Asymmetric Information in Credit Markets and Monetary Policy

Ulrike Neyer*

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Abstract

This paper analyzes the consequences of asymmetric information in credit markets for monetary policy transmission mechanism. It is shown that asymmetric information can reinforce, weaken or overcompensate the effects of the conventional interest rate channel. Crucial is that informational problems lead to an external finance premium, which can be positive or negative for marginal entrepreneurs, i. e. they either have to bear the costs or actually benefit from informational problems. Monetary policy influences this premium, which implies that there is a credit channel of monetary policy due to asymmetric information, but its direction of influence is ambiguous.

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* Martin-Luther-University Halle-Wittenberg, Department of Economics, 06099 Halle/Saale, Germany,
Tel.: +49/345/552 33 33, Fax.: +49/345/552 71 90, e-mail: neyer@wiwi.uni-halle.de

1 Introduction

Since the end of the 1980s consequences of asymmetric information in credit markets on monetary policy transmission mechanism have received a growing attention. According to the credit channel theory, asymmetric information in credit markets amplifies and propagates the effects of the conventional interest rate channel. The credit channel affects especially the so called *bank dependent borrowers*: small and medium-sized firms, which usually face high informational problems in credit markets, whose internally generated funds are low and for which collateralization of loans plays an important role.

There is not a unique division of the various sub-channels of the credit channel. Very often a division into the *bank lending channel* and the *balance sheet channel* can be found. This paper focuses on the latter, because in the literature „...the existence of a balance sheet channel seems very well established. The bank lending channel is the more controversial. … Institutional changes have rendered the bank lending channel … somewhat less plausible." [Bernanke and Gertler (1995), p. 29.]

According to the balance sheet channel, asymmetric information in credit markets leads to adverse selection and moral hazard. The resulting additional capital costs are reflected by a premium for external funds. A tight monetary policy weakens the borrower's financial position (reduced cash flow due to higher interest payments on short term liabilities and a reduced net worth due to decreasing asset prices), which leads to an increase in adverse selection and moral hazard problems and therefore in the external finance premium. This means that a credit market burdened with asymmetric information implies a higher increase in capital costs in the wake of contractionary monetary policy than a credit market without these informational problems. Asymmetric information acts as a financial accelerator. [Bernanke and Gertler (1995), Mishkin (1995), Hubbard (1995), Bernanke, Gertler and Gilchrist (1996).]

Against this background, Germany seems to be a country in which the typical conditions for a balance sheet channel appear to be perfectly met: The bulk of German firms is small and medium-sized, German firms rely heavily on bank finance, and collaterilzation plays an important role. The thesis, that Germany is perfect for balance sheet channel effects, seems to be supported by an empirical study conducted by Lopez Iturriaga (2000). Analyzing twelve OECD countries (Germany is unfortunately not included), he finds balance sheet channel effects in all analyzed countries, but to a different extent. He argues that his result might reflect different features of the countries' financial systems: in those countries having a more market oriented financial system credit channel effects seem to be less significant than in countries with a more bank oriented financial systems.

However, usually there is no empirical evidence for credit channel effects in Germany [Tsatsaronis (1995), Stoeß (1996), Guender and Moersch (1997)], although the German financial system is

one of the best known examples for a bank oriented financial system. Stoeß and Guender and Moersch argue that the traditional close and long-lasting relationship between banks and firms in Germany, which reduces informational problems in credit markets, might be one reason for the result.

This paper focuses on the underlying credit market models. It shows theoretically that asymmetric information does not necessarily amplify the effects of the conventional interest rate channel, but that it is also possible that asymmetric information weakens or even overcompensates the effects of the interest rate channel, i. e. there is a credit channel of monetary policy, but its direction is ambiguous. The interesting aspect is, that independently of the direction, the firms mostly affected by the credit channel are bank dependent borrowers.

The basic story: Due to asymmetric information in credit markets there is a pooling interest rate. Entrepreneurs with investment projects of a different risk have to pay the same interest rate, which is adequate to the *average* risk across all financed projects. This implies an interest subsidy of the entrepreneurs with relatively risky projects by those with relatively safe ones. This means that there is a premium for external funds due to asymmetric information, reflecting a "lemons" premium (compare Gertler and Gilchrist 1993, p. 48). But on contrary to other studies this paper shows that this premium is not positive for all entrepreneurs.: those who *are* subsidized actually benefit from informational asymmetries in the credit market, their external finance premium is negative. The absolute value of the external finance premium reflects the subsidy effect. It depends positively on the costs of external finance. A contractionary monetary impulse leads to an increase in these costs, and therefore in the subsidy. If, on the one hand, the marginal entrepreneurs are those with the relatively safe projects, the conventional effects of a contractionary monetary impulse may be amplified by asymmetric information. If, on the other hand, the marginal entrepreneurs are those with the relatively risky projects, the conventional effects may be weakened or overcompensated.

The rest of this paper is organized as follows: Section 2 presents a credit market model in which asymmetric information leads to the usually expected result: asymmetric information can amplify the effects of the conventional interest rate channel. Section 3 describes a credit market in which asymmetric information can weaken or overcompensate the effects of the traditional interest rate channel. Section 4 summerizes.

2 Reinforcement of Conventional Interest Rate Channel Effects

The aim of this section is to show that monetary policy impulses can be amplified by asymmetric information in credit markets. 2.1 describes the demand side, the supply side and the resulting equilibrium interest rate in a credit market burdened with asymmetric information. 2.2 derives the corresponding equilibrium interest rate in a credit market not burdened with informational problems

(benchmark case). 2.3 compares the two equilibrium interest rates and discusses the consequences of a contractionary monetary impulse.

2.1 The Credit Market with Asymmetric Information

Demand Side

There is a continuum of risk neutral entrepreneurs. The continuum is normalized to one. Each entrepreneur has a cash flow *W*, described by equation 1.

$$W = \overline{U} - \overline{r} \cdot \overline{K} \tag{1}$$

$\overline{U}$ denotes the cash flow before interest payments on short term liabilities, which are $\overline{r} \cdot \overline{K}$. $\overline{K}$ refers to the amount of short term liabilities, $\overline{r}$ stands for the risk free interest rate.[1] A bar indicates exogenous variables.

Furthermore each entrepreneur has marketable collateral *S*. For the sake of simplicity collateral is made up of consols yielding a risk free rate of return $\overline{r}$. $\overline{b}$ shows the number of these bonds, held by each entrepreneur. Collateral value is described by *equation 2*.

$$S = \frac{\overline{b}}{\overline{r}} \tag{2}$$

An entrepreneur *i* can invest *W* either in his investment project or in the capital market. Investing in the capital market an entrepreneur receives the risk free rate of return $\overline{r}$. His project on the other hand can either succeed, yielding a return R_i^s, or fail, yielding no return. (The index *i* indicates entrepreneur-, and therefore project-specific variables.) An entrepreneur will only realize his project, if his expected profit $E[p_i^E]$ is at least as high as the profit of the risk free alternative investment (*equation 3*).

$$E[p_i^E] \geq W \cdot \overline{r} \tag{3}$$

Equation 4 describes an entrepreneur's expected profit from the investment project $E[p_i^E]$.

$$E[p_i^E] = p_i \cdot [R_i^s - (1+r) \cdot (\overline{I} - W) - W] + (1 - p_i) \cdot (-W - S) \tag{4}$$

p_i is the probability of success of his investment project. The project is indivisible and requires an investment $\overline{I}$, with $\overline{I} > W$. This implies that an entrepreneur must borrow $(\overline{I} - W)$ from a bank to realize his project. It is assumed that $S < \overline{I} - W$, which means that the loan cannot be fully secured. If the project succeeds, an entrepreneur's profit will be R_i^s minus principal and interest payments

[1] In this paper risk plays no role in short term finance, so that a possible risk premium is set equal to zero.

$(1+r)\cdot(\bar{I}-W)$, minus the invested wealth. In case of failure an entrepreneur simply loses all his wealth.

In equation 4 asymmetric information in credit markets becomes already obvious. Banks are unable to distinguish entrepreneurs with regard to the specific risk of their project. The probability of success p_i is private information of an entrepreneur. However, p_i is uniformly distributed across the entrepreneurs in the interval $[p^a, p^z]$, and banks do know the density function $g(p_i) = G'(p_i)$. This means that they are able to assess the average risk across the projects. The consequence is, that all entrepreneurs are charged the same interest rate *r*, which is adequate to this average risk. Therefore entrepreneurs with relatively safe projects have to bear additional costs resulting from asymmetric information in credit markets. Generally, there are several possibilities to overcome informational problems, possibilities to separate the credit market. However, in this paper it is assumed that there is always a rest of irreducible asymmetric information: Obviously, entrepreneurs with relatively safe projects have an incentive *to signal* what type of entrepreneur they are. One possible signal may be to offer higher self-financing [Leland and Pyle (1977)]. In this set up it is assumed that entrepreneurs do not have enough cash flow, allowing them to signal their true type, and that possible other signals are too costly, compared to the disadvantage of being charged a higher interest rate, or that the "no-mimicking-condition" is not fulfilled [compare Freixas and Rochet (1997), p. 26]. Another possibility to reduce the informational problems may be screening and monitoring of the firms by banks. Indeed, the often discussed reason for the existence of banks as intermediaries is their capability to reduce informational asymmetries between deficit and surplus units.[2] Here it is assumed that banks are not able to overcome totally the informational problems, because respective information simply does not exist, or because it is too costly to process the relevant information. A further way to reduce asymmetric information is to use different contracts as a *self-selection- mechanism*, for example contracts not only specifying the interest rate, but also collateral requirements [Bester (1985)]. In this case high risk borrowers may choose a contract with a high interest rate and low collateral requirements, whereas low risk borrowers may opt for the opposite. The result is a separated credit market. In this paper it is assumed that this self-selection-mechanism does not work, because firms do not have enough collateral, allowing them to choose between different contracts, or because it is too costly for banks to offer different type of contracts. The conclusion is that in the in this paper considered credit markets there is a rest of irreducible asymmetric information. The extent of these irreducible asymmetries is measured by the variance $\bar{s}^2_{p_i}$.

[2] See for example Leland and Pyle (1977), Diamond (1984), Mayer (1988), Hellwig (1991), von Thadden (1995), Freixas and Rochet (1997), chapter 2.

Crucial in this set up is the identical expected return $\overline{R}$ of all projects. As the projects differ in their probability of success p_i and their return in case of success R_i^s, there is a mean preserving spread (*equation 6*), as in the credit rationing model of Stiglitz and Weiss (1981).

$$\overline{R} = p_i \cdot R_i^s \tag{5}$$

Substituting equation 5 into equation 4 reveals that there is c. p. a *positive* relationship between an entrepreneur's expected profit and the risk of his project (*equation 6*).[3]

$$E[p_i^E] = \overline{R} - p_i \cdot [(1+r) \cdot (\bar{I} - W) - S] - W - S \tag{6}$$

From this follows that a critical probability of success p^{crit} exists (*equation 7*).

$$p^{crit} = \frac{\overline{R} - W \cdot (1+\overline{r}) - S}{(1+r) \cdot (\bar{I} - W) - S} \tag{7}$$

If $p_i > p^{crit}$, an entrepreneur's expected profit is smaller than from the alternative investment in the capital market, so that he prefers the latter. Decisive is that therefore the marginal entrepreneurs are those with the relatively safe projects.

Supply Side

The supply of loanable funds to banks is absolutely elastic to the risk free interest rate $\overline{r}$ (*equation 9*).

$$h_{L^S,\overline{r}} \to \infty \tag{8}$$

This implies that the *availability* of credits plays no role in this model, but the focus is only on the *price*, the interest rate r.[4] If a project succeeds, banks will get principal and interest payments. Should a project fail, banks will receive collateral *S*, where $S < \bar{I} - W$. Equation 9 shows the resulting banks' expected rate of return (before costs of loanable funds) $E[p_i^B]$.[5]

$$E[p_i^B] = (1+r) \cdot E[p_i] + (1 - E[p_i]) \cdot \frac{S}{\bar{I} - W} - 1 = E[p^B] \tag{9}$$

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[3] $(1+r) \cdot (\bar{I} - W) > S$, see page 3.

[4] In Stiglitz and Weiss (1981) a specific "restriction" on loanable funds is a necessary condition for credit rationing to occur. Stiglitz and Weiss model this restriction in form of increasing marginal costs of loanable funds. Capital adequacy requirements for banks can be another "restriction" on loanable funds [see for example Brinkmann and Horvitz (1995)]. Webb (2000) analyzes the impact of liquidity constraints on bank lending policy. He shows that there can be credit rationing due to a poor return on investment on behalf of the banks or due to a higher withdrawal of funds than expected. He shows how this problem can be mitigated by specific contract designs.

[5] Screening and monitoring costs are neglected in this model, because it is assumed that they are not affected by monetary policy impulses.

Banks do not know the project specific risk p_i, but since banks do know the distribution of p_i, they can form respective expectations. The expected probability of success denoted by q (see equation 10) corresponds to the average risk across the projects being financed.[6]

$$E[p_i] = q = \frac{\int_{p^a}^{p^{crit}} p_i \cdot g(p_i) \cdot dp_i}{\int_{p^a}^{p^{crit}} g(p_i) \cdot dp_i} = \begin{cases} \overline{m}_{p_i} & \text{if } p^{crit} \geq p^z \\ \dfrac{p^a + p^{crit}}{2} & \text{if } p^a < p^{crit} < p^z \end{cases} \tag{10}$$

Assumption: $q = p^a$, if $p^{crit} \leq p^a$

An identical interest rate r is offered to all entrepreneurs, being risk adequate to this average risk. This pooling interest rate implies that there is an interest subsidy of the entrepreneurs with relatively risky projects by those with relatively safe projects. *Since the marginal entrepreneurs are those with the relatively safe projects, the marginal entrepreneurs are those who subsidize*. This subsidy effect is crucial in this model. Since r and $E[p_i]$ are the same for all entrepreneurs. $E[p_i^B]$ equals $E[p^B]$. Due to a competitive banking industry banks can only yield the normal profit, which means that $E[p^B]$ equals their costs of loanable funds $\overline{r}$ (*equation 11*).

$$E[p^B] = \overline{r} \tag{11}$$

Solving the equations describing the supply side of the credit market, the offered interest rate r is determined (*equation 12*). r covers the banks´ costs of loanable funds $\overline{r}$ and a risk premium, expressed by $1/q$. Furthermore r will decrease, if the secured part of the loan $S/(\bar{I} - W)$ increases.

$$r = \frac{1 + \overline{r} - (1-q) \cdot \dfrac{S}{\bar{I} - W}}{q} - 1 \tag{12}$$

Equilibrium

Bringing demand and supply side together, the equilibrium critical probability of success p^{crit*}, and therefore the equilibrium interest rate r^*_{asym}, can be determined (e*quations 13* and *14*), whereas equation 13 is not the reduced form of p^{crit*}, since q^* depends on p^{crit*}.

[6] If it were not for the assumption in equation 10, the credit market equilibrium would not be defined for $p^{crit} \leq p^a$, because credit supply would not be defined. But $p^{crit} \leq p^a$ simply states that the credit demand for interest rates being higher than the reservation interest rate of the entrepreneurs with the most risky projects, is zero. The assumption implies that the banks' reservation interest rate is higher than the entrepreneurs reservation rate, if $p^{crit} \leq p^a$, no loan is granted in equilibrium.

$$p^{crit*} = \frac{(\overline{m}_{p_i} - \sqrt{3 \cdot \overline{s}^{\,2}_{p_i}}) \cdot \left(\overline{R} - W \cdot (1 + \overline{r}) - S\right)}{(1 + \overline{r}) \cdot (2 \cdot \bar{I} - \overline{W}) - \overline{R} - S} \tag{13}$$

$$r^{*}_{asym} = \frac{1 + \overline{r} - \left[1 - q^{*}\right] \cdot \dfrac{S}{\bar{I} - W}}{q^{*}} - 1 \tag{14}$$

$$\text{with } q^{*} = \begin{cases} \overline{m}_{p_i} & \text{if } p^{crit*} \geq p^{z} \\ \dfrac{(\overline{m}_{p_i} - \sqrt{3 \cdot \overline{s}^{\,2}_{p_i}}) + p^{crit*}}{2} & \text{if } p^{a} \leq p^{crit*} < p^{z} \end{cases}$$

2.2 Credit Markets without Informational Problems: The Benchmark Case

In credit markets not burdened with informational problems, banks know the probability of success p_i of any project, which means that they can offer each entrepreneur a risk adequate interest rate r_i. Due to the competitive banking industry the equilibrium interest rate $r^{*}_{sym,i}$ corresponds to the banks´ reservation interest rate r_i^{ResB}. By the help of equations 10 and 13, considering that in this situation without informational problems the expected probability of repayment is p_i instead of q^{*}, r_i^{ResB} can be determined. *Equation 15* shows that the equilibrium interest rate covers the costs of loanable funds $\overline{r}$ and a risk premium $1/p_i$. Furthermore the interest rate is negatively influenced by $S/(\bar{I} - W)$, the secured part of the loan.

$$r_i^{ResB} = \frac{1 + \overline{r} - (1 - p_i) \cdot \dfrac{S}{\bar{I} - W}}{p_i} - 1 = r^{*}_{sym,i} \tag{15}$$

2.3 Implications

External Finance Premium

Comparing the equilibrium interest rates of the credit market burdened with asymmetric information and of the credit market in the benchmark case (equations 14 and 15) reveals that there is an external finance premium $e_i = r^{*}_{asym} - r^{*}_{sym,i}$ due to irreducible asymmetric information in credit markets (*equation 16*).

$$e_i = \frac{\left[1 + \overline{r} - \dfrac{S}{\bar{I} - W}\right] \cdot \left[p_i - q^{*}\right]}{q^{*} \cdot p_i} \tag{16}$$

A closer look at equation 16 reveals an interesting aspect: since $S/(\bar{I} - W) < 1$, e_i is only positive for those entrepreneurs whose project has a lower risk than the average risk of all financed projects

$(p_i > q^*)$. Entrepreneurs whose project shows a higher risk $(p_i < q^*)$, do actually benefit from informational problems, their external finance premium is negative. This is logical, since the informational asymmetries lead to the described subsidy effect. *Crucial is that the external finance premium is positive for the marginal entrepreneurs, they have to bear the costs resulting from irreducible asymmetric information in credit markets.*[7]

Monetary Policy

It is assumed that a contractionary monetary impulse is reflected by an increase in the risk free interest rate $\bar{r}$. Considering that

- internal finance decreases as a consequence of a contractionary monetary impulse, since interest payments on short term liabilities increase, lowering the firms' cash flow ($\partial W / \partial \bar{r} = -\bar{K} < 0$), that
- collateral value shrinks a consequence of rising interests rates ($\partial S / \partial \bar{r} = -\bar{b} / \bar{r}^2 < 0$), and that
- $\partial q^* / \partial \bar{r} < 0$ (see equation 18)

equation 17 shows that a contractionary monetary impulse leads to an increase in the external finance premium if $p_i > q^*$. Since this is true for entrepreneurs with relatively safe projects, their capital costs increase more than in the benchmark case. Because they are the *marginal* entrepreneurs, asymmetric information amplifies the effect of the conventional interest rate channel in this case.

$$\frac{\partial e_i}{\partial \bar{r}} = \frac{\left(1 - \frac{1}{\bar{I} - W} \cdot \frac{\partial W}{\partial \bar{r}} - \frac{S}{(\bar{I} - W)^2} \cdot \frac{\partial S}{\partial \bar{r}}\right) \cdot (p_i - q^*)}{q^* \cdot p_i} - \frac{\left(1 + \bar{r} - \frac{S}{\bar{I} - W}\right) \cdot \frac{\partial q^*}{\partial \bar{r}}}{(q^*)^2} \tag{17}$$

$$\frac{\partial q^*}{\partial \bar{r}} = \frac{\left(\bar{m}_{p_i} - \sqrt{3 \cdot \bar{s}^2_{p_i}}\right) \cdot \left[\left(\bar{R} \cdot (\bar{I} - W) - \bar{I} \cdot S\right) + \left(\bar{R} - \bar{I} \cdot (1 + r)\right) \cdot \left[(1 + \bar{r}) \cdot \frac{\partial W}{\partial \bar{r}} + \frac{\partial S}{\partial \bar{r}}\right]\right]}{\left((2 \cdot \bar{I} - W) \cdot (1 + \bar{r}) - \bar{R} - S\right)^2} < 0 \tag{18}$$

The idea behind the increase in e_i can be explained as follows: The external finance premium reflects the costs resulting from asymmetric information, the subsidy which has to be paid by the entrepreneurs with the relatively safe projects. This subsidy is the higher, the higher the costs of external capital are. A contractionary monetary impulse leads to an increase in these costs for three reasons: Firstly, the general interest rate level rises, reflected by an increase in $\bar{r}$. Secondly, the se-

[7] Oliner and Rudebusch (1996) show that moral hazard as a consequence of asymmetric information leads to an external finance premium, which is positive for all considered entrepreneurs. In their paper too, the risk free interest rate is taken as the instrument of monetary policy. Since the external finance premium depends positively on the risk free interest rate, a contractionary monetary impulse is amplified by asymmetric information in credit markets.

cured part of the loan, which is $S/(\bar{I}-W)$, shrinks due to the decrease in S and W. Thirdly, there is an increase in the risk premium, because the average risk becomes higher $(\partial q^*/\partial \bar{r} < 0)$, since there is an adverse selection effect. The innovations to e_i due to the increase in $\bar{r}$ (direct effect) and the decreases in S and W are given in the first fraction of equation 17. The second fraction shows the innovation to e_i due to the adverse selection effect.

Furthermore, equations 17 and 18 make obvious what type of firms are strongly affected by the credit channel: Firms, experiencing high short term liabilities $(\partial W/\partial \bar{r} = -\bar{K})$, facing strong informational problems (reflected by a high $\bar{s}_{p_i}^{-2}$), whose internally generated funds are low, and for which collateralization plays an important role (high $S/(\bar{I}-W)$). That means that those firms are strongly affected, which are usually characterized as bank dependent borrowers.

Result

In this section capital costs of the marginal entrepreneurs increase more in a credit market burdened with asymmetric information than in the benchmark case. There is a credit channel of monetary policy, amplifying the conventional interest rate channel effects, whereas especially firms usually characterized as bank dependent borrowers are strongly affected.

3 Weakening and Overcompensation of Conventional Interest Rate Channel Effects

The aim of this section is to show that monetary policy impulses can also be weakened or overcompensated by asymmetric information in credit markets. 3.1 describes analogously to subsection 2.1 a credit market burdened with asymmetric information. The relevant equilibrium interest rate in the benchmark case is the same as in section 2. Therefore the benchmark case is not described, but subsection 3.2 compares already the two equilibrium interest rates and discusses the consequences of a contractionary monetary impulse. The result is illustrated by a numerical example.

3.1 The Credit Market with Asymmetric Information

The only difference of the set up described in this section and the model of the previous section is the risk-return-characteristic of the investment projects: In the following set up there is no mean preserving spread, but a mean increasing spread: all projects yield the same return in case of success $\bar{R}^s$, but may differ in the probability of success. This idea goes back to de Meza and Webb (1987). The following description of a credit market builds upon their model. In what follows only the equations differing from the respective equations in the previous section are presented.

Demand Side

Equation 19 shows that there is a mean increasing spread.

$$R_i = p_i \cdot \overline{R}^s \tag{19}$$

This implies c. p. a negative relationship between an entrepreneur's expected profit and the risk of his project (*equation 20*).

$$E[p_i^E] = p_i \cdot [\overline{R}^s - (1+r) \cdot (\overline{I} - W) - W] + (1 - p_i) \cdot (-W - S) \tag{20}$$

This results again in a critical probability of success p^{crit} (*equation 21*). But on contrary to the previous model an entrepreneur will only realize his project, if the probability of success of his project is *not lower* than this critical value. Crucial is that therefore in this set up the marginal entrepreneurs are those with the relatively risky projects.

$$p^{crit} = \frac{(1+\overline{r}) \cdot W + S}{\overline{R}^s - (1+r) \cdot (\overline{I} - W) + S} \tag{21}$$

Supply Side

The same informational problems lead again to a pooling interest rate, being adequate to the average risk across the financed projects (equation 22).[8]

$$E[p_i] = q = \frac{\int_{p^{crit}}^{p^z} p_i \cdot g(p_i) \cdot dp_i}{\int_{p^{crit}}^{p^z} g(p_i) \cdot dp_i} = \begin{cases} \overline{m}_{p_i} & \text{if } p^{crit} \le p^a \\ \dfrac{p^z + p^{crit}}{2} & \text{if } p^a < p^{crit} < p^z \end{cases} \tag{22}$$

Assumption: $q = p^z$, if $p^{crit} \ge p^z$.

This pooling interest rate implies again that the entrepreneurs with the relatively safe projects subsidize those with the relatively risky ones. But an important fact is that, due to the different modelling of the risk-return-characteristic of the investment projects, the entrepreneurs with the relatively risky projects are the marginal entrepreneurs. This means that *the marginal entrepreneurs are those who are subsidized*.

Solving the supply side equations, the offered interest rate r is determined. It covers the banks´ refinancing costs $\overline{r}$ and a risk premium, expressed by $1/q$. Collateral influences the interest rate negatively (*equation 23*).

$$r = \frac{1 + \overline{r} - [1-q] \cdot \dfrac{S}{\overline{I} - W}}{q} - 1 \tag{23}$$

[8] Concerning the assumption in equation 22, see analogously footnote 5.

Equilibrium

Solving the equations describing demand and supply side of the credit market one obtains the function describing the equilibrium critical probability of success p^{crit*} (*equation 24*) and the equilibrium pooling interest rate r^*_{asym} (*equation 25*).

$$f(p^{crit*}) = \bar{R}^s \cdot [p^{crit*} \cdot p^z + (p^{crit*})^2] - (1+\bar{r}) \cdot W \cdot (p^z - p^{crit*}) \\ -2 \cdot \bar{I}(1+\bar{r}) \cdot p^{crit*} + S \cdot (p^{crit*} - p^z) \tag{24}$$

with $p^z = \bar{m}_{p_i} + \sqrt{3\bar{s}^2_{p_i}}$

$$r^*_{asym} = \frac{1+\bar{r} - \left[1-q^*\right] \cdot \frac{S}{\bar{I}-W}}{q^*} - 1 \tag{25}$$

with $q^* = \begin{cases} \bar{m}_{p_i} & \text{if } p^{crit*} \le p^a \\ \dfrac{p^z + p^{crit*}}{2} & \text{if } p^a < p^{crit*} \le p^z \end{cases}$

3.2 Implications

External Finance Premium

The external finance premium is the difference between the interest rate entrepreneurs will have to pay for external finance if the credit market is burdened with asymmetric information and the interest rate they will have to pay in the benchmark case. In the set up of this section the latter is the same as in section 2.3 (see equation 15), equation 25 presents the rate if there are informational problems. Equation 26 shows the resulting external finance premium.

$$e_i = \frac{\left[1+\bar{r} - \frac{S}{\bar{I}-W}\right] \cdot \left[p_i - q^*\right]}{q^* \cdot p_i} \tag{26}$$

The crucial difference between the external finance premium of section 2 (equation 16) and the one described by equation 26 is that in the latter *the external finance premium is negative for the marginal entrepreneurs*, since for them $p_i < q^*$ is true. This is due to the fact that they are the entrepreneurs, actually benefiting from irreducible informational problems.

Monetary Policy

A contractionary monetary impulse is reflected by an increase in the risk free interest rate $\bar{r}$. Decisive for possible credit channel effects is the reaction of the subsidy effect, i. e. of the external finance premium. Equation 27 shows that this effect is ambiguous.

$$\frac{\partial e_i}{\partial \bar{r}} = \frac{\left(1 - \frac{1}{\bar{I} - W} \cdot \frac{\partial W}{\partial \bar{r}} - \frac{S}{(\bar{I} - W)^2} \cdot \frac{\partial S}{\partial \bar{r}}\right) \cdot (p_i - q^*)}{q^* \cdot p_i} - \frac{\left(1 + \bar{r} - \frac{S}{\bar{I} - W}\right) \cdot \frac{\partial q^*}{\partial \bar{r}}}{(q^*)^2} \tag{27}$$

$$\frac{\partial q^*}{\partial \bar{r}} = \frac{(p^z - p^{crit*}) \cdot \left(W - (1 + \bar{r}) \cdot \bar{K} - \frac{S}{\bar{r}}\right) + 2 \cdot \bar{I} \cdot p^{crit*}}{2 \cdot \left(2 \cdot \left(\bar{R}^s \cdot q^* - \bar{I} \cdot (1 + \bar{r})\right) + \bar{R}^s \cdot p^{crit*} + W \cdot (1 + \bar{r}) + S\right)} \quad \begin{matrix} \leq \\ > \end{matrix} \; 0 \tag{28}$$

with $p^z = \bar{m}_{p_i} + \sqrt{3\bar{s}^2_{p_i}}$

The subsidy effect, i. e. the absolute value of the external finance premium, is the higher the higher the costs of external capital. A contractionary monetary impulse leads to an increase in these capital costs, because the risk free interest rate increases and because the secured share of the loan shrinks, due to a reduction in W and S. These three positive effects on the absolute value of e_i are reflected by the first fraction of equation 27.[9] However, there is a second, an ambiguous effect influencing the costs of external finance, given by the second fraction of equation 27. It is not clear, whether the average risk will decrease ($\partial q^* / \partial \bar{r} > 0$), leading to a reduction in the costs of external capital, or whether $\partial q^* / \partial \bar{r} < 0$, resulting in a further increase in these costs. $\partial q^* / \partial \bar{r} > 0$ will be true, if there is a favourable selection effect. $\partial q^* / \partial \bar{r} < 0$ will result, if more entrepreneurs with relatively risky projects seek for external finance. The idea behind this argument becomes clear describing the three possible scenarios following a contractionary monetary impulse:

1. *Credit channel effects weaken the effects of the conventional interest rate channel*. This scenario will occur, if the absolute value of the external finance premium increases, but if this additional subsidy effect does not outweigh the effects of the conventional interest rate channel. This means that total capital costs of the marginal entrepreneurs rise, but this upsurge is less than in the benchmark case. In this case $\partial q^* / \partial \bar{r} > 0$, but this negative effect on $|e_i|$ does not outweigh the positive effect resulting from the first fraction of equation 27.

[9] $e_i > 0$ for $p_i > q^*$. In this case the first fraction of equation 27 is positive. $e_i < 0$ for $p_i < q^*$. In this case the first fraction of equation 27 is negative. Therefore, the effect resulting from the first fraction of equation 27 on the *absolute value* of e_i is positive in any case.

2. *Credit channel effects outweigh the effects of the conventional interest rate channel.* This scenario will occur, if the increase in the absolute value of the external finance premium is that strong, that capital costs of the marginal entrepreneurs actually decrease. In this case $\partial q^* / \partial \bar{r} < 0$, the average risk of the financed projects rises, since more entrepreneurs with relatively risky projects seek outside finance, due to the for them declined costs of external capital.
3. *Credit channel effects reinforce the effects of the conventional interest rate channel*. In this case a favourable selection effect, reflected by $\partial q^* / \partial \bar{r} > 0$, outweighs the effects described by the first fraction of equation 27. The subsidy of the entrepreneurs with the relatively risky projects shrinks. This means that capital costs of the marginal entrepreneurs increase more than in the benchmark case. [10]

It remains to answer the interesting question under which conditions which scenario will occur.

Weakening and overcompenation: Equation 27 shows that the increase in the subsidy is the higher, the higher $|\partial W / \partial \bar{r}| = |-\bar{K}|$ and $|\partial S / \partial \bar{r}| = |-S / \bar{r}|$, and the lower $\partial q^* / \partial \bar{r}$ are. This means that the effects of the conventional interest rate channels will be weakened or even overcompensated by credit channel effects, if short term liabilities $\bar{K}$ and collateral S are high and if collateralization plays an important role in outside finance. (Collateralization is the more important the higher $S / \bar{I} - W$, the share of the loan being secured.) Moreover, equation 28 makes clear that the average risk will decrease $(\partial q^* / \partial \bar{r} < 0)$, meaning that there will be overcompensation, if internal finance W is low, if short term liabilities $\bar{K}$ and collateral S are high, and if there are significant informational problems, reflected by a high $s^2_{p_i}$.

Reinforcing: Equation 27 shows that the effects of the conventional interest rate channel will be reinforced due to asymmetric information, i. e. the absolute value of e_i will decrease after a contractionary monetary impulse, if firstly, the effects reflected by the first fraction are relatively small - which is the case if short term liabilities $\bar{K}$ and collateral S are rather low and if collateralization does not plays an important role – and if secondly, there is a strong favourable selection effect (a large increase in q^*), which is the case if W is high and if $\bar{K}$ and S are low.

Result

In this section three possible scenarios following a contractionary monetary impulse were derived:

1. In a credit market burdened with asymmetric information capital costs of the marginal entrepreneurs increase less than in the benchmark case, which means that there is a credit

[10] In this set up asymmetric information in credit markets implies that aggregate investment is higher as if there were no asymmetric information, i. e. there is an overinvestment problem [see de Meza and Webb (1987)]. After the monetary impulse there is still overinvestment, i. e. without informational problems aggregate investment would be lower. But in this context it is crucial that in the benchmark case the *decrease* in aggregate investment would be lower.

channel of monetary policy *weakening* the effects of the conventional interest rate channel. This is due to an increase in the subsidy effect resulting from asymmetric information. In this case especially entrepreneurs are concerned, usually characterized as bank dependent borrowers.

2. In a credit market burdened with asymmetric information capital costs of the marginal entrepreneurs actually decrease. This means that there is a credit channel of monetary policy *overcompensating* the effects of the conventional interest rate channel, due to a sharp rise in the subsidy effect. In this case too, especially bank dependent borrowers are concerned
3. In a credit market burdened with asymmetric information capital costs of the marginal entrepreneurs increase more than in the benchmark case, which means that there is a credit channel of monetary policy, *reinforcing* the effects of the conventional interest rate channel, due to a decline in the subsidy effect. This case will be relevant for firms usually not described as bank dependent borrowers.

Numerical Example

These results are illustrated by the numerical examples described in table 1. In all three examples the contractionary monetary impulse is reflected by an increase in the risk free interest rate from 4 % to 5 %. The crucial differences between the three examples are the amount of short term liabilities $\overline{K}$, the number of consols $\overline{b}$ and the extent of informational problems $\overline{s}_{p_i,k}$.[11] These differences have been chosen, because the balance sheet channel operates through $\overline{K}$ and $\overline{b}$ ($\overline{K}$ determines internal finance and $\overline{b}$ collateral) and because $\overline{s}_{p_i,k}$ is the reason for the existence of the credit channel. In all three examples the entrepreneurs have an indivisible project which requires an investment of 1 million euro.

In the *first example* the cash flow of the entrepreneurs which can be invested, is 0.3 million euro. Therefore they need a credit of 0.7 million euro, which they secure to 70 %. Informational problems in the credit market imply a pooling equilibrium interest rate of 6.3 %. If the credit market is not burdened with asymmetric information the entrepreneurs with the safest projects will only pay an interest rate $r^*_{sym,z}$ of 5.6 %. If there are not informational problems the interest rate of the entrepreneurs with the safest projects will rise by 2.1 percentage points after the contractionary monetary impulse. However, if there are informational asymmetries, their interest rate will rise by

[11] The different return $\overline{R}^S$ and the different average risk $\overline{m}_{p_i,k}$ in example III have been chosen in order to make clear the possible consequences of the higher informational problems: A $\overline{m}_{p_i,k}$ of 92 % would imply that the safest project shows a probability of success of more than 100 %. A $\overline{R}^S$ of 1,13 Mio. € would imply that the increased subsidy effect resulting from the higher informational problems falls flat, because the entrepreneurs with the relatively risky projects are simply not able to bear much higher additional costs.

2.4 percentage points reflecting the increase in the subsidy they have to pay. Since the entrepreneurs with the relatively risky projects benefit from this subsidy, their capital costs increase less in the benchmark case. Since they are the marginal ones, the contractionary monetary impulse is weakened by asymmetric information in credit markets, as the increase in the external finance premium shows.

The differences in the exogenous variables of the *second example* compared to the first, are smaller informational problems, lower short term liabilities and less consols. The loan is only secured to 45 %, which leads to a higher interest rate, compared to the first example. But it can be seen that the positive effect of the contractionary monetary impulse on the external finance premium is so small that the negative effect (favourable selection) outweighs, i. e. the external finance premium shrinks. This implies for the entrepreneurs with the relatively risky projects that their capital costs do not only rise due to the effects of the conventional interest rate channel, but also because of the decrease in the subsidy they receive. Therefore the monetary impulse is amplified by asymmetric information in credit markets.

In the *third example* the extent of informational problems is the highest. Furthermore the amount of short term liabilities and the number of consols are the highest too. The former leads to relatively low internally generated funds (the internal finance rate is 20 %), and the latter means that collateral plays a significant role (75 % of the loan are secured). This implies that the positive effect of the contractionary monetary impulse on the external finance premium is rather large: the premium increases from 3.6 % to 7.1 %. This relatively high increase in subsidy means that total capital costs of the marginal entrepreneurs actually decrease as a consequence of the contractionary monetary impulse, the effect of the conventional interest rate channel is overcompensated: before the monetary impulse all entrepreneurs with a project showing a probability of success of at least 74.4 % realize their project, after the monetary impulse all projects having a probability of success of at least 72.6 % are financed.

Exogenous Variables	**Example I**		**Example II**		**Example III**	
investment $\bar{I}$	1 Mio €		1 Mio €		1 Mio €	
return $\bar{R}^s$	1.13 Mio €		1.13 Mio €		1.36 Mio €	
cash flow $\bar{U}$	0.7 Mio €		0.7 Mio €		0.7 Mio €	
Short term liabilities $\bar{K}$	10 Mio €		3.3 Mio €		12 Mio €	
number of consols $\bar{b}$	19600		7200		24000	
average prob. of success $\bar{m}_{p_i}$	92 %		92 %		83 %	
informational problems $\bar{s}_{p_i}$	2 %		1 %		7%	
risk free interest rate $\bar{r}$	**4 %**	**5 %**	**4 %**	**5 %**	**4 %**	**5 %**
Endogenous Variables						
cash flow (internal finance) *W*	0.3 Mio €	0.2 Mio €	0.6 Mio €	0.53 Mio €	0.2 Mio €	0.1 Mio €
credit $(\bar{I} - W)$	0.7 Mio €	0.8 Mio €	0.4 Mio €	0.47 Mio €	0.8 Mio €	0.9 Mio €
collateral *S*	0.49 Mio €	0.39 Mio €	0.18 Mio €	0.14 Mio €	0.6 Mio €	0.48 Mio €
average prob. of success $E(p_i)^*$	93.6 %	93.9 %	92.8 %	93.3 %	85 %	84.1 %
critical prob. of success p^{crit*}	91.6 %	92.2 %	91.8 %	92.8 %	74.4 %	72.6 %
prob. of success p^a, p^z	88.5 %, 95.5 %		90.3 %, 93.7 %		70.9 %, 95.1 %	
equilibrium pooling interest rate r^*_{asym}	6.3 %	8.7 %	8.58 %	10.40 %	9.1 %	14.8 %
equilibrium interest rate $r^*_{sym,z}$	5.6 %	7.7 %	7.97 %	10.06 %	5.5 %	7.7 %
External finance premium e_z	0.7 %	1 %	0.61 %	0.34 %	3.6 %	7.1 %
Result: Monetary impulse is ... by asymmetric information	...modified...		...amplified...		...overcompensated...	

Table 1: Numerical Examples for the Consequences of a Contractionary Monetary Impulse

Final Remark

Crucial for the type of influence is the modelling of the projects' risk-return characteristics. Generally, existing studies speak for a dominance of the mean-preserving-spread projects described in section 2, since empirical evidence indicates a positive relationship between internal finance and investments (de Meza and Webb 1999). But adapting the model of de Meza and Webb (1999) it can be shown that although having a positive relationship between these two variables, asymmetric information may modify the effects of the conventional interest rate channel: In de Meza and Webb (1999) there are asymmetric information about the projects' risk and about entrepreneurial ability. The latter determines a project's probability of success and therefore the risk of the bank loan financing the project. Asymmetric information about the projects' risk leads to adverse incentives

(the higher the loan's interest rate the riskier the project an entrepreneur chooses) and asymmetric information about the entrepreneurial ability may lead to a favourable selection (the marginal entrepreneurs are the less able entrepreneurs). The main point of de Meza and Webb is that the credit market equilibrium is characterized by two inefficiencies due to asymmetric information: a) There is an excessive amount of risk taking due to the adverse incentive effect. b) There is overinvestment due to asymmetric information about the entrepreneurial ability, which results in a pooling interest rate and therefore in a subsidy for the less able entrepreneurs. Without this subsidy they would not invest. An important aspect in de Meza and Webb's set up is that an increase in internal finance can induce entry, so that there is a positive relationship between internal finance and investments. Therefore they solve a "problem" of their 1987 model: the negative relationship between internal finance and investments. Using the model of de Meza and Webb (1999) in order to analyze a possible balance sheet channel of monetary policy the following conclusion may be drawn: A contractionary monetary impulse leads to higher capital costs due to an increase in the general interest rate level and a reduction in collateral value. These higher capital costs reinforce the incentives to choose riskier projects, i. e. capital costs rise more than if it were not for this adverse incentive. Therefore the asymmetric information about the projects' risk amplify the effects of the conventional interest rate channel. The adverse incentive effect is reinforced by a decline in internal finance induced by the contractionary monetary impulse. However, the possible drop out of the less able entrepreneurs works into the opposite direction. This favourable selection reduces the risk premium in the credit interest rate and therefore modifies the effect of the conventional interest rate channel. Which effect outweighs depends among other things on the importance of collateral, the amount of short term liabilities (if internal finance is modelled in the same way as in this paper) and the distribution of the projects' risk and entrepreneurial ability.

4 Summary

This paper shows that asymmetric information in credit markets may not only reinforce the effects of the conventional interest rate channel, but that it is also possible, that asymmetric information weakens or overcompensates these effects. There are asymmetric information in credit markets, because banks cannot assess the specific risk of the projects to be financed, whereas the entrepreneurs know this risk. This leads to a pooling interest rate, implying that entrepreneurs with relatively risky projects are subsidized by those with relatively safe ones. This subsidy effect is reflected by an external finance premium, which is positive for entrepreneurs with relatively safe projects, entrepreneurs with relatively risky projects face a negative external finance premium. A contractionary monetary impulse may lead to an increase in the absolute value of this external finance premium. If the entrepreneurs with the relatively safe projects are the marginal ones, the effects of

the conventional interest rate channel may be amplified. If the entrepreneurs with the relatively risky projects are the marginal ones, the effect of the interest rate channel may be weakened or overcompensated. Therefore this paper has shown that there can be a credit channel of monetary policy due to asymmetric information in credit markets, but its direction of influence is ambiguous. The interesting fact is that typically bank dependent borrowers are affected strongly by the credit channel, independently of its direction.

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