-11.90]	[-10.99]	[-11.24]	[-11.38]	[-10.86]
	(-3.44)	(-3.46)	(-3.38)	(-3.35)	(-3.77)	(-3.33)
$(Y/K)_{it}$	-0.021	-0.020	-0.021	-0.024	-0.025	-0.021
	[-12.65]	[-12.35]	[-8.35]	[-14.35]	[-15.64]	[8.38]
	(-1.39)	(-1.38)	(-1.60)	(-1.56)	(-1.76)	(-1.60)
$(i-\pi)_t$	0.413	–	0.210	0.462	0.623	0.160
	[1.80]	–	[0.91]	[1.94]	[2.47]	[0.68]
	(0.59)	–	(0.00)	(0.47)	(0.57)	(0.14)
$(B/K)_{it}$	0.065	0.067	0.069	0.071	0.077	0.069
	[11.13]	[12.00]	[10.65]	[10.14]	[9.53]	[10.55]
	(2.82)	(2.85)	(2.99)	(3.21)	(3.39)	(2.97)
$(B/K)^2_{it}$	-0.000	-0.000	-0.000	-0.000	-0.001	-0.000
	[-4.80]	[-5.49]	[-4.66]	[-4.41]	[-4.06]	[-4.56]
	(-1.27)	(-1.33)	(-1.17)	(-1.42)	(-1.52)	(-1.16)
$(B/K)_{it} * X_{it}$	–	–	0.008	0.017	0.057	0.010
	–	–	[4.25]	[2.37]	[6.12]	[5.28]
	–	–	(1.11)	(2.63)	(2.00)	(1.25)
$(B/K)^2_{it} * X_{it}$	–	–	-0.001	-0.003	-0.005	-0.001
	–	–	[-8.58]	[-6.87]	[-10.25]	[-9.20]
	–	–	(-1.20)	(-2.84)	(-2.72)	(-1.28)
Sargan	76.97	79.54	76.34	72.09	74.04	76.65
	(0.15)	(0.12)	(0.12)	(0.23)	(0.16)	(0.12)
AC(1)	-7.92	-8.01	-7.86	-7.92	-8.00	-7.87
AC(2)	-0.97	-0.83	-0.98	-0.90	-0.59	-0.97

Notes: $(I/K)_{it+1}$ is the dependent. Below the coefficients, one-step (two-step) t-values are given in brackets (parentheses). Sargan tests for validity of the instruments (p-values in parentheses). AC(1) and AC(2) are tests for autocorrelation of the residuals. They are distributed $\mathcal{N}(0,1)$. Since we first-difference the data, we expect negative autocorrelation of first order and no second-order autocorrelation.

5 Conclusions

This paper has investigated the importance of financial structure and the effects of monetary policy actions on investment in Germany. The main findings are that the interest rate channel seems to be of little importance for investment decisions, i.e. a higher interest rate leads to only small shifts of investment. On the other hand, the credit channel, which has been found to be important in the US and the UK, is also influential in Germany. The debt/asset ratio is significant for credit constrained firms over various specifications. To account for the fact that firms are credit constrained only in some periods I use time-varying measures of financial tightness.

I also investigate the effects of monetary policy. It turns out that the credit channel matters more in periods of tight monetary policy. The interest rate channel is of little importance, and even less so when the credit channel is allowed to influence investment differently during periods of tight monetary policy.

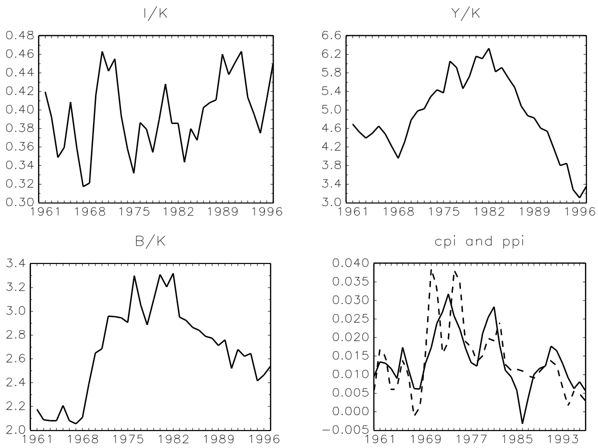
The results are especially interesting because the paper deals with German stock-quoted firms. So far, only small and unquoted German firms have been found to be influenced strongly by agency problems. In contrast, the present sample displays a strong bias towards large and strong firms. The fact that several firms drop out during the sample period, the sample may include firms that have been credit constrained in some periods. Our findings are in stark contrast to those by Stöß (1996), but reinforce the findings by Ehrmann (2000). With respect to a common monetary policy by the European Central Bank the results suggest that monetary policy actions will influence investment less differently across countries than assumed so far. The German financial structure is not too different from those of the other Euro area countries.

A Data Description

Firm level data were collected from firm's annual reports. Except for Y, which is given directly in the reports, Albach et al. (1994) constructed the series from the data. Details on the construction of the series can be found there.

K Equity
I Investment in fixed assets: Change in fixed assets plus write-offs.
Y Net Sales
B Outside Capital

Figure 5: Annual means of variables



Note: Shown are sample means of the variables used in the regressions.

To compare the panel with aggregate German data I use value added since it is available on an aggregate level. This series and the interest rates were taken from the Bundesbank database. To construct annual interest rate series I averaged monthly series of the overnight rate, interest rates paid on governments bonds with maturities of up to ten years.

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