In Quest of the Bank Lending Channel: Evidence for Switzerland Using Individual Bank Data

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1. Introduction

In this paper we test the existence of the so-called bank lending channel in Switzerland using data for individual banks. The basic idea underlying the concept of the bank lending channel is that, due to financial market imperfections, the reaction of a bank's credit supply to a monetary policy shock depends on specific characteristics of that bank. More precisely, according to the bank lending view, the transmission of a monetary shock to the economy depends on variables such as capital and liquidity, which are potentially important determinants of a bank's credit supply.

The relevance of this strand of empirical research goes beyond a mere academic interest in testing for the existence of an appealing theoretical mechanism. Without a better understanding of the way banks' credit supply interacts with changes in the monetary stance – and a reliable quantification of this interaction – the transmission of monetary policy will remain something of a black box and the exercise of monetary policy an art rather than a science.[1]

Capital may play a role as a determinant of a bank's credit supply for two reasons. First, in Switzerland, as in every country where banks are subject to

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1 See BERNANKE and BLINDER (1988) and KASHYAP and STEIN (1995) for a detailed discussion of the theorertical fundaments of the lending channel as well as its practical and policy relevance.

Basel I type capital requirements, the maximum size of a bank's loans portfolio is a function of its capital base. As a consequence, a bank's lending capabilities will be constrained, at some point, by its capital base. Second, a bank's capital is a sign of its financial strength, i.e. the higher a bank's capital, the lower its marginal debt or equity funding cost. Hence, ceteris paribus, better capitalised banks should encounter more profitable lending opportunities. Taken together, these elements imply that $\partial L_i/\partial C_i > 0$, where L_i is bank *i*'s measure of lending activity, C_i is a measure of its capital base, and $\partial L_i/\partial C_i$ measures the degree to which lending is capital constrained.

Liquidity may play a similar role. Excess liquidity can be seen as a substitute for the additional debt or equity required for expanding a bank's loan portfolio. Hence, the more liquid a bank, the lower the marginal (opportunity) cost of an additional credit. In addition, banks active in Switzerland are also subject to minimum liquidity requirements. Taken together, these two elements imply that more liquid banks should encounter more – and should be in a better position to take advantage of – profitable lending opportunities. Formally, we should have $\partial L_i/\partial B_i > 0$, where L_i is a bank-level measure of lending activity, B_i is a measure of liquidity and $\partial L_i/\partial B_i$ is the degree to which lending is liquidity constrained.

The degree to which lending is capital or liquidity constrained is not expected to be constant over time, however. It may depend on a number of factors, including the monetary policy stance. A tight monetary policy generally implies high interest rates, which tend to be associated with higher levels of credit risk in the economy. As a consequence, for a given level of capital, the likelihood that a bank will be undercapitalised in the future – and hence the likelihood that it will feel capital constrained today – will be higher, the tighter the monetary policy stance. This mechanism, whereby monetary policy affects bank lending through its impact on banks' current or future capital, is one aspect of the bank lending channel. It is sometimes referred to in the literature as the *bank capital channel*[2]. In the same vein, a tightening of monetary policy will tend to reduce the reserves held in the banking sector. This in turn may translate into lower deposits and, for banks with low levels of excess liquidity, increased pressure to reduce the size of their loans portfolio. As a consequence, a given level of liquidity is more likely to constrain a bank's lending activity when the central bank tightens its monetary policy. This mechanism, whereby monetary policy affects

2 To our knowledge, the term *bank capital channel* was first used by Van den Heuvel (2002a, 2002b) to describe this mechanism. Also see Stein (2002) and Gambacorta and Mistrully (2004).

bank lending through its impact on banks' reserves, i.e. focuses on liquidity, is known as the *"traditional" bank lending channel.*[3]

Formally, we have:

$$\partial(\partial L_{it}/\partial C_{it})\partial M_t = \partial(\partial L_{it}/\partial M_t)\partial C_{it} > 0 \tag{1}$$

$$\partial(\partial L_{it}/\partial B_{it})\partial M_t = \partial(\partial L_{it}/\partial M_t)\partial B_{it} > 0, \tag{2}$$

where M is a monetary policy indicator (the higher values of M, the tighter the policy stance).

Expressions (1) and (2) capture two intuitions. Looking first at the cross-bank derivative $\partial(\partial L_{it}/\partial C_{it})$ or $\partial(\partial L_{it}/\partial B_{it})$, they imply that the degree to which bank lending is capital or liquidity constrained depends on the monetary policy stance. Alternatively, looking first at the time-series derivative $\partial L_{it}/\partial M_t$, expressions (1) and (2) imply that the lending activity of banks with weak balance sheets is relatively sensitive to changes in the monetary policy stance. Based on the latter intuition, they allow us to test directly two particular aspects of the bank lending channel, namely the hypotheses that the transmission of a monetary policy shock will depend on the banks' capital (the bank capital channel) or liquidity (the "traditional" bank lending channel). As it turns out, the data for Switzerland provide some evidence in support of the bank capital channel.

The paper is organised as follows. Section 2 contains a short overview of the related empirical literature. Section 3 presents the baseline econometric specification. Section 4 describes our data and variables. The results are presented in section 5. The robustness of our results is assessed in section 6 using an alternative econometric specification. We discuss our results in section 7 and section 8 contains some concluding remarks.

3 In our view, the bank capital channel and the "traditional" bank lending channel are two aspects of the bank lending channel, which is itself part of the more general credit channel. See Bernanke and Gertler (1995) and Kashyap and Stein (1995) for a review of the bank lending channel literature.

2. Related Literature

The empirical literature on the bank lending channel can be broadly divided into two categories. In the first category we find authors like Bernanke and Blinder (1992) and Kashyap et al. (1993) who work with *aggregate* data. They find that a monetary contraction tends to be followed by a decline in aggregate bank lending. While this result is consistent with the bank lending channel, it is also consistent with the "traditional" transmission mechanism. Unfortunately, the use of aggregate data makes it almost impossible to disentangle demand from supply effects, thus preventing a proper identification of the bank lending channel.

In order to address this identification issue, authors found in the second category – among them Peek and Rosengren (1995), de Bondt (1998), Hancock and Wilcox (1998), Kashyap and Stein (2000) Kishan and Opiela (2000), Gambacorta and Mistrulli (2004) – work on *bank level data*. In their influential paper, Kashyap and Stein (2000) focus on liquidity and test hypothesis (2) based on a large panel of data at the individual bank level. They find evidence supporting the existence of a "traditional" bank lending channel in the US. According to their results, more liquid banks exhibit higher credit growth, and the tighter the monetary policy, the stronger this effect. An alternative interpretation of this result, which is in line with the theory of the bank lending channel, is that the impact of a tightening of the monetary policy on a bank's lending activity will be stronger for less liquid banks. Also focusing on the liquidity of banks, de Bondt (1998) finds evidence of a bank lending channel in Germany, Belgium and the Netherlands, whereas the cases of France and Italy are less clear, and no evidence is found for England.

Using US data, various authors, and in particular Peek and Rosengren (1995), Hancock and Wilcox (1998) and Kishan and Opiela (2000), show that capital plays an important role as a determinant of bank lending. They do not, however, test explicitly for the existence of a bank lending channel and the role of capital in that context, i.e. they do not test for the existence of the bank capital channel. Gambacorta and Mistrulli (2004) make that additional step. Using Italian data, they examine the role of banks' capitalisation in the transmission of monetary policy. With this approach, they find evidence in support of a bank capital channel in Italy.

As far as Switzerland is concerned, we are aware of only one paper that explicitly investigates the existence of the bank lending channel. Steudler and Zurlinden (1998) work at an intermediate level of disaggregation, in other words, they conduct their analysis for three different bank categories. Focusing on liquidity and in line with the bank lending channel theory, they check whether the liquidity holdings and lending activity of smaller banks are more sensitive to interest rate shocks than the bigger banks. Their results are not consistent with this hypothesis, that is to say, they do not find evidence in support of a credit channel in Switzerland.

Our contribution to the existing literature on the bank lending channel is twofold. First, we extend the two-step methodology proposed by Kashyap and Stein (2000), so that both the role of capital and liquidity in the transmission of monetary policy can be tested. Second, it is, to the best of our knowledge, the first paper that investigates the existence of the bank lending channel in Switzerland using data disaggregated at the individual bank level.

3. Econometric Specification

As emphasised in the introduction, our research is based on the key assumption that the degree to which banks' lending is capital-constrained or liquidity-constrained is expected to vary over time, depending in particular on the monetary policy stance. Kashyap and Stein (2000) propose a two-step methodology that enables this assumption to be tested formally.[4] Their approach, however, is designed to examine the role of one bank characteristic only (liquidity). We take this a step further, in order to allow the testing of both the role of capital (the bank capital channel) and liquidity (the "traditional" bank lending channel).

The characteristics of the approach are as follows. The *first step* consists of a series of *cross-section* regressions where the extent to which banks' lending activity is capital and/or liquidity constrained is estimated at each period *t*. Formally, we regress the log change in bank *i*'s lending $\hat{L}_{it}$ against four lags of itself, and a measure of its capital C_{it-1} and liquidity C_{it-1} base:

$$\hat{L}_{it} = \alpha_{t,0} + \sum_{j=1}^{4} \alpha_{t,j} \hat{L}_{i,t-j} + \beta_t^C C_{it-1} + \beta_t^B B_{it-1} + \varepsilon_{it}, \qquad (3)$$

where $\alpha_{t,0}$ is a constant and ε_{it} is an iid error term. The key coefficients from this regression are β_t^C and β_t^B, which measure the intensity of the capital and liquidity constraint, respectively. Lagged values of lending activity are included to account for heterogeneity across banks regarding lending behavior. Hence, a

4 Also see Campello (2002).

positive value for β_t^C or β_t^B in (3) would mean that the average lending activity at time *t* of relatively low capitalised and/or illiquid banks will tend to be below their "natural" level, as extrapolated from past levels of lending activity. This would be consistent with the hypothesis that banks' lending at time *t* is capital or liquidity constrained. In other words, (3) allows us to test the null hypothesis $\beta_t^C = \beta_t^B = 0$ against the alternative $\beta_t^C > 0$ or $\beta_t^B > 0$ or both $\beta_t^C, \beta_t^B > 0$.

According to the bank lending channel theory, the extent to which banks' lending activity is capital or liquidity constrained changes over time, following changes in the monetary policy stance. Hence, β_t^C and β_t^B should be (positively) related to changes in the monetary policy stance. This relationship is tested in the *second step* of our procedure where the estimated values of β_t^C and β_t^B are regressed against a measure of the changes in the monetary policy stance in a pure *time-series* regression. Formally, we regress:

$$\hat{\beta}_t^C = b^C + \sum_{j=0}^{4} \phi_j^C dM_{t-j} + \delta^C TIME + \varepsilon_t^C \tag{4}$$

$$\hat{\beta}_t^B = b^B + \sum_{j=0}^{4} \phi_j^B dM_{t-j} + \delta^B TIME + \varepsilon_t^B, \tag{5}$$

where $\hat{\beta}_t^C$ and $\hat{\beta}_t^B$ are the first-step estimates of β_t^C and β_t^B, b^C and b^B are constants, M_t is a measure of the monetary policy stance at time *t* (with higher values of M_t corresponding to a more restrictive policy), δ^C and δ^B account for a possible linear time trend and ε_t is an iid error term. The parameters of interest are

$$\Phi^C = \sum_{j=0}^{4} \phi_j^C \text{ and } \sum_{j=0}^{4} \phi_j^B.$$

They measure the extent to which changes in the intensity of the banks' capital and liquidity constraint on lending activities are related to changes in the monetary policy stance. The assumption we test is $\Phi^C = \Phi^B = 0$, against the alternatives $\Phi^C > 0$ (bank capital channel) and/or $\Phi^B > 0$ ("traditional" bank lending channel). The ability to reject H_0 in favour of the alternatives would provide evidence of the significance, at least in the statistical sense, of the bank lending channel for Switzerland.

The main advantage of this two-step approach is that it is relatively well suited to deal with the simultaneity issue raised by the fact that observed bank lending activity is affected both by demand and supply shocks. Because we are interested in the supply component only, it is of central importance to be able to disentangle the two elements. The two-step approach allows us to do so for the following reason. Assume for instance that, at a given point in time, all banks active in our sample are confronted with the same demand shock. In this case, differences in lending activity across banks, at this point of time, will reflect exclusively differences in the banks' credit supply function. Under this assumption, β_t^C and β_t^B – which are estimated cross-sectionally – will measure differences between banks' credit supply functions that can be attributed to differences in their capital or liquidity base. This result will also hold in the more realistic case where, at a given time, banks' loans demand is affected by shocks that have both a systematic as well as a geographically randomly distributed regional component.

4. Data and Variables

Our dataset is an unbalanced panel of quarterly data covering the 1996:Q1 to 2003:Q1 period, i.e. 29 quarters. Only banks for which lending constitutes a substantial part of total activity have been included.[5] In addition, a number of outliers – mainly reflecting jumps in the data due to mergers – have been dropped from the sample. After adjustment, our database comprises a number of banks that varies between a maximum of 122 (1996:Q1) and a minimum of 96 (2002:Q2). The dataset is summarised in Table 1 and the variables are defined below.

4.1. Bank Variables

In the first step of our analysis, we use individual bank data. This data is derived from the banks' balance sheets and is reported to the Swiss National Bank (SNB). It is confidential.[6]

4.1.1. Lending Activity

As a measure a bank's lending activity (L_{it}) we use the value of its total loan portfolio, i.e. mortgage and non-mortgage credits of domestic and foreign origin. Interbank loans are excluded. Based on this measure, the quarterly

5 Our selection is based on the categorisation used by the Swiss National Bank (SNB). Only banks belonging to bank category 10, 15, 20, 25 or 30 have been included.

6 The Swiss National Bank collects this data on behalf of the Swiss Federal Banking Commission, the banks' regulatory body in Switzerland.

growth rate of lending for the average bank during the period considered – $\hat{L}_{it} = \log L_{it} - \log L_{it-1}$ – is 0.8% or about 3.2% on a yearly basis (see Table 1).

4.1.2. Capital and Liquidity Base

Unlike most previous empirical research on the bank lending channel – which focuses on simple capital or liquidity ratios – we measure banks' capital and liquidity as deviations from their legally required levels.[7] Our approach is motivated by the fact that – from an economic point of view – the strength of a bank's capital or liquidity base has to be judged in relation to its risk-profile. Accordingly, a bank's capital base at time t (C_{it}) is defined as the ratio between its excess capital – the eligible minus the required capital – and the required capital. The latter is a function of the bank's risk-weighted assets, where the risk-weights are based on the Basel I capital requirements scheme. The same approach is used in the case of liquidity, i.e. B_{it} is defined as the ratio between a bank's excess liquidity – the eligible minus the required liquidity base – and the required liquidity base. The latter is defined according to the size of the bank's short-term liabilities, i.e. assuming that the shorter the maturity of a bank's liabilities, the more liquidity it has to hold in order to keep the illiquidity risk constant.[8]

As can be seen from Table 1, the capital and liquidity base of the average bank in our sample is comfortable: the average level of excess capital (liquidity) amounts to 60% (100%) of the required minimum during the period considered. While the variance across banks and across periods is relatively high, more than 99% of all observations regarding C_{it} or L_{it} are positive. In other words, only a small number of banks have been characterised by insufficient levels of capital and/or liquidity at some point in our sample.

4.2. Macroeconomic Variables

For the second step of our analysis, we use a measure of the monetary policy stance. We also include a measure of economic activity to serve as a control variable.

7 Gambacorta and Mistrulli (2004) follow a similar approach.

8 According to the Swiss banking regulation, banks are subject to two different liquidity requirements: Liquidity I and the broader Liquidity II. We focus on the latter in our analysis.

Table 1: Descriptive Statistics

	Obs.	Mean	Std. Deviation	Min	Max
Bank variables					
$\widehat{L}_{it}$	3166	.008	.018	–.086	.103
C_{it}	3166	.604	.440	–.480	2.636
B_{it}	3166	.999	.879	–.396	5.519
Macro variables					
$dLIBOR_t$	29	–.056	.417	–1.013	.902
$dMCI5_t$	29	–.132	.487	–1.137	1.056
$dMCI3_t$	29	–.185	.660	–2.023	1.181
GDP_t	29	.003	.040	–.055	.068

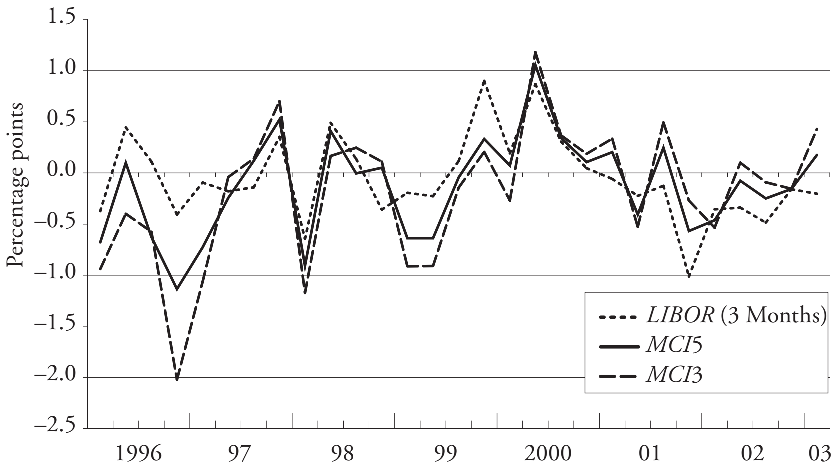
4.2.1. Monetary Policy Stance Indicator

Monetary policy, which interacts with the banks' lending activity, is at the centre of our analysis. To account for the fact that a dominant measure for the monetary policy stance has not yet emerged, we conduct our analysis using 3 alternative indicators. First, we use the three-month London Interbank Offered Rate *(LIBOR)* nominal interest rate. In this case, our monetary policy indicator is defined as $dM_t = dLIBOR_t = \overline{LIBOR}_t - \overline{LIBOR}_{t-1}$, where $\overline{LIBOR}_t$ stands for the arithmetic mean of the daily values taken by the three-month *LIBOR* during quarter *t*. Second, we use the monetary conditions index (*MCI*5), which is a weighted average between the *LIBOR* and the natural logarithm of the Swiss franc exchange rate, where the weights are 5 and 1, respectively. In this case, our monetary policy indicator is $dM_t = dMCI5_t = MCI5_t - MCI5_{t-1}$. Finally, we run our analysis using *MCI*3, i.e. we reduce the relative weight given to the short-term interest rate from 5 to 3. The inclusion of the exchange rate in the measure of the monetary stance is *a priori* desirable in a small and open economy like Switzerland. However, the relative weight attributed to each component is, to some extent, arbitrary. Ideally, it should reflect the relative importance of both variables in the transmission of monetary policy shocks. Our choice is motivated by Lengwiler (1997), who shows that, depending on the methodology and specifications adopted, the optimal weights for Switzerland lie between 5 to 1 and

Table 2: Correlation between Monetary Policy Stance Indicators

Number of observations: 29			
	$dLIBOR_t$	$dMCI5_t$	$dMCI3_t$
$dLIBOR_t$	1		
$dMCI5_t$	0.72	1	
$dMCI3_t$	0.51	0.93	1

Figure 1: Monetary Policy Stance Indicators



3 to 1. As can be seen from Table 2 and from Figure 1, the correlation between the 3 indicators is relatively high. As it turns out, however, the results of our analysis are sensitive to the definition adopted.

4.2.2. Economic Activity Indicator

As a measure of economic activity, used as a control variable in the second step of our analysis, we use the quarterly growth rate of nominal GDP. As can be seen (Table 1), the average growth of the Swiss economy – $GPD_t = \text{logGPD}_t - \text{logGPD}_{t-1}$ – during the period considered was low: 0.3% (or about 1.2% annually). There were repeated quarters of negative growth.

5. Results

5.1. Step 1

We estimate the parameters of equation (3) for each period t, i.e. run a series of cross-section regressions, using OLS.[9] One standard assumption in the bank lending channel literature is that small banks, because of their limited access to capital markets, are particularly exposed to the consequences of financial market imperfections. Therefore, their lending activity is more likely to be capital or liquidity constrained than the activity of bigger banks. To account for this possibility, we run our regressions separately for three different categories of banks: the whole sample, the small banks – those in the bottom 75% of the size distribution – and the big banks – those in the top 25% of the size distribution. According to this categorisation, the small banks hold about 5% of the assets of the banking sector, reflecting the high level of concentration of the banking industry in Switzerland. As a consequence of this concentration, the category of big banks is relatively heterogeneous, as reflected by a mean to median ratio of 3.8 in that quartile. The size of our sample, which ranges from 96 to 128 banks during the period considered, prevents us, from further refining this category.

The main results from the set of cross-section regressions are reported in Table 3. For each sample definition, we report (i) the number of quarters (as a share of all quarters) for which β_t^C, respectively β_t^B, is positive at the 5% significance level, (ii) the average value of β_t^C and β_t^B over the whole period, (iii) the average R^2 of the regression, (iv) the average sample size and (v) the average bank size.

The results can be summarised as follows. First, it appears that, in particular for the smaller banks, capital plays a systematic role as a determinant of credit supply. In the case of the banks which belong to the bottom 75% of the size distribution, the capital constraint is active – i.e. we reject the assumption $\beta_t^C = 0$ against the alternative $\beta_t^C > 0$ – in 11 out of 29 quarters considered – or 38% of the time. When considering the whole sample, that number drops to 31%. Finally, when focusing on the biggest banks, the constraint is binding in only 1 out of 29 quarters (or 3%). This result is consistent with the hypothesis that bigger banks are less likely to be constrained in their lending activity. It should be stressed, however, that the latter result draws on a relatively small sample (20 degrees of freedom on average).

9 We clean up our data using the *hadimvo* procedure proposed by Stata, whereby outliers in multivariate data are being identified. We set the significance level for outlier cutoff at $p = 0.01$.

Table 3: Estimation Results, Step 1

	(i)		*(ii)*		*(iii)*	*(iv)*	*(v)*
Sample	$\#\beta^C > 0$ [(a)]	$\#\beta^B > 0$ [(a)]	β^C [(b)]	β^B [(b)]	R^2 [(b)]	obs. [(b)]	assets [(c)]
All banks	31%	3%	.0049	–.0003	.191	108	11.6
Small banks (< 75%)	38%	3%	.0047	.0003	.203	80	0.7
Large banks (> 75%)	3%	0%	.0080	–.0022	.467	28	44.4

(a) Number of positive coefficients (at or below the 5% level of significance) in % of total.
(b) Average values (1996:Q1–2003:Q1).
(c) Average sum of assets (in billion Swiss francs).

The liquidity constraint, on the other hand, is almost never binding. In only 1 out of 29 quarters can the null hypothesis $\beta_t^B = 0$ be rejected in favour of the positive alternative, when the whole sample or the smaller banks are considered. When the bigger banks are considered, the null hypothesis can never be rejected. Hence, while capital indeed appears to be a relatively important component of banks' loan supply function, liquidity seems to be irrelevant.

Two qualifying comments are in order at this stage. First, even for the "small banks" category, which appears to be capital constrained on a regular basis, the size and the statistical significance of the constraint varies strongly from one quarter to the other. This result is, *a priori*, consistent with the aspect of the credit channel we are testing in this paper. As was highlighted above, we expect the degree to which banks' lending activity is capital or liquidity constrained to vary through time, in particular depending on changes in the monetary policy stance. Hence, the variability in the value taken by $\hat{\beta}_t^C$ should be seen as a favourable outcome in the perspective of the second step of our analysis. Second, the relatively low number of quarters where $\hat{\beta}_t^C$ is significantly positive, even for smaller banks, might appear disappointing. It is in fact a surprisingly strong result in the light of the size of the banks' capital base, i.e. the fact that in our sample it is most likely that banks' lending activity was almost never *directly* constrained by regulatory capital requirements: the average excess capital, measured as a percentage of regulatory capital, is 57% (median: 47%) for all banks[10] and 65% (median: 54%) for the smaller banks. The fact that, in spite of these comfortable buffers, the capital

10 Banks considered as outliers in the regression are excluded from the computation.

constraint was binding on a regular basis is consistent with the assumption that capital is affecting banks' lending activity (indirectly) through its effect on the cost of external finance.

5.2. Step 2

To account for the likely correlation between ε_t^C and ε_t^B – which results from the fact that the distribution of $\widehat{\beta}^C$ and the distribution of $\widehat{\beta}^B$ depend on the same error term in equation (3) – we estimate the parameters of (4) and (5) using Zellner's seemingly unrelated regression model. According to the output of the first step estimation, we have 29 observations – covering the 1996:Q1 to 2003:Q1 period – for both $\widehat{\beta}^C$ and $\widehat{\beta}^B$.

As was underlined by Kashyap and Stein (2000), the estimation of the parameters of (4) and (5) might be biased because of the endogenous nature of banks' capital and liquidity base. This is in particular the case when there is an endogenous link between C_{it} or B_{it} and the cyclical sensitivity of loan demand. Suppose, for instance, that some banks are systematically more exposed to cyclically sensitive borrowers and, as a protection against this volatility, hold a bigger capital or liquidity buffer. Those banks – characterised by relatively high levels of C_{it} and B_{it} – will experience relatively high levels of lending activity during economic booms. Hence, through this effect, the correlation between capital and/or liquidity and lending activity is expected to be relatively high during periods of economic booms and relatively low during periods of economic busts. Under the assumption that a relaxed monetary policy stimulates economic activity, this effect will bias the parameters of the monetary stance in (4) and (5) downwards, i.e. we will tend to be too conservative, failing to reject the null hypothesis even when it is false. To account for this possibility, we test an additional specification where a measure of economic activity is included. Formally, in addition to the *univariate* specification given by (4) and (5), we estimate the parameters of the following *bivariate* alternative specifications:

$$\widehat{\beta}_t^C = \eta^C + \sum_{j=0}^{4} \phi_j^C dM_{t-j} + \sum_{j=0}^{4} \gamma_j^C GDP_{t-j} + \delta^C TIME + \varepsilon_t^C \qquad (6)$$

$$\widehat{\beta}_t^B = \eta^B + \sum_{j=0}^{4} \phi_j^B dM_{t-j} + \sum_{j=0}^{4} \gamma_j^B GDP_{t-j} + \delta^B TIME + \varepsilon_t^B, \qquad (7)$$

where GDP_{t-j} is defined as the quarterly growth rate of the gross domestic product. All other variables were previously defined.

Results for the *univariate* and the *bivariate* specifications are reported in tables 4 and 5, respectively. Both tables are divided into three sections reflecting the different measures of the monetary policy stance (*LIBOR*, *MCI*5, *MCI*3). Again, results are shown for three different sample definitions, to account for the possibility that smaller banks are more exposed to credit channel related financial-market imperfections. For each sample definition we report the values for the parameters of interest,

$$\Phi^C = \sum_{j=0}^{4} \phi_j^C \quad \text{and} \quad \Phi^B = \sum_{j=0}^{4} \phi_j^B,$$

as well as the *p-values* corresponding to an *F-test* of the null hypothesis that $\Phi^C = 0$ and $\Phi^B = 0$, respectively. We also report the estimated values of the linear time trend parameters, δ^C and δ^C, as well as, in the *bivariate* case, the estimate of

$$\Gamma^C = \sum_{j=0}^{4} \gamma_j^C \quad \text{and} \quad \Gamma^B = \sum_{j=0}^{4} \gamma_j^B$$

and the associated *p-values*.

The main result can be summarised as follows. Focusing on the *LIBOR* as a measure of the monetary policy stance in Table 4, it appears that, for the smaller banks, the null hypothesis $\Phi^C = 0$ can be rejected at the 1% level of significance in favour of the alternative $\Phi^C > 0$. This result is consistent with the existence of a bank lending channel, i.e. with the hypothesis that the degree to which the banks' lending activity is capital constrained is positively correlated with the degree of restrictiveness of the monetary policy stance (the bank capital channel). In other words, this result is consistent with the assumption that, for the smaller banks, monetary policy has a direct impact on the credit supply function. As can be seen from Table 5, the result also holds when the *bivariate* specification is adopted. While relatively robust to a change of specification, this result is sensitive to the definition of the measure of monetary policy stance adopted. Comparing the results across sections, it appears that when using the *MCI* rather than the short-term interest rate, the hypothesis $\Phi^C = 0$ can no longer be rejected at any reasonable level of significance. For instance, when adopting the *MCI*5 in the *bivariate* setup, Φ^C is almost certainly equal to zero (p-value: 0.99). This sensitivity to alternative definitions appears somewhat surprising in the light of the relatively strong correlation observed between the different measures of monetary policy stance.[11]

Table 4: Estimation Results, Step 2, Univariate

LIBOR				
Sample	Φ^C	Φ^B	δ^C	δ^B
All banks	.001	–.002	–.0002 (b)	.0000
p-value	(.695)	(.274)	(.043)	(.766)
Small banks (< 75% quantile)	.007 (c)	–.003 (b)	–.0001 (a)	.0000
p-value	(.010)	(.032)	(.073)	(.411)
Large banks (≥ 25% quantile)	–.006	–.024 (c)	–.0004	.0000
p-value	(.652)	(.004)	(.350)	(.932)

MCI5				
Sample	Φ^C	Φ^B	δ^C	δ^B
All banks	–.001	–.003 (b)	–.0002 (a)	.0001
p-value	(.793)	(.043)	(.063)	(.268)
Small banks (< 75% quantile)	.004	–.004 (c)	–.0003 (b)	.0000
p-value	(.193)	(.008)	(.019)	(.557)
Large banks (≥ 25% quantile)	.004	–.025 (c)	–.0002	.0004
p-value	(.776)	(.006)	(.595)	(.190)

MCI3				
Sample	Φ^C	Φ^B	δ^C	δ^B
All banks	–.002	–.003 (b)	–.0002	.0001
p-value	(.479)	(.036)	(.201)	(.214)
Small banks (< 75% quantile)	.001	–.003 (b)	–.0002 (a)	.0000
p-value	(.666)	(.038)	(.079)	(.471)
Large banks (≥ 25% quantile)	.010	–.019 (b)	–.0004	.0005
p-value	(.432)	(.019)	(.429)	(.175)

(a), (b), (c) indicate coefficients significantly different from zero at or below the 10%, 5% and 1% levels, respectively.

11 See Table 2.

Table 5: Estimation Results, Step 2, Bivariate

Sample	Φ^C	Φ^B	δ^C	δ^B	Γ^C	Γ^B
LIBOR						
All banks	.002	–.004	–.0002[a]	.0000	–.1492	.1132
p-value	(.644)	(.208)	(.058)	(.903)	(.685)	(.589)
Small banks (< 75% quantile)	.009[b]	–.005[b]	–.0001	.0000	–.3389	.1322
p-value	(.025)	(.050)	(.120)	(.120)	(.223)	(.219)
Large banks (≥ 25% quantile)	–.029	–.038[c]	–.0005	.0000	2.1145	.6590
p-value	(.174)	(.006)	(.123)	(.881)	(.151)	(.472)
MCI5						
All banks	–.001	–.006[b]	–.0002[a]	.0001	.1540	.0669
p-value	(.881)	(.042)	(.067)	(.137)	(.684)	(.706)
Small banks (< 75% quantile)	.000	–.003	–.0002[a]	.0000	.2617	–.0031
p-value	(.990)	(.171)	(.058)	(.754)	(.417)	(.984)
Large banks (≥ 25% quantile)	–.047[b]	–.039[c]	–.0007	.0005[b]	–2.1704	.2978
p-value	(.034)	(.003)	(.105)	(.029)	(.136)	(.724)
MCI3						
All banks	–.002	–.004[b]	–.0002	.0001	.2523	–.0836
p-value	(.566)	(.042)	(.187)	(.177)	(.330)	(.504)
Small banks (< 75% quantile)	–.003	–.001	–.0001	.0000	.4624[a]	–.1301
p-value	(.340)	(.426)	(.302)	(.945)	(.051)	(.278)
Large banks (≥ 25% quantile)	.042[c]	–.021[b]	–.0010[b]	.0005	–1.7487[a]	–.8477
p-value	(.002)	(.023)	(.022)	(.102)	(.070)	(.199)

(a), (b), (c) indicate coefficients significantly different from zero at or below the 10%, 5% and 1% levels, respectively.

The remainder of our results can be summarised as follows. In general, $\Phi^C = 0$ cannot be rejected in favour of the positive alternative when considering alternative sample definitions, i.e. all banks or the bigger banks only. There are two exceptions, however. It appears that in the bivariate setup $\Phi^C > 0$ can be accepted with a reasonable level of confidence for the bigger banks when the monetary policy stance is measured according to the *MCI*. This result is somewhat puzzling because it is inconsistent with the widely accepted idea that the credit channel is less likely to affect big banks than small banks. Second, regarding Φ^B, it appears that the null hypothesis can never be rejected in favour of the positive alternative. In fact, in many cases, there appears to be a significant *negative* correlation between the degree of restrictiveness of the monetary policy stance and the intensity of the liquidity constraint. This result is also puzzling, in the sense that it is difficult to reconcile with any convincing economic intuition. However, the results regarding Φ^C for the bigger banks and Φ^B for all categories of banks must be viewed with extra caution. As can be seen from equations (4)–(7), these parameters were estimated using the series of $\hat{\beta}_t^C$ and $\hat{\beta}_t^B$ respectively as left-hand variables. However, according to the results from the first step, at most 3% of the values taken by $\hat{\beta}_t^C$ and $\hat{\beta}_t^B$ are statistically significantly different from zero for these categories of banks. This suggests that randomness plays a prominent role (i) in the series of $\hat{\beta}_t^B$ (for all sample definitions) and $\hat{\beta}_t^C$ (for the bigger banks), which are used as input and, as a consequence, (ii) in the estimates of Φ^C and Φ^B for these categories of banks.

Finally, a few comments should be made regarding the control variables included, i.e. the linear time trend and the measure of economic activity.[12] First it appears that δ^C is negative, in both the univariate and the bivariate specification, and significantly so in the former. This suggests that, if at all, the importance of the average capital constraint tends to decrease over time and implies a flattening of the relation between the capital base and the cost of external finance for banks. Second, Γ^C, the sum of the parameters measuring the impact of GDP growth, is not significantly different from zero. This is an indication that the endogeneity problem highlighted previously in this section should not be of too much concern.

12 We focus on the estimation results of equations (6) and (7) for the smaller banks using the LIBOR as a measure of the monetary policy stance, which constitute the main findings in our paper.

6. Robustness

As was argued by KASHYAP and STEIN (2001, p. 421), "the two-step method probably errs on the side of being overparameterised". An alternative approach would be to impose more structure on the data and analyse both the cross-sectional and time-series dimensions of our panel dataset within a single model. Following KASHYAP and STEIN (2001), we conduct this additional analysis as a robustness check.

We compress our two-step model into the following one-step model:

$$\begin{aligned}\hat{L}_{it} = &\sum_{j=1}^{4} \alpha_{t,j} \hat{L}_{i,t-j} \\ &+ \sum_{j=0}^{4} \mu_j^M dM_{t-j} + \sum_{j=0}^{4} \mu_j^G GDP_{t-j} \\ &+ C_{it-1}\left(\beta_t^C + \sum_{j=0}^{4} \phi_j^C dM_{t-j} + \sum_{j=0}^{4} \gamma_j^C GDP_{t-j}\right) \\ &+ B_{it-1}\left(\beta_t^B + \sum_{j=0}^{4} \phi_j^B dM_{t-j} + \sum_{j=0}^{4} \gamma_j^B GDP_{t-j}\right) \\ &+ \delta^T TIME + \sum_{j=1}^{4} \delta_j^Q QUARTER_{kt} + \varepsilon_{it},\end{aligned} \tag{8}$$

where *QUARTER* is a quarter dummy variable included to account for possible seasonal effects in lending activity. The remaining variables have all been previously defined. The three-month *LIBOR* is used as a measure for the monetary policy stance. The main difference between the one-step and two-step approaches is that in the former, the macroeconomic effect of the monetary policy stance and the economic activity variables – i.e. their effect on the lending activity of the average bank – are explicitly modelled and estimated. In contrast, in the two-step approach, the parameters of the lending activity equation are reestimated each quarter and changes in average lending activity across time are left unexplained. Imposing more constraints – as under the one-step approach – might be beneficial as it requires the estimation of fewer parameters using the same set of information. On the other hand, imposing the constraint of a linear and constant relationship between economic activity or changes in the monetary policy stance and lending activity might be excessively restrictive.

The parameters of equation (8) are estimated using the Arellano-Bond (1991) Generalised Method of Moments estimator, which properly accounts for the dynamics of the model.[13] The estimation results for the parameters of interest –

$$\Phi^C = \sum_{j=0}^{4} \phi_j^C \quad \text{and} \quad \Phi^B = \sum_{j=0}^{4} \phi_j^B$$

– as well as the associated *p-values* are reported in Table 6.[14] As can be seen, when compared with Table 5 *(LIBOR)*, the results from both approaches are broadly consistent. First, in both cases, the null hypothesis $\Phi^C = 0$ can be rejected in favour of the alternative $\Phi^C > 0$ (the bank capital channel) for – and only for – the smaller banks in our sample. In addition, while the point estimates for Φ^C differ – 0.0009 in the two-step case compared with 0.021 in the one-step case for the smaller banks – this difference is not statistically significant. Second, regarding Φ^B, the null hypothesis $\Phi^B = 0$ cannot be rejected in favour of the positive alternative (the "traditional" bank lending channel) regardless of the approach and the sample considered.

This consistency of results between the one-step and two-step approaches suggests that our main result is relatively robust. A word of caution is in order at this stage, however. First, as already mentioned, the results from the *two-step* approach are not robust to changes in the definition of the measure of monetary policy stance adopted. Second, the results from the *one-step* approach turn out to be relatively sensitive to changes in model specifications. For instance, the statistical significance of the parameters fluctuates considerably depending on the maximum number of lags of the dependent variable that are used as instruments in the estimation of the parameters of (8). While the choice of this value

13 We use the *xtabond* command available in Stata 8.0. All variables besides the lagged values of the dependent variable ($\dot{L}$) are treated as strictly exogenous. The maximum number of lags of the dependent variable that are used as instruments *(maxldep)* is set at 16. The variance-covariance matrix of the parameters estimates is computed using a robust estimator.

14 The values reported in this table for Φ^C and Φ^C are adjusted to account for the fact that capital and liquidity base (the variables C and B) are defined as the *natural logarithm of* the ratio – unlike the ratio itself as in the two-steps case – between excess and required levels of capital and liquidity respectively. Hence, in order to compare the parameter estimates between the one-step and two-step approaches, the results from the former have been divided by the sample average for C and B respectively. The sample average for C is 0.72, 0.42 and 0.65 for the smaller banks, the bigger banks and all the banks respectively. The corresponding values for B are 1.16, 0.63 and 1.05, respectively.

is to some extent arbitrary, the value taken by the Arellano-Bond (specification) test of absence of second-order autocorrelation in the errors suggests that the specification that we choose is appropriate.[15] Under the line, based on both within- and between-models observations, the robustness of our results appears to be moderate.

7. Discussion of the Results

Our results show that banks, in particular those belonging to the lower 75% of the size distribution, are capital constrained in their lending activity on a regular basis. And we found some evidence that the intensity of this constraint depends on the monetary policy stance. An increase in the degree of restrictiveness of monetary policy intensifies the constraint. Taken together, these results provide evidence in support of the existence of a *bank capital channel*, i.e. of one aspect of the bank lending channel in Switzerland. So far our focus was on statistical rather than economic significance. But the objective of this strand of research is to achieve a better understanding of the transmission mechanism of monetary policy, thus helping to improve the performance of central banks. In this sense, it is of crucial importance to obtain an idea of the economic significance of the effects identified so far.

Regarding the intensity of the capital constraint, the values taken by $\hat{\beta}_C$, when significant at the 1% level, range between 0.007 and 0.016. This means that a difference of 10 percentage points in excess capital – say, 20% and 30% of required capital, respectively – would correspond to an average difference of 7–16 basis points (bp) in loan portfolio quarterly growth. In other words, assuming that all banks are hit by an identical positive loan demand shock – which could be caused by a more accommodating monetary policy –, credit growth at a bank with an excess capital ratio of 30% would on average be 7–16 bp higher than credit growth at its less capitalised (20%) counterpart. These figures are economically significant. They correspond to 10–20% of the average quarterly credit growth rate, which amounted to 78 bp during the period considered.

15 According to Arellano and Bond (1991, p. 281), the consistency of their estimator requires the absence of second-order autocorrelation in the residuals. First-order autocorrelation, on the other hand, is unproblematic. As can be seen from Table 6, our results are consistent with this pattern. The *absence* of first-order autocorrelation *can* be rejected in all cases, while the *absence* of second-order autocorrelation *cannot* be rejected.

As was highlighted in the introduction, equation (1) suggests that the lending activity of banks with a weak balance sheet should be relatively sensitive to changes in the monetary policy stance. To put it simply, our results suggest that (i) the lending activity of a bank is a function of its capital base, and (ii) that this function depends on the monetary policy stance. Formally, substituting (4) into (3), dropping the indices and focusing on the variables of interest gives:

$$\hat{L} = \beta^C(dM) \cdot C + (\ldots),$$

where $\beta^C(dM) = \Phi^C dM + (\ldots)$. That is, our results imply that:

$$\hat{L} = \Phi^C dM \cdot C + (\ldots), \tag{9}$$

The impact of a change in the monetary policy stance on a bank's lending activity – the partial derivative of (9) with respect to dM – is given by $\Phi^C C$. Hence, using our estimates for Φ^C, which are 0.007 in the univariate *(LIBOR)* and 0.009 in the multivariate *(LIBOR)* case,[16] this implies that a monetary tightening, which leads to a 100 bp increase in the short-term interest rate would depress credit growth of a bank with 20% excess capital by 7–9 bp more than credit growth of a bank with 30% excess capital. Again, in the light of the average quarterly credit growth rate over the period considered, these figures are far from negligible.

Two final qualifying comments are in order at this stage. First, the two-step procedure adopted for our analysis prevents us from drawing conclusions regarding the aggregate effect of a change of the monetary stance on *aggregate* credit supply. Based on (9) and the fact that $\Phi^C > 0$, our results might give rise to the erroneous idea that a monetary tightening ($dM > 0$) in fact *increases* the banks' credit supply.[17] This interpretation would be wrong, because the impact of banks' characteristics (capital and liquidity) on their lending activity is based on a strictly cross-sectional analysis (the first step of our analysis). Thus, our results are uninformative regarding the level of the aggregate effect of a monetary policy shock

16 We focus on the results based on the LIBOR measure for the monetary policy stance. This choice is motivated by the fact that these are the most robust results throughout our study. In addition, we concentrate on the smaller banks, for which the effect is statistically significant.

17 As we underlined above, our results suggest that for the smaller banks one can write $L_{it} = (\ldots) + \beta^C_{it}(M_{it}) \cdot C_{it}$, where $\beta^C(M) = \Phi^C \cdot dM$. With both estimates for β^C and Φ^C being positive, this would suggest that a more restrictive monetary policy ($dM > 0$) increases the banks' lending activity.

on banks' lending supply. They only tell us that (i) a monetary policy shock *has* an impact on (the smaller) banks' credit supply and (ii), *assuming that the average impact is negative*, the impact will be smaller (in absolute terms) for banks with higher levels of excess capital.

Second, scaling-up our results, i.e. assuming that *average* lending of the whole sample of smaller banks will be depressed by 7–9 bp more if their average excess capital decreases by 10 percentage points, we can get an idea of the overall implication of the bank lending channel for monetary policy. Given Switzerland's concentrated banking market, it would be of limited value for the SNB to take into account the bank lending channel when fine-tuning its monetary policy. This conclusion draws on the fact that, over the period considered, the banks belonging to the lower 75% of the size distribution – which, according to our results, form the only group for which evidence regarding the bank lending channel could be identified – represented less than 5% of the banking sector's total assets. Hence, following a rule of thumb, our results suggest that the effect of a 100 bp interest rate increase on bank lending is only 0.4 bp stronger if the excess capital decreases by 10 percentage points.

8. Conclusion

Using data at the individual bank level, we were able to find evidence supporting the existence of a bank lending channel in Switzerland. First, our results suggest that banks' lending activity is constrained by their capital base. Liquidity, which is another variable often cited as an important characteristic of a bank's credit supply function, does not appear to explain differences between banks' lending activity in Switzerland. Second, the intensity of the capital constraint appears to vary through time. Consistently with the hypothesis of the *bank capital channel*, these changes are positively correlated with changes in the monetary policy stance for the smaller banks in our sample: the lending activity of the banks belonging to the lower 75% of the size distribution tends to be more capital constrained when the monetary policy stance becomes more restrictive. This result implies that better capitalised banks are relatively immune to changes in the monetary policy stance. These results are particularly interesting given the lack of evidence regarding the existence of a bank lending channel in Switzerland so far.

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SUMMARY

We study the role of bank capital and liquidity in the transmission of monetary policy in Switzerland. Using a large set of data, we test the assumptions that the effect of a change in the monetary policy stance on a bank's lending activity depends (i) on its capital (the bank capital channel) and (ii) on its liquidity base (the "traditional" bank lending channel). Our findings are consistent with the first hypothesis: lending by banks with a relatively weak capital base reacts more to a change in the monetary policy stance than lending by better capitalised banks. Liquidity, on the other hand, does not appear to play a role in this context. This result constitutes evidence for the existence of a bank lending channel in Switzerland.

ZUSAMMENFASSUNG

Wir untersuchen, was für eine Rolle das Eigenkapital und die Liquidität von Banken im Transmissionsmechanismus der Geldpolitik in der Schweiz spielen. Basierend auf einer breiten Datenbasis testen wir die Hypothesen, dass der Einfluss geldpolitischer Impulse auf das Wachstum von Bankkrediten (i) von der Kapitalbasis und (2) von der Liquidität der Banken abhängt. Unsere Schätzungen stützen die erste Hypothese: die Kreditvergabe von Banken mit einer schwachen Kapitalbasis reagiert stärker auf geldpolitische Impulse als die Kreditvergabe von Banken mit mehr Eigenkapital. Hinsichtlich der Liquidität besteht kein solcher Zusammenhang. Unsere Resultate deuten darauf hin, dass in der Schweiz angebotsseitige Effekte der Geldpolitik im Sinn eines „Bank Lending Channels" existieren.

RÉSUMÉ

Nous étudions le rôle de la dotation des banques en fonds propres et en liquidité dans le contexte de la transmission de la politique monétaire en Suisse. Nous basant sur une base de données détaillée, nous testons les hypothèses selon lesquelles les effets d'une modification de la politique monétaire dépendent de la dotation des banques (i) en fonds propres et (ii) en liquidité. Nos résultats sont consistants avec la première de ces hypothèses: l'activité de crédit des banques relativement faiblement dotées en capital réagit plus fortement à un resserrement de la politique monétaire que celle des banques disposant d'une dotation en fonds

propres relativement élevée. Par contre, la liquidité ne semble pas jouer de rôle dans ce contexte. Ce résultat constitue une évidence empirique concernant l'existence d'un canal du crédit bancaire en Suisse.