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The Risk-Taking Channel of Monetary Policy in Norway*

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Abstract

We identify the effects of monetary policy on credit risk-taking using a unique dataset covering the population of corporate borrowers in Norway. We find that a lower benchmark interest rate (interbank rates or overnight rates) induces the average bank to grant more loans to risky firms. We also find that the strength of the bank's balance-sheet is important: less capitalized banks are more likely to increase loan volumes to ex-ante risky firms compared to more capitalized ones (Jimenez et al., 2014). The data allow us to distinguish the changes in the supply of credit from the changes in credit demand. In all our specifications we control for both observed and unobserved firm and bank heterogeneity by using financial statement information and firm, bank and time fixed effects.

Keywords: Risk-taking channel, monetary policy, financial stability, credit risk
JEL classification numbers: E44, E5, G01, G21, G28, L14

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1 Introduction

After the onset of the Great Recession in the summer of 2007, a number of policy makers, academics and market participants argued that low interest rates prior to the crisis had led to increased risk on lenders' balance sheets; lenders had softened their lending standards or engaged in yield-seeking by shifting from safe assets (that now yielded even lower rates) towards riskier, higher-yield assets. Borio and Zhu (2007) labeled this effect as the "risk-taking channel" of monetary policy through which expansionary monetary policy affects the willingness of financial institutions to engage in search-for-yield and take on further risk exposures. This may eventually impact the real-economy decisions.

In this paper we explore the workings of the risk-taking channel in the Norwegian banking sector. In doing so, we focus on the impact of the monetary policy stance and the implied short-term borrowing costs on banks' risk-taking.

What causes risk-taking? Rational as well as irrational factors may create a tendency to follow nominal returns at a time of lower interest rates (Gambacorta, 2009). An example of an irrational factor is money illusion: investors may ignore the fact that nominal interest rates can decline to compensate for lower inflation. Other factors may stem from institutional or regulatory constraints. Many financial institutions, such as pension funds and life insurance companies, include promised annual payments on the liability side, and manage the assets with reference to their liabilities. Liabilities are often linked to a minimum guaranteed nominal rate of return reflecting long-term assumptions, but not the current level of yields. In a period of declining interest rates, such promised returns may exceed the yields available on the assets the institution invests in, such as highly rated government bonds.[1] The resulting gap can lead institutions to shift to higher-yielding, higher-risk instruments. More generally, financial institutions regularly enter into long-term contracts committing them to producing relatively high nominal rates of return.

Another channel works via the impact of the interest rate on valuations, incomes

[1] For this reason, this channel is particularly important for institutions that have promised annual payments on the liability side of their balance sheets. See Gambacorta (2009) for more discussion on the factors affecting risk-taking.

and cash flows. This is similar to the familiar financial accelerator, in which increases in collateral values reduce borrowing constraints (Bernanke et al, 1996). Adrian and Shin (2009) argue that the risk-taking channel differs from and strengthens the financial accelerator because it focuses on amplification due to financing frictions in the lending sector.

Finally, a reduction in the policy rate can also boost asset and collateral values, which in turn can modify bank estimates of probabilities of default, loss given default and volatilities. For example, by increasing asset prices low interest rates tend to reduce asset price volatility and thus risk perception.

We provide firm-level evidence of the risk-taking channel of monetary policy in Norway utilizing a long panel of a unique firm-bank matched dataset. For monetary policy, our main variable is the change in short-term benchmark interest rates.[2] Even though banks may rely on other funding sources, such as foreign or long-term funding, low short-term rates at home may spur risk-taking, because most interest rates float in tandem with interbank or overnight interest rate fluctuations.[3] To measure risk-taking by lender, we mostly focus on firm-level variables. As a proxy of the firm's true risk, we use credit rating information, which we have for almost every Norwegian firm and for each year during our sample, provided by a private credit rating bureau. Moreover, over a quarter of our population of firms have multiple banking relationships in our data. Exploiting these relationships, we show that expansionary monetary policy induces banks to take more risk: risky firms are more likely to get a new loan when policy rates are lower.

Furthermore, we show that for a given firm different banks vary in their willingness to extend credit at any given time and that a bank's response depends on its capital ratios. That is, for a given firm we demonstrate that the supply of credit to riskier firms varies across banks, and that the degree of variation depends on the equity-to-asset ratio of the bank. In line with Jimenez et al. (2014), we find that for a given firm with several banking relationships, banks with higher equity are less willing to extend credit.

[2] Jimenez et al. (2014) also use the change in the interest rate. Our main results are not generally affected when we use interest rate levels instead.

[3] Still, in the regression analysis we take account of banks' funding structures (e.g., equity funding, funding with foreign liabilities).

With more skin in the game, the willingness to take risks is reduced (Holmstrom and Tirole, 1997). For the average bank, our finding is qualitatively similar for Norway - local banks engage in risk-taking during times of expansionary monetary policy.

In terms of economic magnitude, our findings suggest that a one percentage point decrease in the benchmark interest rate makes it on average 2 to 3.2 percent more likely that a risky borrower will obtian a new loan. When we analyze heterogeneity across banks according to their equity ratios, we find that with a one percentage point (one standard deviation) decrease in the benchmark policy rate, a low equity-to-asset ratio bank is around 0.9 (1.6) percentage point more likely to extend a new loan to a risky borrower compared to a high equity-to-asset ratio bank, when the ratios differ by one standard deviation (s.d.=1.7%).

One issue in our empirical analysis is endogeneity in monetary policy. For instance, unobservable factors that affect credit levels and risk estimates may also affect monetary policy. Risk in the overall economy may rise when the economy is cooling and monetary policy is expansionary. This may bias any result showing the effect of an expansionary monetary policy on risky lending. To overcome the issue, we also instrument the monetary policy stance with two variables: US monetary policy and the oil price.

The rest of the paper is organized as follows. Section II provides a literature review. Section III describes data and model specifications. Section IV provides empirical methodology and regression analysis, and Section V concludes.

2 Related literature

Theoretical and empirical literature on bank risk-taking has examined the different ways in which low interest rates can influence risk-taking. The first theoretical study to our knowledge is based on the search-for-yield incentive (Rajan, 2005). Low interest rates may increase incentives for asset managers to take on more risks for contractual, behavioral or institutional reasons. For example, during 2003 and 2004 many investors shifted from low-risk government bonds into higher-yielding, riskier corporate and emerging market bonds. They may have been seeking to meet the nominal returns they had been able to achieve when interest rates were higher (BIS, 2004).

Models of costly effort and agency problems may create similar incentives, too. In Allen, Carletti and Marquez (2011) low interest rates may entail more risk-taking in lending by banks via weakening monitoring standards of the banks. In their model, banks grant loans to firms and monitor them, which helps improve firms' expected payoff. But monitoring is costly and banks have limited liability, and these two effects create a moral hazard problem in the choice of monitoring effort. Equity capital is one way to ameliorate the issue and provide banks with greater incentives for monitoring. A higher capital level will make banks internalize the costs of their default, and soften the limited liability problem banks face due to their extensive reliance on deposits.

Related to the above models, severe agency problems in banking may create similar effects. For instance, due to bail-outs and liquidity assistance low interest rates may induce banks to soften their lending standards by improving banks' liquidity (Allen and Gale, 2007).

Empirically, the impact of short-term interest rates on credit variables has been extensively analyzed since the early 1990s. Due to a lack of data and a focus on macro-analysis, early literature examined changes in the aggregate volume of credit in the economy (Bernanke and Blinder, 1992; Kashyap and Stein, 2000). More recent studies use micro-level data to analyze risk-taking at the firm level, distinguishing demand from supply. Jimenez et al. (2014) explore this issue in Spain; Ioannidou, Ongena and Peydro (2014) analyze risk-taking in Bolivia, while Adrian and Shin (2011) and Adrian, Estrella and Shin (2009) have studied the risk-taking channel for the US. For instance, using credit registry data from the entire population of firms in Spain, Jimenez et al. (2014) look at the risk-taking channel of the ECB's monetary policy. They show how expansionary monetary policy impacts lenders' appetite for risk. In doing so, they utilize unique information on both credit applications (and their acceptance vs. rejection), as well as approved applications and granted amounts.

Jimenez et al. (2014) examine the impact of the level of bank capitalization. Our results are in line with their findings: more capitalized banks take less risk. This is also consistent with Holmstrom and Tirole (1997). In the latter, banks must obtain positive dividends to compensate for zero returns in cases of default as a result of firms' limited liability. With higher skin in the game, they must get even higher dividends. However, because of higher dividends, banks will engage in even more careful lending.

In their empirical analysis, Dell'Ariccia, Laeven and Suarez (2013) use the interaction of the capital ratio and monetary policy to account for the varying levels of risk-taking appetite in banks with different capital ratios (which would be analogous to the triple interaction specification in Jimenez et al. (2014) and our case).[4] Using data from the US, they show the interaction of the capital ratio and monetary policy has a different impact: when key rates go down, higher equity banks are the more likely risk-takers compared to low equity banks. Based on an earlier theoretical work (Dell'Ariccia, Laeven and Marquez, 2014), they outline a theory that supports the empirical findings of their study.

A more recent strand of literature analyzes international monetary policy transmission channels. Bruno and Shin (2015) show that global banks increase lending to their regional subsidiaries when their home policy is expansionary. Regional banks then increase the size of loans when their funding costs are lower, but this also spurs risk-taking. Bruno and Shin (2014) then assume that the exchange rate varies inversely with the loan amount outstanding: when there is more lending at home more foreign currency has to be exchanged in the spot market for the local currency to finance the projects in the local currency. This currency appreciation makes the borrower a safer one and allows the banks to lend more. Thus lending increases further. Cetorelli and Goldberg (2015) show that US banks with international subsidiaries are less sensitive to US monetary policy.

3 Data and model specification

3.1 Data

Our data come from several sources. Our main dataset consists of firm-bank account data. It contains information about the end-of-year balance on all bank deposit and

[4] They use somewhat different specifications in their empirical section. In their regression models, the measure of risk is the dependent variable and triple interactions are therefore not in place.

bank loan accounts in the period 1997-2010 for all firms in Norway. This means the dataset shows end-of-year balances of the account (or accounts) for each firm with each of its banks.[5] The dataset includes a unique firm identifier, which enables us to link the observations with the firm's financial statements. Furthermore, there is a unique bank ID corresponding to each account, and we link the dataset to banks' financial statements.

The firm-bank account data (or the "Tax data") is collected annually by the Norwegian Tax Administration for tax purposes. It therefore is a highly accurate dataset. The database is confidential, but has been made available at Norges Bank under confidentiality conditions regarding data access and the disclosure of the identities of the firms and the lenders. Its purpose is to ensure proper tax reporting by the firms, and the reporting from the banks has to be verified by their external auditor. The banks are required to report the following information to the tax authorities for each account: the account number; the name of the account holder and the unique organization (ID) number; the deposit or *loan balance* at the end of the year; and, finally, interest accrued during the year for each account. In addition to the actual interest payments, the variable showing interest accrued includes any fees or commissions related to the loan. Most Norwegian bank accounts carry a floating interest rate. The database includes all bank accounts held by Norwegian firms at a domestically operating bank, including Norwegian branches of foreign banks.

Our banking dataset comprises bank balance sheet data from several bank reports.[6] Most of the data are available at Norges Bank at a monthly frequency, except for some of the variables, which are available only at a quarterly frequency. We take asset and liability side variables from the reports to construct our main set of control variables.

Our data source for the firms provides information on all Norwegian firms' financial statements at the end of each year. It contains annual accounting data for all Norwegian private and public limited liability companies for the period 1997-2010. The database is known as "SEBRA" data, and it is the source of our firm-level controls.

[5]The dataset also comprises, in principle, bank-bank account data, since banks also borrow from the other lenders, i.e., interbank loans.

[6]These are ORBOF 10 (balance sheet), ORBOF 11 and ORBOF 21 (income statement)

Main dataset

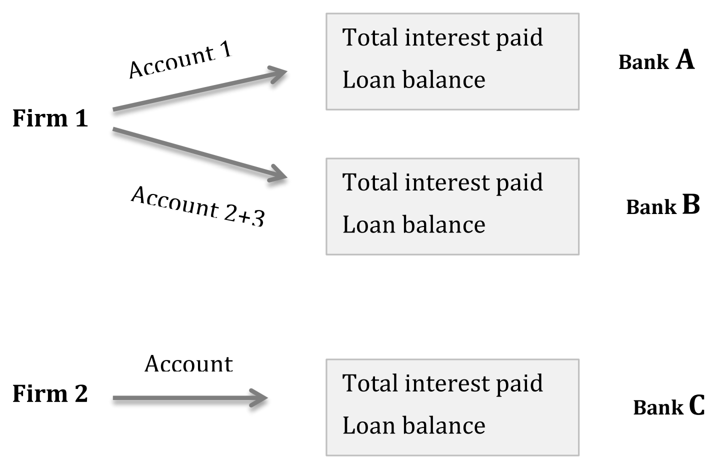

Figure 1: The figure illustrates the merge between datasets and aggregation of outstanding balances over account for a firm-bank pair

Norwegian companies are required to have an authorized auditor and must file their annual financial statements after each accounting year.[7] The accounting database includes the profit and loss account, the balance sheet, industry information and legal form.

We link each observation in the firm-bank account database to both the banks' reports and the firms' financial statements (see Figure 1).

In addition, the above dataset is then linked to firm-level ratings data. The ratings data is provided by a private credit-rating firm, Bisnode. Bisnode may rate firms more than once annually, in which case we keep the last rating in the year in our final dataset. Thus, the main measure of firm credit risk is a firm-level end-of-year rating value. In the rating, each firm takes values from A (most secure, redefined with value 6) to F

[7]In July, to be more exact. SEBRA and the tax data are described in more detail in Hetland and Mjos, 2012.

(least secure, value 1). In most specifications we use the modified rating variable: a *risk dummy, which takes value 1 if the firm is rated with the lowest two ratings and 0 otherwise*. We then match these firm-risk variables to the above dataset at the firm-year level. In the regressions, we take the lagged value of the risk measure, based on the last rating value of the previous year.[8]

Finally, we complement our micro-data with a number of macro-level variables from Statistics Norway and Norges Bank. These include several measures of short-term interest rates in Norway, inflation and GDP growth.

3.2 The sample

We restrict our sample to all non-financial limited liability firms. To reduce the number of inactive borrowers in our sample, we keep only firms with more than NOK 5000 (approximately USD 600) of outstanding credit on average over their life during the sample period. These firms are usually smaller, but are distributed quite proportionately across all industries, with a slightly higher weight in the industry of academic and cultural services.[9]

Unless otherwise mentioned, in most of our analysis we aggregate all bank accounts for each firm with a given bank in a given year, such that our observations are at the firm-bank-year level. This means that in a given year a firm with several banks will have several firm-bank observations. Our two main dependent variables are the $Newloan$ and *Loan*. Newloan is a dummy variable that takes value 1 in year t if the amount of credit owed by firm i to bank b in year t is higher than credit owed in the previous year, indicating that the firm must have taken a new loan. *Loan* is the log increase in outstanding credit from the previous to the current year at the bank-firm

[8]Taking the average rating value of the previous year does not alter our result much. In fact, most firms are rated once. Further, in unreported robustness checks we also assess risk by using a separate firm default probability model, developed by Norges Bank and the Financial Supervisory Authority of Norway, the output of which is a default probability assigned to each firm in each year.

[9]In addition, in our robustness checks we check that exclusion of certain industries (following Hetland and Mjos, 2012) does not alter our results: these include agriculture, forestry, electricity production, water management, government sector, education, health care, waste disposal, political and religious groups, cultural services, international and non-governmental organizations (NGOs), and non-classified firms.

level. [10]

Table 1 presents summary statistics for the dependent and main independent variables.

4 Empirical method

Our benchmark specification takes the following form:

$$Credit_{ibt} = \beta * (RISK_{it}) + \gamma MP_{t-1} * (FIRMRISK_{it}) +$$
$$+\delta MP_{t-1} * LN(EQUITY_{t-1}) * (RISK_{ti}) + Controls_{ibt} +$$
$$+ \alpha_t + \alpha_i + \alpha_b + \epsilon_{ibt} \quad (1)$$

where $Credit_{ibt}$ is one of our two main independent variables, $Loan$ or $Newloan$.

In most of the specifications, we include time fixed effects to capture developments in the efficiency of the Norwegian banking sector during the time period covered. The efficiency of the banking sector may be changing in Norway due to new regulations and adaptations of banks to them. These issues may potentially bias our results if we do not control for the effects of the unobserved time-varying characteristics.

Time trends may also capture the volatility of GDP growth, changes in inflation or other macro variables. We also add these variables instead of time fixed effects in some of our specifications.

[10] It might well be possible that a firm takes a new loan in the current year but the end-of-year balance is still smaller than in the previous year. That can happen if in the meantime a loan has been repaid, and the repaid loan was larger than the amount of the new loan. However, since we are not able to observe this, these cases are not taken into consideration. Nevertheless, granting smaller loans is presumably a decision that is less demanding for the bank to make. The smaller loans should be easier for the bank to grant since the repaid amount is higher.

4.1 Identification

To analyze whether or not a low monetary policy rate induces risk-taking by banks, one needs to disentangle the impact of the short-term interest rate on the risk of the supply of credit from changes in the volume of the supply, as well as from changes in the risk and the volume of the demand. The existence of multiple banking relationships helps us address these issues by including firm fixed effects.

More precisely, our identification strategy includes the following: (i) saturate the model in equation (1) with time, firm and bank fixed effects; (ii) horserace the reference interest rate, in its interaction with bank capital and firm risk. At the same time, in the analysis we control for the impact of other key macro variables, and bank and time controls. This way the bank risk-taking channel identified will address qualitative changes in the supply of credit at the bank-firm level.[11] We now discuss each of our approach in more detail, along with our measures of credit risk.

4.1.1 Monetary policy

Anotoher key identification issue in our empirical analysis is endogeneity in monetary policy: for instance, at times when the economy is in a declining phase, monetary policy is expansionary. However, the risk estimates in firms and corporations in the economy may be growing as well. Indeed, this may happen via the firm balance sheet and the interest rate channel of monetary policy (Bernanke and Gertler, 1995); the balance sheets of firms are growing stronger, and risky firms may have improved their net worth, investment opportunities, and collateral values. This may bias our results. Therefore, to suppress simultaneous changes in the risk estimates of firms we also instrument the monetary policy stance with that of U.S. For the home monetary policy stance, we use several short-term policy rates. Banks are mostly funded by short-term debt, the interest rates of which will likely respond to changes in the monetary policy rate. And even though banks also rely on long-term funding, low short-term rates may be important there too, because most funding rates may be floating in response to

[11] Jimenez et al.(2014) are able to observe loan applications, their outcome and granted amounts. Using such information a further identification strategy they use is a selection model

interbank rate fluctuations (e.g., NIBOR plus a constant rate). For robustness checks, we use several policy-based rates present in the Norwegian market. During the sample period, the key policy rate in Norway varied between 1.5 and 8 percent.

4.1.2 Firm-level risk measures

For measures of risk we take several approaches. To measure directly the change in risk-taking by lenders, we mostly focus on firm-level variables. We take the firm-year level credit rating variable described above and use it in our firm-level analysis.

4.1.3 Fixed effects

The risk-taking channel implies that expansionary monetary policy spurs banks into risky lending. The risk-taking incentive, however, may be higher when banks are less capitalized. Leverage in the banking industry is high, and most banks are affected by moral hazard problems (Holmstrom and Tirole, 1997). The issue is that this implication can also be consistent with the demand side, in particular, with the firm balance sheet and the interest rate channel of monetary policy (Bernanke and Gertler, 1995). Therefore, to suppress simultaneous changes in the balance-sheet strength of firms (they may have improved their net worth and collateral values) and volume of the firm's demand for credit, we add time and firm fixed effects in our regressions in line with existing empirical work. The former will account for observed and unobserved time-varying factors in the economy, and the latter for time-invariant firm characteristics. We alternatively control for time-varying observed measures at the firm level by taking firm profitability, size, age and other key variables into the regressors instead of firm fixed effects. Identification comes from comparing changes in lending to the same firm by different banks (with respect to their capital-to-asset ratios and other key measures), controlling for time-varying unobservable factors by using time fixed effects. Around 25 percent of the firms in our sample have accounts with multiple banks and maintain multiple banking relationships.[12]

[12] Results are similar, however, whether or not we use whole population (without fixed effects and with firm controls) or only firms with multiple banking relationships.

In some models we have added bank fixed effects to our benchmark specification. This way we account for observed and unobserved bank heterogeneity. Identification comes from comparing changes in lending by the same bank to firms that differ in terms of credit risk.

4.1.4 Triple interactions

We further use triple interactions of the interest rate, firm risk and bank capital ratios. Identification of the risk-taking channel is captured by exploiting the following testable prediction: risk-taking by banks at times of expansionary monetary policy is stronger for banks that are subject to more severe agency problems. As in Jimenez et al. (2014), banks' capital-to-assets ratio is included to measure the intensity of the agency conflict that banks encounter (Holmstrom and Tirole, 1997). More specifically, to identify the risk-taking channel of monetary policy, we interact the lagged short-term interest rate (or the change in the short-term interest rate) with the lagged bank capital ratio (Kashyap and Stein, 2000; Jimenez et al., 2014) and our measure of firm risk.

4.2 Results

In our specifications, we use different short-term interest rates to account for the monetary policy stance in Norway. The main short-term rate is the three-month Norwegian interbank interest rate (known as NIBOR). In unreported regressions we confirm that our results hold true when we instead use the other benchmark rates which are highly correlated with the NIBOR (above 0.9): the key policy rate of Norges Bank (sight deposit rate, and the overnight lending rate.

We include bank controls in most of our specifications to take account of banks' varying ability to withstand monetary policy shocks. The ratio of liquid assets to total assets is included to capture the fact that banks with larger share of liquid assets may be more able to continue lending since they are able to more liquidate some of the assets and generate cash for loans (Kashyap and Stein, 2000). Similarly, we include the share of foreign liabilities since banks with access to foreign funding may be less affected by contractionary monetary policy at home (Cetorelli and Goldberg, 2015). The size of a bank, as measured by its total assets, may matter for the same reason.[13]

In Table II below, we run linear models as in equation (1), with the change in loans as the dependent variable: the log difference of the outstanding increase at the firm-bank level. To understand more about the exact magnitude of these effects as well as provide alternative measurement and robustness of results, we use our constructed dummy variable of risk as the main independent variable, following similar approaches in the literature (Jimenez et al., 2014), i.e. risk is 0 if the firm has one of the highest four ratings and it is 1 if its rating is either of the lowest two.

In the first three columns of the table we run specifications without firm fixed effects, and we take the whole sample of firms (rather than the subsample of firms with multiple relationships, which will be the suitable subsample throughout the specifications with firm-level fixed effects). Columns 4 to 6 repeat the specifications in columns 1 to 3 in the same order, but they all include firm fixed effects. In the first column (and in the fourth column) we run a regression without bank and year fixed effects, and keep year-level macro variables such as the GDP growth, monetary policy rate and inflation. We also keep time-varying bank controls. In the second and third columns we also add bank and year fixed effects, and do not keep year level variables. In the third and sixth columns we add the triple interactions and all the relevant double interactions to the model.

When we instead use the *Newloan* dummy as the dependent variable to fit equation (1), our results are similar. Note that economic effects are not negligible, but are not extremely high either. For instance, a 1 percentage point decrease in the overnight interest rate would result in a 2 to 2.8 percentage point higher likelihood of granting a new loan to a risky firm. Note that the mean probability of extending a new loan, captured by the variable *Newloan*, is 28 percent in our data. For comparison, in Dell'Ariccia, Laeven and Suarez (2013), who study a similar period using a sample of US firms from almost the same period (1997-2011), risk-taking magnitudes are higher. They find that a one standard deviation decrease in the interest rate (which is 1.85 in their sample) would bring about an increase in loan risk-taking of 0.057 in the overall

[13]However, excluding it does not affect the regression estimates in our specifications.

sample, which compared to our case, is 50 percent higher. Note that in their case the rating goes from 1 to 5, and this is more comparable to our analysis in Table V, where we use ratings from 1 to 4. In our case, for a one standard deviation decrease in the interest rate, i.e. a similar 1.759, we get around 0.023×1.76, approximately a 0.04 increase in loan risk-taking as measured by a rating change, for our average samples as in columns 1 to 4 of Table V.

These results are generally confirmed in alternative models. In Table III we run a conditional logit model, where the fixed effects are at the firm level. Additionally, as specified below in the table, in each column we take further fixed effects.

The results in column 1 show that the interaction of a change in monetary policy with the risk variable indeed has the expected sign. A negative sign means that a more negative change in the policy rate makes it more likely that a risky firm will be extended a loan. The magnitudes in these specifications are not immediately obvious, but we calculate the marginal effects. For instance, the marginal affect of the interaction of risk and Δ mp shows that by decreasing the interest rate by 0.25 percentage point (pp) a new loan is 0.8 to 1 pp more likely for a risky firm (approximately 3.2 pp more likely for a 1 pp change in the interest rate).

Banks that have less equity are more prone to moral hazard and are therefore expected to have more appetite for risk. The specification in column 2 shows that for a given borrower banks with less equity are more likely to lend to riskier borrowers when interest rates are low (the specification includes borrower fixed effects). However, this effect in most specifications is not statistically significant. This model includes time fixed effects to account for time-varying unobservables.

The marginal effect of the triple interaction in column 2 of the monetary policy change, risk and equity is as follows: a 0.25 percentage point decrease in the benchmark rate increases the likelihood that poorly capitalized banks extend credit to a risky firm compared to highly capitalized banks by around 0.9 pp point more likelihood.

4.3 Robustness

To tackle endogeneity of monetary policy, we use two instruments in the subsequent models; the change in the spot oil price and the US monetary policy rate. The correlation between our main benchmark rate, the three month interbank rate in Norway (NIBOR, and the US federal funds target rate is 0.53. However, the correlation between the changes (annual) in the nibor and fed funds rate is 0.17. At the same time, the correlation of the change in the benchmark rate and the change in the spot oil price is 0.69.

In table IV, the first two columns use the change in the federal funds target rate as an instrument for the change in the Norwegian reference rate. The last two columns use the change in spot oil price as an instrument. One issue with instrumenting is that foreign monetary policy or the oil price may not satisfy the exclusion restriction. To partially ameliorate this issue, we take out the oil industry from the sample. In fact the oil price is not statistically significant in the model without the oil industry. As one can see, in all specifications the interaction of risk and monetary policy have the expected sign. In our specifications with time fixed effects the interactions are statistically significant and have similar magnitude as before (a 6-10 pp change in loans granted to a risky firm as a result of a 1 pp change in the monetary policy rate).

Finally, we also use the original *rating* variable rather than the modified *risk* variable. In Table V we start with the most parsimonious model to measure risk-taking (column 1). Note that the sign on the main interactions between ratings and monetary policy should reverse since ratings are inversely related to risk. In column 1 we do not control for bank fixed effects. Our main variable of interest is the interaction between the rating variable and monetary policy. In columns 2 and 3, we add bank fixed effects. As shown, the main variables still remain highly statistically significant. Column 3 does not include time fixed effects, but we add macro-level variables such as GDP growth and cluster standard errors at the annual level. Column 4 includes time fixed effects, and finally in column 5 we include the triple interaction of *rating and equity and monetary policy*; if risk-taking is in place, then we should observe that the degree of risk taken will differ for banks that have different amounts of skin in the game. [14]

Our results, seem nevertheless to strongly support implications in line with agency models of bank capital (Holmstrom and Tirole, 1997). Because banks obtain zero returns in cases of as a result of firms' limited liability, they must get positive dividends in successful scenarios to offset the loss. With more skin in the game, these losses are higher and they must get even higher dividends. However, because of higher dividends, banks will engage in even more careful lending.

5 Conclusion

We study the impact of monetary policy on banks' risk-taking in Norway using a comprehensive administrative dataset. Norway provides an excellent setting as its economy is dominated by banks. Our findings provide evidence of risk-taking by banks. In the analysis we address endogeneity by analyzing firms with multiple banking relationships, as well as by instrumenting for home monetary policy. We find that when monetary policy is expansionary, banks are more likely to extend credit to ex-ante riskier firms.

We further show that for a given firm various banks may show different degrees of willingness to extend credit. This means that the supply side matters. In particular, we find that banks with higher equity ratios are less prone to risk-taking than low-equity banks.

[14] However, one of the challenges that remains is that bank-firm exposure increases that are just due to drawing on credit lines, cannot be distinguished from increases due to new approved loans.

6 References

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7 Appendix

7.1 Variable definitions

Dependent variables

Newloan: dummy variable that is 1 if credit exposure from the bank to the firm has increased

Loan: Log of increase in total credit exposure between the bank and the firm.

Firm level

Rating: the firm's last rating in the year *Risk:* dummy variable (= 0 when the firm is rated with the lowest two grades)

Bank level

Total assets: the logarithm of the total assets of the banks

Foreign funding: total foreign currency liabilities as a share of total liabilities

Equity: the ratio of own funds to total assets (equity to asset ratio)

High equity: dummy variable taking the value 1 if a bank's equity ratio is above the median ratio

Liquid assets: the ratio of liquid assets to total assets. Liquid assets are cash and cash held at central banks, loans to the government and to other lenders

Macro level

Mp: Norwegian interest rate representing stance of monetary policy (our main variable will be the average 3-month NIBOR rate, but for robustness we use other measures, each defined in the table captions, respectively)

Fed funds: the federal funds target rate

Oil price: growth in Brent Oil spot price

GDP growth: growth in real gross domestic product

Inflation: growth in the consumer price index

Table 1: Summary statistics: entire sample 1997-2010.

variable	**mean**	**sd**	**min**	**median**	**max**
newloan	.283	.492	0	0	1
loan (log of new loan amount)	1.759	4.414	0	0	22.819
risk	.032	.178	0	0	1
rating	3.429	.933	1	4	4
total assets	17.186	1.810	11.105	17.274	20.626
equity	.039	.016	-.040	.0367	.424
liquid assets	.062	.040	.002	.054	.448
foreign funding	.074	.090	0	.039	4.839
Δ mp	-.385	1.722	-3.691	.229	1.933
GDP growth	1.758	1.544	-1.623	2.085	3.959
inflation	.021	.009	.004	.021	.037

Table 2: Risk-taking: Loan (log of new loan)

The dependent variable Loan. is log of increase in outstanding credit at the firm-bank level. Mp stands for the difference in average annual benchmark rate (3 month NIBOR), risk is a dummy measuring the firm's risk in a given year; it is 1 when the firm takes one of the lowest two rates. Firm, year and bank fixed effects are included as detailed at the end of the table. All other variable definitions can be found in the appendix. Standard errors are in parentheses. Stars *, **, *** indicate significance at 10, 5 ,1 percent respectively.

risk*Δ mp	-0.051**	-0.053**	-0.103*	-0.059**	-0.063**	-0.050
	[0.02]	[0.02]	[0.06]	[0.03]	[0.03]	[0.08]
risk	-0.017	-0.012	-0.148	-0.570***	-0.534***	-0.810***
	[0.04]	[0.04]	[0.10]	[0.06]	[0.06]	[0.14]
total assets	-0.129***	0.105**	0.093*	-0.132***	-0.094	-0.103*
	[0.01]	[0.05]	[0.05]	[0.01]	[0.06]	[0.06]
equity	1.049**	6.013***	5.245***	0.674	7.708***	6.976***
	[0.43]	[1.13]	[1.15]	[0.63]	[1.28]	[1.30]
foreign liability	0.171	0.485**	0.534**	0.361**	0.323	0.358
	[0.12]	[0.23]	[0.23]	[0.16]	[0.25]	[0.25]
liquid assets	2.411***	1.035***	1.106***	1.482***	2.264***	2.316***
	[0.16]	[0.28]	[0.28]	[0.23]	[0.36]	[0.36]
risk*equity*Δ mp			1.312*			0.664
			[0.83]			[1.83]
risk*equity			4.044			7.156**
			[2.48]			[3.38]
equity* Δmp			-0.986***			-0.695**
			[0.23]			[0.27]
Δ mp	-0.002			-0.023***		
	[0.00]			[0.01]		
GDP growth	0.163***			0.203***		
	[0.01]			[0.01]		
inflation	23.625***			23.334***		
	[0.82]			[1.00]		
firm age	0.003***	0.003***	0.003***	0.000	0.000	0.000
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
firm profitability	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
time fixed effects	no	yes	yes	no	yes	yes
bank fixed effects	no	yes	yes	no	yes	yes
firm fixed effects	no	no	no	yes	yes	yes
r-squared	0.01	0.01	0.01	0.18	0.18	0.19
number of obs.	775775.00	775775.00	775775.00	444650.00	444650.00	444650.00

Table 3: Risk-taking: Newloan

The dependent variable is *Newloan*: a credit dummy equal to 1 if there is an increase in outstanding credit for the firm firm-bank pair in a given year. Mp stands for the difference in average annual benchmark rate (3 month NIBOR), risk is a dummy measuring the firm's risk in a given year; it is 1 when the firm takes one of the lowest two rates. Firm, year and bank fixed effects are included as detailed at the end of the table. All other variable definitions can be found in the appendix. Stars *, **, *** indicate significance at 10, 5 and 1 percent respectively.

risk*Δ mp	-0.045**	-0.072**	-0.074**	-0.077*
	[0.04]	[0.04]	[0.02]	[0.09]
risk	-0.240***	-0.252***	-0.265***	-0.249***
	[0.03]	[0.05]	[0.04]	[0.04]
total assets	-0.039***	-0.054***	-0.044***	-0.053***
	[0.00]	[0.01]	[0.00]	[0.01]
high equity	0.026**	0.024**	0.028**	0.027**
	[0.01]	[0.01]	[0.01]	[0.01]
foreign liability	0.408***	0.695***	0.390***	0.689***
	[0.08]	[0.10]	[0.08]	[0.10]
liquid assets	0.083	0.016	0.023	0.002
	[0.14]	[0.17]	[0.14]	[0.17]
risk*high equity *Δ mp		0.020	0.017	
		[0.04]	[0.03]	
risk*high equity			0.064	
			[0.06]	
high equity*Δ mp		-0.027***	-0.019***	
		[0.01]	[0.01]	
time fixed effects	yes	yes	yes	yes
bank fixed effects	no	no	no	yes
firm fixed effects	yes	yes	yes	yes
r-squared	0.01	0.01	0.01	0.01
number of obs.	372707	205888	372707	205888

Table 4: Instrumenting monetary policy stance with federal funds rate and oil price

The dependent variable is log of increase in outstanding credit at the firm-bank level. Mp stands for the difference in average annual benchmark rate (3 month NIBOR), risk is a dummy measuring the firm's risk in a given year; it is 1 in case the firm takes one of the lowest two rates. First two columns use change in federal funds target rate as an instrument, while the last two use the change in oil price. Firm, year and bank fixed effects are included as detailed at the end of the table. All other variable definitions can be found in the appendix. Standard errors are in parentheses. Stars *, **, *** indicate significance at 10, 5 ,1 percent respectively.

risk*Δ mp	-0.108	-0.112*	-0.111	-0.063*
	[0.15]	[0.07]	[0.15]	[0.04]
risk	-0.227***	-0.287***	-0.216***	-0.268***
	[0.08]	[0.08]	[0.07]	[0.05]
total assets	-0.076***	-0.055***	-0.077***	-0.063***
	[0.01]	[0.00]	[0.01]	[0.01]
equity	0.560***	0.091***	0.5658***	0.972*
	[0.06]	[0.02]	[0.06]	[0.53]
foreign liability	0.422***	0.491***	0.401***	0.389***
	[0.07]	[0.08]	[0.07]	[0.07]
liquid assets	2.142***	1.843***	2.139***	1.825***
	[0.40]	[0.21]	[0.38]	[0.21]
Δ mp	0.655***		0.659***	
	[0.09]		[0.09]	
GDP growth	-0.388***		-0.391***	
	[0.07]		[0.07]	
inflation	-24.778***		-24.801***	
	[6.38]		[6.35]	
time fixed effects	no	yes	no	yes
bank fixed effects	no	no	yes	no
firm fixed effects	yes	yes	yes	yes
number of obs.	457881.00	457881.00	457881.00	452023.00

Table 5: Risk-taking: using firms' ratings

The dependent variable is log increase in the outstanding credit at the firm-bank level. Mp stands for monetary policy at home (3 month NIBOR), rating is the firm-year level rating of the firm taking values 1 to 4, higher values representing less risk. OLS output with fixed effects as detailed at the end of the table. P-values are in parentheses. Stars *, **, *** indicate significance at 10, 5 ,1 percent respectively.

rating*Δ mp	0.027***	0.022***	0.027***	0.021***	0.046***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
rating*equity* Δ mp					-0.612**
					[0.012]
rating*equity		0.000***	0.000	0.000***	0.000***
		[0.000]	[0.715]	[0.000]	[0.000]
equity* Δ mp		0.538	-0.913**	-0.403	1.770**
		[0.225]	[0.040]	[0.372]	[0.047]
equity		-20.311***	15.871***	-1.873	-1.965
		[0.000]	[0.000]	[0.607]	[0.589]
foreign liability	0.195	0.385**	0.434**	0.341**	0.333
	[0.15]	[0.16]	[0.17]	[0.15]	[0.27]
liquid assets	1.187***	1.125***	1.236***	1.399***	1.884***
	[0.11]	[0.18]	[0.22]	[0.24]	[0.26]
firm age	0.005*	0.006*	0.005	0.006*	0.006*
	[0.084]	[0.072]	[0.114]	[0.067]	[0.068]
firm profitability	-0.001	-0.001	-0.001	-0.001	-0.001
	[0.116]	[0.116]	[0.115]	[0.112]	[0.111]
time fixed effects	yes	yes	yes	yes	yes
bank fixed effects	no	no	yes	yes	yes
firm fixed effects	yes	yes	yes	yes	yes
r-squared	0.21	0.22	0.22	0.22	0.22
number of obs.	444650.00	444650.00	444650.00	444650.00	444650.00