

BANK LENDING CHANNEL DURING AN EXOGENOUS LIQUIDITY SHOCK*

Gøril Havro and Bent Vale
Norges Bank (The central bank of Norway)[†]

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Abstract

A bank lending schedule for commercial installment loans is identified and estimated using a panel of Norwegian bank level data for loans and interest rates on loans. We find evidence of a bank lending schedule increasing in the loan interest rate. Loan supply reacts negatively to a higher money market rate, indicating a bank lending channel. Well-capitalized banks react somewhat less to the money market rate. Banks with a more liquid portfolio may lend a little more. Norwegian banks were not exposed to subprime related assets, and the crisis after Lehman can be regarded as an exogenous liquidity shock to these banks. Following the shock, banks' lending schedule became considerably steeper in the loan interest rate and the bank lending channel of traditional monetary policy may not have been working in the crisis period.

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*Thanks to ...

[†]Address: Norges Bank, Box 1179, Sentrum, N-0107 Oslo, Norway.

Fax: +47 22 42 40 62. Corresponding autor's e-mail: bent.vale@norges-bank.no

1. Introduction

On 9 August 2007 there was a shock in the global supply of short term interbank deposits following an announcement by BNP Paribas that it would no longer evaluate net asset values in three of its investment funds. Furthermore, on 15 September 2008 as Lehman Brothers filed for Chapter 11 bankruptcy protection the global interbank market was brought to a standstill. To shore up bank lending, central banks responded promptly to these events by supplying banks with ample liquidity. Nevertheless, we have seen a decline in bank lending to households and non-financial firms in most countries following these events. At end-2009 bank credit growth was near -3 per cent on average in the Euro area, United Kingdom and United States (IMF 2010) . At the outset one cannot say to what extent these declines were due to lower demand for loans, a credit supply shock due to lack of liquidity in spite of central bank interventions, or supply shock due to the large write-offs of assets banks holding subprime related securities had to do.

Identifying supply effects on lending from demand effects has been a major subject in the literature on bank lending channel over the last decade or so. See for instance Kashyap and Stein (2000) or Ashcraft (2006) who identify loan supply effects from reduced form estimation for panels of banks. In the current paper we use a slightly different approach. Our quarterly bank level data covering Norwegian banks from 2001Q4 to 2010 Q1 contains both loan quantity and interest rates on specific types of bank loans. This setup can facilitate identification and estimation of separate bank lending schedules including interest rates for these types of bank loans, and study of the interest rate sensitivity of the bank lending schedule. To our knowledge, this approach has so far not been used in the bank level lending channel literature.

Furthermore, one can argue that banks directly exposed to subprime losses did not face pure exogenous liquidity shocks, indeed for such a bank its problems in borrowing from the interbank market may be caused by the quality of its own assets. Hence, for these banks it may be difficult to distinguish contraction in lending due to the liquidity shock and more fundamental threats to their solvency, stemming from the quality of their loan books. It would therefore be interesting to look at banks that at the outset of the liquidity shocks, August 2007 and September 2008, had not suffered any major loan losses or write-offs on marked to market securities directly related to the subprime debacle. To

Total provisions as a share of total assets.

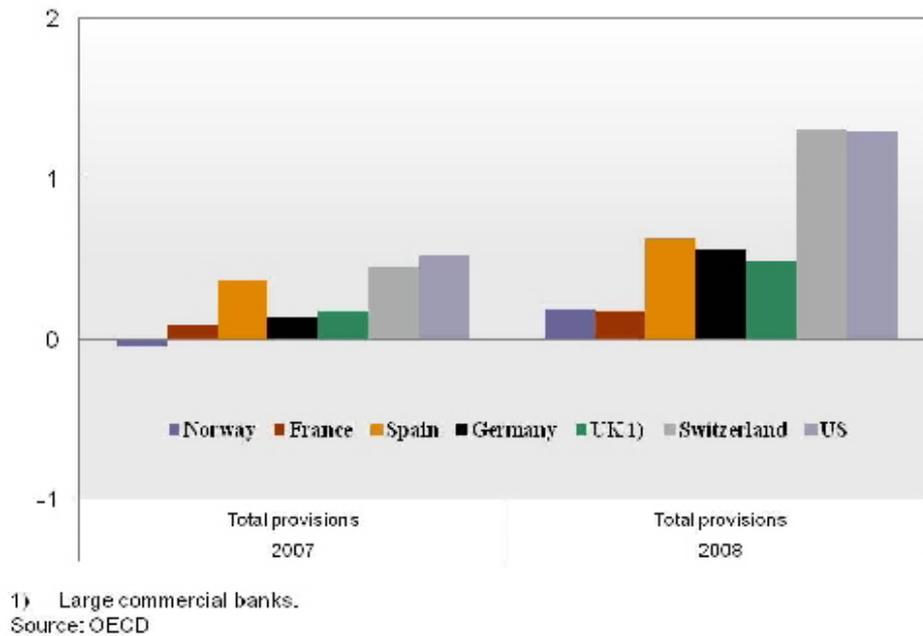


Figure 1.1: Loan loss provisions

these banks the liquidity shocks were truly exogenous events. Indeed, compared to banks in a number of other countries, banks in Norway that constitute our sample had not faced any loan losses out of the ordinary when the liquidity shocks occurred. Norwegian banks' annualized losses made up 0.1 per cent of gross lending for the first three quarters of 2008. In 2008 Q4, the rate had increased to 0.8 per cent. A third of these losses were so-called group write-downs, as banks chose to record higher write-downs in 2008 Q4, in anticipation of the loan losses to follow. Figure 1.1 shows Norwegian banks' total provisions in 2007 and 2008 in comparison with banks in other countries. Furthermore, Norwegian banks were not directly exposed to subprime securities. We will argue that based on these facts the banking sector in Norway during 2007 and 2008 is a good "laboratory" to study the effects of an exogenous liquidity shock on bank lending.

In our set up we will, nevertheless, investigate to what extent bank's lending response to the liquidity shock depended on bank characteristics such as its equity ratio, the quality of its loan book, and its size.

In a situation with a general liquidity shock to the economy, it is important to distinguish between the amount of borrowing facilities extended by banks, i.e., how much

credit a bank will allow a borrower to draw on a bank, and actual lending, i.e., how much the borrowers actually utilize these lending facilities. The reason is obvious, when liquidity in an economy gets scarce any borrower who has not yet utilized his borrowing facilities to the maximum will have a strong incentive to do so. Hence, by looking at actual lending one could easily end up concluding that a liquidity shock enhances bank lending. Chari, Christiano, and Kehoe (2008), for instance, argued in autumn 2008 that since lending volumes did not appear to be falling, the reported fall in loan supply was best described as a myth.¹ In this paper, on the contrary, we distinguish between two types of loans: ordinary installment loans to non-financial firms and loans drawn under credit line facilities. Unlike in other countries, for instance the US, more than three quarters of bank lending to non-financial firms² in Norway consists of installment loans, and only one quarter is granted as credit line facilities. Looking at actual lending under these facilities the numbers change to approximately 85 and 15 per cent, respectively. In this paper we thus focus on installment loans to non-financial firms.

Results indicate that we are able to identify and estimate a bank lending schedule for bank installment loans to non-financial firms. The lending schedule depends positively on the interest rate the bank achieves on its lending. We also find some evidence that lending from banks with high equity to total assets is less responsive to shocks in the money market rate. The liquidity shock caused by the collapse of Lehman seems primarily to have lowered the interest rate sensitivity of lending, i.e, made lending schedule steeper.

The paper is organized as follows: In section 2 we discuss identification issues, while also referring to some of the previous literature identifying bank lending channels. Section 3 presents the data. Estimation results are presented in Section 4, whereas Section 5 concludes.

2. Identification

Access to bank level loan data from various categories of loans and data on bank level loan interest rate for exactly the same categories of loans, facilitates identification and estimation of a schedule for a bank's lending depending, among others, on the loan interest rate.

¹This claim was, nevertheless, refuted by Cohen-Cole, Duygan-Bump, Fillat, and Montoriol-Garriga (2008).

In general, to be able to identify a supply schedule from data that contain observations of matching quantity (loans) and (loan interest rate) one needs to have at least one exogenous variable unique to the demand schedule (the ‘exclusion restriction’). In the case of bank lending this may be hard because a lot of the potential exogenous variables shifting the demand schedule, like the overall state of the economy, GDP, borrower solvency etc., may as well also have a direct effect on the supply schedule.

In our identification strategy we assume the following general but simple model of bank i operating in a market characterized by monopolistic competition I.e., bank i can "play on" its demand curve because loans from banks other than bank i are imperfect substitutes to loans from bank i .

$$\begin{aligned} l_i &= l(r_i, \overline{r_{-i}}) \text{ demand for loans from bank } i \\ c_i &= c(l_i, k_i) \text{ bank } i\text{'s cost function} \end{aligned}$$

where l_i are loans from bank i , r_i is interest rate on loans from bank i , $\overline{r_{-i}}$ is the average of the interest rate on loans from bank i 's competitors, c_i is bank i 's costs, k_i can be thought of as other factors influence the bank i 's costs, for instance the interest rate on the bank's funding or bank characteristic (e.g., losses, leverage ratio, liquidity ratio). The demand function can be inverted to read

$$r_i = r(l_i, \overline{r_{-i}})$$

Bank i will set l_i so as to maximize its profits

$$\pi_i = r(l_i, \overline{r_{-i}}) \cdot l_i - c(l_i, k_i)$$

Bank i takes into account that by offering more loans it will receive a lower interest rate on all its loans. Furthermore, it considers $\overline{r_{-i}}$ as given, i.e., no conjectural variation. k_i is also considered as given. To make things simple, consider the following linear versions of the inverted demand function and the cost function

$$\begin{aligned} r_i &= \alpha_1 l_i + \alpha_2 \overline{r_{-i}} + \alpha_0 & \alpha_1 < 0, \alpha_2 > 0 \\ c_i &= \gamma_1 l_i^2 + \gamma_2 l_i k_i + \gamma_3 k_i & \gamma_1, \gamma_2, \gamma_3 > 0 \end{aligned}$$

and the profits become

$$\pi_i = (\alpha_1 l_i + \alpha_2 \overline{r_{-i}} + \alpha_0) \cdot l_i - (\gamma_1 l_i^2 + \gamma_2 l_i k_i + \gamma_3 k_i).$$

The bank's f.o.c. becomes

$$\frac{\partial \pi_i}{\partial l_i} = \alpha_1 l_i + \underbrace{(\alpha_1 l_i + \alpha_2 \bar{r}_{-i} + \alpha_0)}_{r_i} - 2\gamma_1 l_i - \gamma_2 k_i = 0 .$$

Solving the f.o.c. gives

$$l_i = \frac{-\alpha_2 \bar{r}_{-i} - \alpha_0 + \gamma_2 k_i}{2\alpha_1 - 2\gamma_1} \Rightarrow \frac{dl_i}{d\bar{r}_{-i}} > 0, \frac{dl_i}{dk_i} < 0 . \quad (2.1)$$

(2.1) is the reduced form equation for l_i , containing exogenous variables(parameters) from the demand side (\bar{r}_{-i} , α_0), and from the supply side (k_i). For bank i , \bar{r}_{-i} is a positive demand shifter, causing it to offer more loans. Now, taking into account that the term in parantheses in the f.o.c. is equal to r_i , one can from the maximizing behavior of loan supplier i derive the following relation between l_i and r_i , the two endogenous variables in this system

$$l_i = \frac{1}{2\gamma_1 - \alpha_1} r_i - \frac{\gamma_2}{2\gamma_1 - \alpha_1} k_i . \quad (2.2)$$

(2.2) shows an increasing relation between the lending and the interest rate of bank i and a negative relationship between bank i 's lending and the bank characteristic k_i . Since (2.2) does not contain \bar{r}_{-i} other than indirectly through r_i it can be econometrically identified using \bar{r}_{-i} as an exogenous instrument shifting the inverted demand schedule. Note, however that (2.2) is not a pure supply schedule, its properties also depend on properties of the demand schedule, in this case α_1 , the sensitivity of r_i to lending from bank i . In particular, a lending schedule for bank i increasing in r_i is fully compatible with a constant marginal cost of lending ($\gamma_1 = 0$). In that case, if in (2.2) one finds that lending becomes less responsive to r_i , that may only be due to a higher absolute value of α_1 , i.e., lower interest rate sensitivity in the demand for loans from bank i . To know whether it also can be caused by a steeper marginal cost curve, one would also need to identify and estimate the demand schedule.

Rather than using aggregate time series of bank lending and loan rates, in this paper we use a panel of banks. Assuming the monopolistic competition model above, the cross-sectional dimension of the data makes it possible to use the interest rates charged by bank i 's competitors as an exogenous variable shifting the demand. As it does not enter the lending schedule of bank i directly, it provides us with the necessary exclusion restriction. In Section 4 we estimate a bank lending schedule similar to (2.2) using this identification

strategy. Since both $l_{i,t}$ and $r_{i,t}$ are endogenous when estimating the supply schedule we instrument $r_{i,t}$ using the exogenous variables in the demand schedule including $\bar{r}_{-i,t}$ as instruments. Further details on the instrumentation and estimation are presented in Section 4.

Our identification strategy differs from that used in much of the literature on bank lending channel. In most papers a reduced form equation is estimated. Supply side effects are identified by relying on differences in for instance banks' access to nondeposit funding (Kashyap and Stein (1995)), the liquidity of banks' assets (Kashyap and Stein (2000)), or bank size (Ashcraft (2006)). More to follow

3. Data

Bank data are acquired from the Norwegian Bank Statistics, which contains quarterly observations from 1987. The statistics comprise extended financial information reported by banks. From 2001 Q4, the start of our sample period, the Bank Statistics include detailed information on bank level interest rates at a quarterly basis. They also include banks' ordinary installment loans, credit line facilities, actual credit line lending and interest and fee payments from these assets. As opposed to current practice in the US, a relatively minor share of bank lending to firms takes the form of credit line facilities, or loan commitments. In 2010 Q1, the last quarter of our sample, such facilities made up NOK 241 billion and actual credit line lending made up NOK 116 billion (1 USD \approx 6 NOK), compared to NOK 808 billion in ordinary installment loans to Norwegian firms.² The Bank Statistics also contain data on banks' loan losses, for instance amount of delinquent loans and group write-downs. The latter is a component of bank loan losses that are not assigned to individual loans. For our purposes, they largely reflect banks' sentiment with regard to losses ahead.

The Norwegian banking sector is made up of one large bank, DnB NOR, several medium-sized banks, and a large number of small banks, primarily savings banks. In the sample period, the bank sector structure has evolved somewhat. In 2003, the two largest Norwegian banks, DnB and Gjensidige NOR, merged to form DnB NOR. The two banks made up 23% and 15%, respectively, of banking assets in 2001. At the end of 2010 Q1,

²Lending from all banks in Norway.

DnB NOR had a market share of 39%.³ At the same time, a number of foreign banks have entered the Norwegian market and have extended their operations. While foreign-owned banks made up 28% of bank lending to Norwegian companies at the end of 2001, this figure had increased to 39% at the end of 2010 Q1. Our sample includes foreign-owned subsidiaries, but does not include branches of foreign banks, as these banks do not have capital allocations for their Norwegian branches. Norwegian-owned banks and foreign-owned subsidiaries made up 89% of corporate lending at the beginning of the period, and 81% at the end.

In our data set, as mentioned earlier, we only look at installment loans to non-financial firms, installment loans for which residential houses are not pledged as collateral. Of these installment loans 82% or NOK 566 billions were supplied by Norwegian banks or foreign owned subsidiaries as of 2010 Q1. We exclude the very smallest banks, with assets below NOK 4 billion at the end of our sample. We also exclude newly established banks and a few other special purpose foreign owned banks. This reduces the aggregate installment loans we are looking at to NOK 536 billions in 2010 Q1.

The number of banks has been reduced somewhat through the sample period, and in particular we have seen a reduction in the number of small Norwegian savings banks. In 2000 Q4 there were 130 Norwegian savings banks, while in 2010 Q2 this number was reduced to 119. The reduction in numbers has only occurred through mergers and acquisitions. Whenever we use lagged variables in the estimation we aggregate the variables backwards, i.e., when we lag a variable by h quarters we force the bank structure at quarter t onto quarter $q - h$, when calculating the lagged variable.

A description of the data used in the estimation is presented in Table 3.1

During the international financial crisis, the importance of banks' liquidity risk was swiftly recognized. As a measure of liquidity through the crisis, we use an adapted version of Finanstilsynet's (The financial supervisory authority of Norway) bank liquidity indicator as at December 2003. Liquid assets, by this indicator, is measured as cash, central bank deposits and government and government guaranteed bonds net of those pledged as collateral, plus other bonds placed as collateral for overnight-loans at Norges Bank. Liquid assets are divided by bank liability, defined as deposits from others than banks, net bank funding and net bond and certificate debt.

³The share of corporate lending was somewhat smaller, at 28%.

Table 3.1: Summary of data in estimating sample

Variable	Mean	Std. Dev.	Min.	Max.
Commercial loans	8,172.6	26,850.2	0.1	239,973.2
Interest rate on commercial loans	5.96	1.75	0.22	11.09
Money market interest rate	4.18	1.97	1.93	7.52
Bank equity ratio	8.00	2.44	3.58	17.47
Write-down ratio, commercial loans	1.82	4.74	0	66.17
Ratio of delinquent loans, loan book	1.35	1.34	0	13.79
Ratio of group write-downs, loan book	0.57	0.39	0	2.65
Liquidity indicator, ratio	7.35	3.72	-0.15	27.73
Bank total assets	41,457.1	141,897.2	961.4	1,440,334
Bank bond spread	0.33	0.464	0.015	1.675

Loans and total assets are reported in NOK millions, 1 NOK \approx 0.17 USD. Commercial loans refers to installment loans to non-financial firms. Interest rates and spreads are reported in percentage points, as are all ratios. Number of observations is 1497, number of banks is 54, estimation period is 2001 Q4–2010 Q1.

Our sample period includes the worldwide financial crisis starting in August 2007, and culminating with the fall of Lehman Brothers in September 2008. While Norwegian banks were not exposed to sub-prime assets, they saw their funding drying up as liquidity shocks hit international markets. Norwegian banks' indicative bond spreads increased from an average of 7 basis points from 2001 to July 2007, to 82 basis points from August 2007 to March 2010. They reached a peak of 205 basis points in the week of October 29th 2008. Funding in US dollars was particularly affected, and banks complained that funding was hard to come by at any price. The end of quarter money market rate, measured by the 3 months effective NIBOR rate, surged from 6.83 to 8.03 between 2008 Q2 and 2008 Q3 even if the central bank's key policy rate was kept constant. At the same time, banks took losses to their trading portfolio as asset values declined substantially. Over half of the decrease in bank profits between 2007 and 2008 were due to losses on securities. For the Norwegian banks, therefore, the crisis at its onset was primarily one of liquidity and market risk. In the medium term, as the international downturn affected Norwegian exporters and the Norwegian economy at large, corporate defaults and bank credit risk also increased somewhat. Many of the Norwegian banks made large group write-downs in Q4 2008, in expectation of the losses to ensue.

Following the international liquidity shocks, Norges Bank (the central bank of Norway) increased its supply of liquidity through fixed-rate loans (F-loans) substantially.

While average yearly lending (F-loans and intraday-loans) amounted to just under NOK 13 billion in the period 2000-2006, this figure increased to NOK 47 billion in 2007 and NOK 68 billion and 66 billion in 2008 and 2009 respectively. On September 29th 2008, Norges Bank announced a USD currency swap line with the Federal Reserve. From October 6th, the scope for pledging securities at Norges Bank was broadened. Furthermore, the key policy rate was substantially reduced, from 5.75% at the time of Lehman's debacle, down to 1.25% in June 2009.

On October 22nd 2008, the Ministry of Finance announced further steps to increase Norwegian banks' availability of funding, through establishing a fixed-term swap arrangement. It allowed banks to exchange OMF covered bonds⁴ for government securities which could be sold or used as collateral for central bank loans. Most swap arrangements will mature in 2013 and 2014.⁵ Altogether, the government acquired OMF covered bonds for NOK 239 billion through this arrangement. Two special long-maturity F-loan auctions aimed at small banks took place on November 29th 2008 (2 year maturity) and February 13th 2009 (3 year maturity, floating rate). In both auctions there was a maximum allocation of NOK 1 billion per bank. A total of NOK 12.6 billion was allocated through the first of these auctions and NOK 22.6 billion through the second.

In addition, the Norwegian government established the Norwegian State Finance Fund and the Government Bond Fund in February 2009. The Government Bond Fund was established with the aim of easing liquidity in the bond market, as the fund would invest in financial and non-financial corporate bonds. At the same time, the State Finance Fund aimed to increase Norwegian banks' solidity through the crisis, through supply of Tier 1 capital. While Norwegian banks had been seen as well capitalized before the crisis, market requirements for bank solidity had increased through the crisis. As a result, Norwegian banks substantially increased their Tier 1 capital ratio during the crisis, both through the State Finance Fund, retaining profits and raising capital in equity markets. A total of 28 banks were allocated NOK 4.1 billion from the State Finance Fund, increasing their average Tier 1 ratio from 9.6% to 11.9%. Altogether, Norwegian Banks' Tier 1 ratios increased from an average of 8.6% at the end of 2008 to 10.5% one year on.

From June 2007, Norwegian banks were allowed to securitize mortgages, and trans-

⁴For more on OMF covered bonds, see Bakke, Rakkestad, and Dahl (2010)

⁵See Norges Bank Financial Stability report 1/10 p. 30.

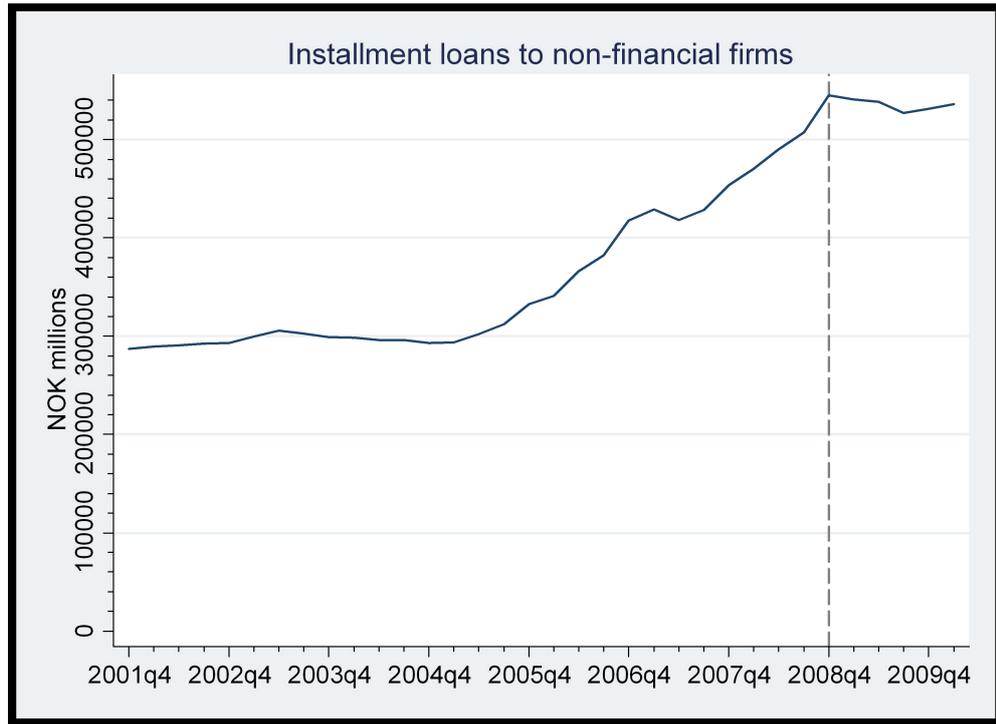
ferred part of their mortgage portfolio to OMF covered bond mortgage companies. This process was speeded up as the financial crisis hit, by the government loan exchange arrangement. This arrangement led to a rapid increase in the transfer of mortgages to the OMF covered bond mortgage companies. At the end of 2010 Q1, 41% of banks' and mortgage companies' total loans to households were held by OMF covered bond mortgage companies, but only 5% of corporate loans. In our sample, mortgages are excluded, so as to exclude this transfer affecting our results.

In a crisis period, bank behavior is likely to differ from bank behavior in a non-crisis period. As a measure of the degree of crisis sentiment, we use bond spreads for Norwegian banks in the period 2001 Q4 – 2010 Q1. These indicative spreads are set by the DnB NOR markets on a weekly basis based on the pricing of Norwegian bank bonds. Indicative spreads reflect the spread of investment grade⁶ rated banks' three-year bonds over the three-year swap rate.⁷

Figure 3 shows how the aggregated installment loans across all banks in our sample developed through the sample period. The dashed vertical line indicates 2008 Q3 when Lehman collapsed. Clearly, the growth in lending stopped in the quarters thereafter. However, one cannot at the outset say whether this is primarily due to lower loan demand caused by lower overall growth in the economy or whether it is also due to a negative effect from banks' loan supply. We hope to be able to indicate an answer to the latter.

⁶A large majority of Norwegian banks are not rated by the main international credit rating agencies. DnB NOR Markets regularly rate almost all Norwegian banks, however, and it is this rating which is used for the indicative spreads.

⁷The swap rate is the rate used for the conversion of fixed rate to floating rate loans. It is similar to the interbank rate.



Installment loans to non-financial firms aggregated over banks in sample

4. Estimation and results

First, we estimate the lending schedule of installment loans to non-financial firms using the following baseline equation

$$\begin{aligned}
 loans_{i,t} = & \beta_1 r_{i,t} + \beta_2 nibor_t + \beta_3 eqrat_{i,t-1} + \beta_4 nibor_t \cdot eqrat_{i,t-1} + \beta_5 loss_{i,t-1} \\
 & + \beta_6 \Delta delinq_{i,t-1} + \beta_7 \Delta grls_{i,t-1} + \beta_8 lik_{i,t-1} + \beta_9 size_{i,t-1} + \beta_{10} gdp_{t-1} \\
 & + \gamma_i + \epsilon_{i,t}
 \end{aligned} \tag{4.1}$$

where

$loans_{i,t}$ is the ln of the stock of installment loans from bank i in quarter t to non-financial firms.

$r_{i,t}$ is the interest rate on installment loans from bank i in quarter t to non-financial firms, measured in percentage points.

$nibor_t$ is the 3 months NIBOR money market rate averaged over quarter t , measured in percentage points.

$eqrat_{i,t-1}$ is the ratio of bank i 's equity over total assets at the end of quarter $t - 1$, like all other ratios, measured in percentage points.

$loss_{i,t-1}$ is the ratio of bank i 's accumulated write-downs of installment loans to non financial firms at the end of quarter $t - 1$ over the bank's installments loans to the same.

$delinq_{i,t-1}$ is bank i 's ratio of all delinquent loans to its total loans at the end of quarter $t - 1$.

$grls_{i,t-1}$ is bank i 's ratio of forward looking group write-downs to its total loans at the end of quarter $t - 1$.

$lik_{i,t-1}$ is bank i 's liquidity indicator at the end of quarter $t - 1$, measured in percentage points. Details are described in Section 3.

$size_{i,t-1}$ is bank size represented by \ln of total assets of bank i at the end of quarter $t - 1$.

gdp_{t-1} is \ln of GDP in quarter $t - 1$.

γ_i **and** $\epsilon_{i,t}$ are bank fixed effects and residuals respectively.

As discussed in Section 2, $r_{i,t}$ is endogenous and instrumented using exogenous variables from a demand schedule: the average of the loan interest rates of the other banks, the NIBOR money market rate, and GDP. $eqrat_{i,t-1}$ is also instrumented using the equity rates of other banks, NIBOR, Oslo Stock Exchange index, the average bank bond spread, a time trend, itself lagged one more quarter, and $size_{i,t-2}$.

In order to see how the liquidity crises of 2007 and 2008 affected the bank lending schedule for the installment loans to non-financial firms, we follow two strategies. The first is to simply estimate (4.1) as described and see how the surges in the NIBOR money market rate like those that occurred in 2007 Q3 and then in 2008 Q3 (Lehman) shift the loan supply. In addition through the coefficient β_4 of the interaction term, we can see whether a bank's solvency matters, i.e., will it dampen or exacerbate the shifts in the bank lending schedule caused by changes in the money market rate.

Secondly we interact the RHS variables⁸ with a dummy *crs* taking the value 1 in quarters where the liquidity crisis is considered severe and 0 in all other quarters. As a measure of this severeness, we use the average spread on 3 years bank bonds. In particular we estimate this interaction version of (4.1) when the crisis is defined as bank bond spread being above 100 basis points and also when it is above 150 basis points. In order to allow for some delay in bank reaction to the liquidity shocks we interact with the dummy lagged one quarter. In the first case (above 100 basis points), this implies we consider potential crisis induced shifts from 2008 Q4 until and included 2009 Q3. In the second case, we only consider potential shifts during the two quarters 2008 Q4 and 2009 Q1. Results of the estimation of these three versions of (4.1) are presented in Table 4.1.

Model 1 represents the version of the model where the crisis is represented through surges in the money market rate. In Model and 2 and 3 we interact the RHS variables with the crisis dummy with crisis quarters defined as 2008 Q4–2009 Q3 and 2008 Q4–2009 Q1, respectively. From all the model versions it is evident that the supply of installment loans depends positively on the interest rates the banks achieve on their loans. The coefficient of $r_{i,t}$ is clearly significant at 5 percent level in all three model versions. Throughout the whole estimation period a partial increase in the loan interest rate by 1 percentage point will increase the installment loans a bank extends by about 11 per cent, corresponding to an elasticity of 0.65 at sample mean where the loan rate is 5.96. An increase in the money market rate will significantly reduce the loans supplied by banks. This is evidence of a bank lending channel effect from monetary policy. Note also that in Model 1 the interaction term between the equity ratio and the money market rate is also significant but positive. Thus, the effect on loan supply by a partial 1 percentage point increase in the money market rate at sample mean (with the money market rate at 4.18 and the equity ratio at 8.0 percentage points) would reduce the bank's loan supply by 7.1 per cent, corresponding to an elasticity of -0.30 . For a bank with an equity ratio at the lower 1 percentile (4.2 percentage points), however, the drop in lending would be 7.8 per cent, corresponding to an elasticity of -0.33 . Thus, lending by better capitalized banks seems somewhat less sensitive to changes in the money market interest rate than lending by lesser capitalized banks. Similar results are found by Gambacorta and Mistrulli (2004)

⁸We leave out, however, the interaction between the NIBOR and the bank equity ratio.

Table 4.1: Estimation results: installment loans

Variable	Model 1	Model 2	Model 3
$r_{i,t}$	0.1123*** (2.84)	0.1520*** (3.21)	0.1397*** (3.40)
$r_{i,t} \cdot crs_{t-1}$	—	-0.1078** (-2.23)	-0.1057 (-1.50)
$nibor_t$	-0.1066*** (-3.28)	-0.1023*** (-2.76)	-0.0920*** (-2.91)
$nibor_t \cdot crs_{t-1}$	—	0.0744* (1.85)	0.1007 (1.47)
$eqr_{i,t-1}$	-0.0044 (-0.23)	0.0223 (1.41)	0.0211 (1.34)
$nibor_t \cdot eqr_{i,t-1}$	0.0043** (2.02)	—	—
$eqr_{i,t-1} \cdot crs_{t-1}$	—	0.0150 (0.101)	0.0097 (0.48)
$loss_{i,t-1}$	-0.0284*** (-8.32)	-0.0291*** (-8.43)	-0.0289*** (-8.40)
$loss_{i,t-1} \cdot crs_{t-1}$	—	-0.0211 (-0.94)	0.0238 (0.66)
$\Delta delinq_{i,t-1}$	-0.0126 (-0.76)	-0.0105 (-0.61)	-0.0131 (-0.77)
$\Delta delinq_{i,t-1} \cdot crs_{t-1}$	—	0.0354 (0.49)	-0.0411 (-0.40)
$\Delta grls_{i,t-1}$	0.0242 (0.23)	0.0436 (0.40)	0.0268 (0.24)
$\Delta grls_{i,t-1} \cdot crs_{t-1}$	—	-0.5274 (-1.14)	0.0304 (0.05)
$lik_{i,t-1}$	0.0092** (2.47)	0.0090** (2.08)	0.0092** (2.34)
$lik_{i,t-1} \cdot crs_{t-1}$	—	0.0017 (0.23)	0.0047 (0.43)
$size_{i,t-1}$	0.9392*** (13.27)	0.9407*** (13.09)	0.9361*** (13.10)
$size_{i,t-1} \cdot crs_{t-1}$	—	0.0196 (1.22)	0.0047 (0.43)
gdp_{t-1}	0.0570 (0.45)	0.1207 (0.89)	0.1095 (0.81)
R^2 within	0.4108	0.4122	0.4109
R^2 between	0.7523	0.7530	0.7525
R^2 overall	0.7406	0.7400	0.7398
Crisis period	—	2008 Q4 – 2009 Q3	2008 Q4 – 2009 Q1

The LHS variable is \ln of installment loans to non-financial firms. crs is a dummy with value 1 for quarters defined as crisis quarters, 0 otherwise. Models are estimated using a 2SLS fixed effect panel within estimation. Numbers in parantheses below are t -values. $r_{i,t}$ is instrumented using $\bar{r}_{-i,t}$ (the average interest rate of other banks), the NIBOR and \ln of GDP. The R^2 within of of this instrumentation is 0.8735 and the overall is 0.7979. $eqr_{i,t-1}$ is instrumented using the average equity ratio of other banks, NIBOR, Oslo Stock Exchange index, the average bank bond spread, a time trend, itself lagged one more quarter and the bank's total assets lagged two quarters. The R^2 within of of this instrumentation is 0.7961 and the overall is 0.9541. Number of observations is 1497, number of banks is 54, estimation period is 2001 Q4–2010 Q1.

and by Jimenez, Ongena, Peydro, and Saurina (2010). As described in Section 3 the global financial crisis in 2008 Q3 materialized itself in Norway primarily as a liquidity crisis, with a surge in the spread between the money market interest rate and the policy rate set by the central bank. Our findings indicate that this surge resulted in a negative shift in banks' lending schedule of installment loans, and somewhat more so at the less well-capitalized banks.

Across all three models it is clearly evident that the larger are the accumulated write-downs or loss provisions on commercial installment loans the more the lending schedule shifts inwards. A 1 percentage point partial increase in the loss ratio (its sample mean value is 1.82) would cause a reduction in commercial lending by 2.84 per cent. As the sample mean value of this loss ratio increases by approximately 0.5 percentage points from 2008 Q3 towards the end of the sample it has contributed to a slight inwards shift of the supply curve at about 1.4 per cent.

Although both the ratio of delinquent loans in the entire loan portfolio and the ratio of group write-downs increased, they did not have any significant effect on the commercial installment loans. Only write-downs on this particular loan group had a statistically significant negative impact.

The liquidity ratio has a positive and significant impact on the loan supply across all the three model versions. A 1 percentage point partial increase (its sample mean value is 7.36 percentage points) would cause a 0.9 per cent increase in installment lending. Its sample mean value fell slightly from 2008 Q2 to 2008 Q3, although its median value was maintained. Hence, it probably did not contribute a lot to any negative shift in the supply curve. Nevertheless, it increased quite a lot in 2008 Q4 and remained high also the next quarter, after which it fell in 2009 Q2, and fell slightly towards the end of the sample. It thus may have contributed somewhat to a negative shift in the supply curve from 2009 Q3.

In Model 2 and 3 the interaction terms between the crisis-dummy and most of the RHS variables are not significant at any reasonable level. Nevertheless, there are fairly clear indications that the crisis caused banks' lending to be less sensitive to the interest rate on loans. The quasi elasticity of $r_{i,t}$ estimated for the entire period, including the crisis quarters, in Model 1 is lower than the quasi elasticities for non crisis quarters (the coefficient of $r_{i,t}$ alone). More strikingly, the interaction terms between $r_{i,t}$ and the crisis

dummy are negative and indicate that the impact of the loan rate on loan supply is reduced by about two thirds. The statistical significance of this interaction term is only at 15 percent level in Model 3, but at a 5 percent level in Model 2. Thus, we find evidence of a steeper bank lending schedule during the crisis quarters. It is also interesting to note that during the crisis period, the effect of the money market rate on loan supply was almost eliminated. The interaction term with the crisis dummy is significant at 10 percent level in Model 2. This can indicate that the traditional monetary policy stopped working through this bank lending channel right after the crisis.

Since the symptoms of the 2008-crisis primarily appeared as a liquidity shock for the Norwegian banks, one might have expected that the liquidity indicator would have had a stronger impact on bank lending during the crisis period. However, the quick response by the central bank in supplying banks ample liquidity as well as the government swap arrangement that was introduced during 2008 Q4, may have dampened the immediate scarcity of liquidity at banks following the fall of Lehman. Thus, the frequency of our data, quarterly rather than monthly, may prevent us from seeing any effect on lending decisions from such immediate and short-lived scarcity of liquidity.

Neither did the crisis increase the impact of banks' equity ratio on their commercial lending. This may indicate that most of the banks in our sample were sufficiently capitalized. The sample mean value of the equity ratio in 2008 Q4 was 6.89 per cent, and the minimum value was 3.72 per cent.

5. Concluding remarks

We have identified and estimated a bank lending schedule for installment loans to non-financial firms using a panel of 54 Norwegian banks covering the period 2001 Q4 to 2010 Q1. As expected, we find that the lending schedule is positively related to the interest rate a bank achieves on its loans. Furthermore the lending schedule reacts negatively to an increase in the money market rate, providing evidence of a bank lending channel for monetary policy in Norway. Banks with a higher equity ratio seem to react somewhat less to changes in the money market interest rate. This makes them a little less vulnerable to shocks in the money market rate like that experienced in September and October 2008 after Lehman was closed. However, during the year after Lehman, banks' lending

seems to be far less sensitive to changes in the money market rate, thus providing less scope for traditional monetary policy in stemming the negative effects of the crisis on the Norwegian economy.

Our findings also indicate that banks with a more liquid portfolio (at least as measured by the liquidity indicator applied by Finanstilsynet from 2003) are willing to lend somewhat more. Furthermore, the banks' supply of installment loans to non-financial firms reacts negatively to higher write-downs on these loans. However, it does not seem to react to the overall quality of a bank's loan book, although in our sample only a few banks experience a loan book that may be characterized as somewhat weak.

Right after the Lehman crisis in 2008 Q3, banks' lending schedule seems to be quite less elastic w.r.t. the loan rate, i.e., the lending schedule gets steeper. This seems to be one of the main effects from the crisis on the estimated bank lending behavior, and may have contributed to the flattening we see after 2008 Q3 of the aggregate curve for commercial installment loans.

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