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THE BANK LENDING CHANNEL DURING FINANCIAL TURMOIL

MNB WORKING PAPERS | 5

2020

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MNB Working Papers 2020/5

The bank lending channel during financial turmoil

(A banki hitelcsatorna válság idején)

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Budapest, September 2020

Published by the Magyar Nemzeti Bank

Publisher in charge: Eszter Hergár

H-1054 Budapest, Szabadság tér 9.

www.mnb.hu

ISSN 1585-5600 (online)

* I am grateful to Dzsamilla Vonnák, Péter Gábriel and Álmos Telegdy for their useful comments. All remaining errors are mine.

Contents

Abstract

This paper uses a natural experiment to study the impact of a loan supply shock on a Hungarian matched bank-firm dataset. The event studied is a funding shock Hungarian banks faced following the collapse of the Lehman Brothers. Banks were affected via their external funding and positions on the swap market. The existence of firms with multiple bank links is utilized to separate demand and supply, and to find instruments to calculate the impact of the supply shock on lending and firms' real outcome. According to the results banks with large exposure on the swap market and with heavy reliance on foreign market funding cut their lending more, while foreign group funding provided a buffer. Firms were not able to fully offset the impact of the supply shock by shifting to less exposed banks, their overall lending fell too. The supply shock affected various groups of firms differently: banks reallocated lending towards larger firms. The squeeze on lending in turn had an impact on firms' real performance, by lowering their net investment. The real impact was more detrimental for small and risky firms.

JEL: E22, E51, G01, G21

Keywords: Financial crisis, Bank lending, Real effect of credit, Firm-level data, Hungarian economy

Összefoglaló

Ez a tanulmány egy természetes kísérlet segítségével vizsgálja egy hitelkínálati sokk hatásait magyar bank-vállalat adatokon. A vizsgált esemény a Lehman Brothers bukását követő banki finanszírozási sokk, mely a bankokat külsö finanszírozási és devizaswap piaci pozícióikon keresztül érintette. A több bankkal kapcsolatban lévő vállalatok létezése teszi lehetővé a hitelkereslet és kínálat szétválasztását, a hitelkínálati instrumentumok azonosítását illetve a hitelkínálati sokk reálhatásának meghatározását. Az eredmények szerint azok a bankok, melyek nagy kitettséggel rendelkeztek a devizaswap piacon vagy jelentős mértékben támaszkodtak külső piaci forrásokra nagyobb mértékben fogták vissza a hitelezést, míg a külföldi anyabanki források bufferként szolgáltak. A vállalatok nem voltak képesek teljesmértékben hatástalanítani a hitelkínálat visszaesését keresletük kevésbé sérülékeny bankok felé való átcsoportosításával; a sérülékeny bankoknak kitett vállalatok teljes hitelállománya is csökkent. A hitelkínálati sokk nem egyformán érintette az egyes vállalatokat, a bankok a nagyobb vállalatok felé csoportosították át hiteleiket. A hitelkínálat csökkenése a vállalatok reál teljesítményére is hatással volt, csökkentve nettó beruházásaikat. A reál hatás a kicsi és a kockázatos vállalatokat esetében volt a legnagyobb.

1 Introduction

This paper studies the effect of a loan supply shock by using a matched bank – firm – loan dataset. The event considered is the collapse of the Lehman Brothers, which triggered a capital outflow and a freeze on financial markets. As a result, at the autumn of 2008, Hungarian banks faced a severe liquidity crisis, which led to a squeeze on their lending. I search for drivers – foreign funding, position on the swap market – of the loan supply and estimate its impact on lending and on firms' real outcome. The shock was exogenous, and banks' exposure was large but heterogenous; which makes it a promising case to conduct a natural experiment type analysis.

The Hungarian economy was in a vulnerable state when the crisis hit, with large double deficit, external imbalances and Net Foreign Assets, high government indebtedness, and unhedged foreign currency borrowing by firms and households. As to the banking sector, major vulnerabilities built up in the form of unhealthy funding structure – dependence on external and often short-term financing from the wholesale market, – and the provision of unhedged foreign currency loans to households but also to firms without natural hedge. Before the crisis, the surge in lending to the private sector was mainly financed by external foreign funds. Part of external funding came from the foreign parent banks. At that time, foreign owned banks had 70% market share in terms of total assets. However, banks also relied extensively on the wholesale market. Before the crisis, the share of total foreign funds reached 31% of total banking sector assets, about half of which was provided by foreign parents or group members. The dependence on wholesale funding was also reflected in the Loan to Deposit (LTD) ratio, which exceeded 140% by 2008.

Another feature of the pre-crisis period was the build-up of foreign currency (FX) swap positions related to the extensive lending in foreign currency. Banks provided long-term foreign currency loans to both hedged and unhedged borrowers. The resulting open FX position in banks' balance sheet was closed by FX swaps, which also provided the necessary foreign currency liquidity for lending. Banks practically created a synthetic foreign currency loan by combining domestic HUF funds with FX swap. It has become popular as this synthetic position taking was more attractive than direct foreign borrowing. The FX swap positions were typically of much shorter maturity than the FX loans, which made banks exposed to rollover risk. The position on the swap market was large, during 2007 it ranged between 5-10% of total banking sector assets; and most positions were short-term, with less than 1-year maturity.

Hungarian banks faced a funding and a foreign currency liquidity crisis at the end of 2008. Foreign capital fled, the government bond and the interbank markets, both foreign and domestic, dried up; the exchange rate sharply depreciated. For a rather short period, the swap market also froze, and some banks had difficulties rolling over their expiring FX swaps. The MNB took measures to ease the liquidity problems, among others by providing an FX swap line, raising interest rates, and acting as a lender of last resort. In addition, the country had to turn among the firsts to international organizations (IMF, EU) to gain financial support, because both public finance and balances of financial institutions were unsustainable. Parent banks played a role in resolving the funding problems by providing direct lending to their subsidiaries and by replacing the vanishing counterparties on the swap market. Due to these measures, the funding problems were eased, nevertheless the crisis unveiled the vulnerability of banks' funding structure and triggered adjustment by banks on both their funding and lending side. Banks' capacity and willingness to lend fell. Corporate borrowers were more affected by the credit crunch, due to the lower margins and the higher regulatory risk weights on corporate loans relative to household loans [1].

On a longer term, loan portfolio losses, especially those on unhedged FX denominated loans, also contributed to the deterioration of banks' balance sheet. But this is not the subject of this analysis. Loan losses started materializing later, in the initial period funding was the major source of vulnerability.

[1] See Banai 2016.

Several papers have already examined the drivers of lending in Hungary and specifically the 2008 crisis episode by using bank level instead of loan transaction level data.[2] Banai (2016) shows that sound funding position, measured with the loan to deposit ratio, supported lending; while large position on the swap market lowered lending growth. Temesváry and Banai (2017) in a similar analysis on Central and Eastern European banks find, that the balance sheet conditions of both the subsidiary and the parent bank mattered for lending growth. In addition to portfolio quality and solvency, the liquidity of the parent bank mattered too, although it had negative impact only during the crisis. They also find that participation in the Vienna Initiative was effective, as the involved subsidiaries were subject to lower fall in lending. Páles et al. (2010) documents how and why the swap market position of banks built up before the crisis and what happened during the crisis, what role the parent banks played in curbing the liquidity problems.

This paper uses a matched bank-firm-loan dataset to identify the drivers of the supply shock, its impact on lending and firms' real performance. One of the contributions to the existing Hungarian results comes from the use of micro data and the identification strategy facilitated by this dataset. The major challenge in studies on the bank lending channel or loan supply is the separation of demand and supply. To deal with that I follow the seminal paper of Khwaya and Mian (2008) and exploit the existence of firms with multiple-bank links to show that such firms faced steeper cut in their loans at more vulnerable banks. The novelty of this approach is that in a diff-in-diff setup firm fixed effects can control for any firm-specific changes, including loan demand. Therefore, the comparison of lending developments of the same firm at banks with varying exposure to the liquidity crisis facilitates the identification of the drivers and the within impact of the supply shock.[3] Banks' exposure to the funding shock is captured by their use of foreign funding and position on the swap market. These variables will be used to generate instruments of credit supply.

After establishing the within firm impact of the funding shock, it is shown that firms' total lending was also affected: if a firm on average was linked to more risky banks, its total outstanding lending fell more too. Even if a significant within impact is estimated, the between effect may be lower or entirely disappear, depending on firms' ability to shift their demand from vulnerable banks to less exposed bank.

The richness of the dataset is also used to get a more detailed picture on the behavior of banks during the shock. This gives the paper's second contribution to the existing Hungarian evidence. I examine if the effect of external funds depended on, whether they were coming from the parent bank or from the wholesale market. In addition to the change in lending of continuing clients, the impact of the supply shock on the probability of financing "expanding" firms and on exit and entry is also investigated. The effect on exit and entry captures the adjustment at the extensive margin. The heterogeneity of banks' response is studied by asking whether banks differentiated among their clients based on their age, size or riskiness. Finally, the impact of the supply shock on firms' real performance and its heterogeneity is examined. The effect on real performance is likely to depend on the ability of the firm to use alternative funding sources and thus not all groups might have been equally affected.

This paper belongs to the literature, which study natural experiments to identify and analyze the impact of loan supply shocks on matched bank-firm data. Paravisini et al. (2014) examines the impact of a capital outflow in Chile during the recent financial crisis. Several papers study the jump in sovereign risk in the EU in 2010 following the Greek bailout (Bottero et al 2019, Buera and Karmakar 2018, Bripi et al 2017). Khwaya and Mian (2008) exploits the introduction of temporary administrative measures in Pakistan, which affected banks' liquidity. These papers exploit that the event was exogenous, and banks had varying exposure to the shock. The nature of the shock dictates what measures of exposure (foreign funds, sovereign exposure, change in liquidity) are considered to instrument credit supply. To validate the credit supply instrument and to disentangle demand and supply, this branch of the literature mainly use the methodology of Khwaja and Mian (2008).[4] A different approach is followed in Amiti and Weinstein (2017), Amador and Nagengast (2014),

[2] Two Hungarian papers use macro data to identify credit supply shocks, Tamási and Világi (2011) estimate a Bayesian SVAR model, while Hosszú (2016) relies on a time-varying parameter FAVAR model.

[3] Firm-bank-transaction level data can also alleviate certain measurement issues in our case. Given the large share of foreign currency lending and the volatility of exchange rate during the crisis, it is crucial to filter its impact out from the lending data. Which is easy to do with transaction level data, as we know the exchange rate at the time of origination.

[4] A different approach is introduced by Almeida (2009), who exploit the heterogeneity of firms instead of banks, in terms of loan maturity before the crisis, and use it to infer about the impact of credit supply.

and Manaresi end Pierri (2019)[5], who use matched bank-firm-loan data and fully decompose the change of aggregate loan into bank, firm, industry and common shocks. The decomposition is done for the entire time series, not just around crisis periods, and inform about the aggregate importance of each shock.

One contribution of the current paper to this literature is the analysis of a new channel of funding shock, through the exposure on the swap market. This paper is also unique due to the analysis of multiple channels of funding risk and the separate treatment of external funds by their source (group versus non-group). To our best knowledge, none of the matched bank-firm studies do that, most likely due to data constraints[6]. This is crucial in our case, as group and non-group funds have been found to behave differently during the first phase of the crisis.

All the papers cited above detect significant impact of the banking shocks on loan supply. Results regarding the heterogeneity of banks' response are mixed. Liberti and Sturgess (2017) find that, banks reallocate to larger and less risky borrowers, while Cingano et al. (2016) detect stronger supply effect in the case of small and young firms. De Jonghe et al. (2019) on the other hand, on Belgian data did not find heterogenous impact in lending by size or age, but the risk of the firms. However, they detect sectoral pattern: banks reallocate to sectors in which they have large market share, and which are important in their portfolio.

Regarding the real impact of the lending supply shock on investment, export or productivity, available estimations on the size of the impact are dispersed in a rather wide range. Heterogeneity is found in many cases, even when the impact on lending was rather homogenous – implying that even if bank had not differentiated among firms, the real impact varied, as firms had varying access to alternative sources of finance.

The following chapters report some stylized facts and describe the data and methodology. Then, estimation results regarding the impact of the funding shock on loan supply and the heterogeneity of banks' responses are summarized. In the next step it is shown that firms were not able to fully substitute their falling loan at vulnerable banks: exposed firms' total loan deteriorated as well. Finally, the impact on real performance is reported, then conclusion is drawn.

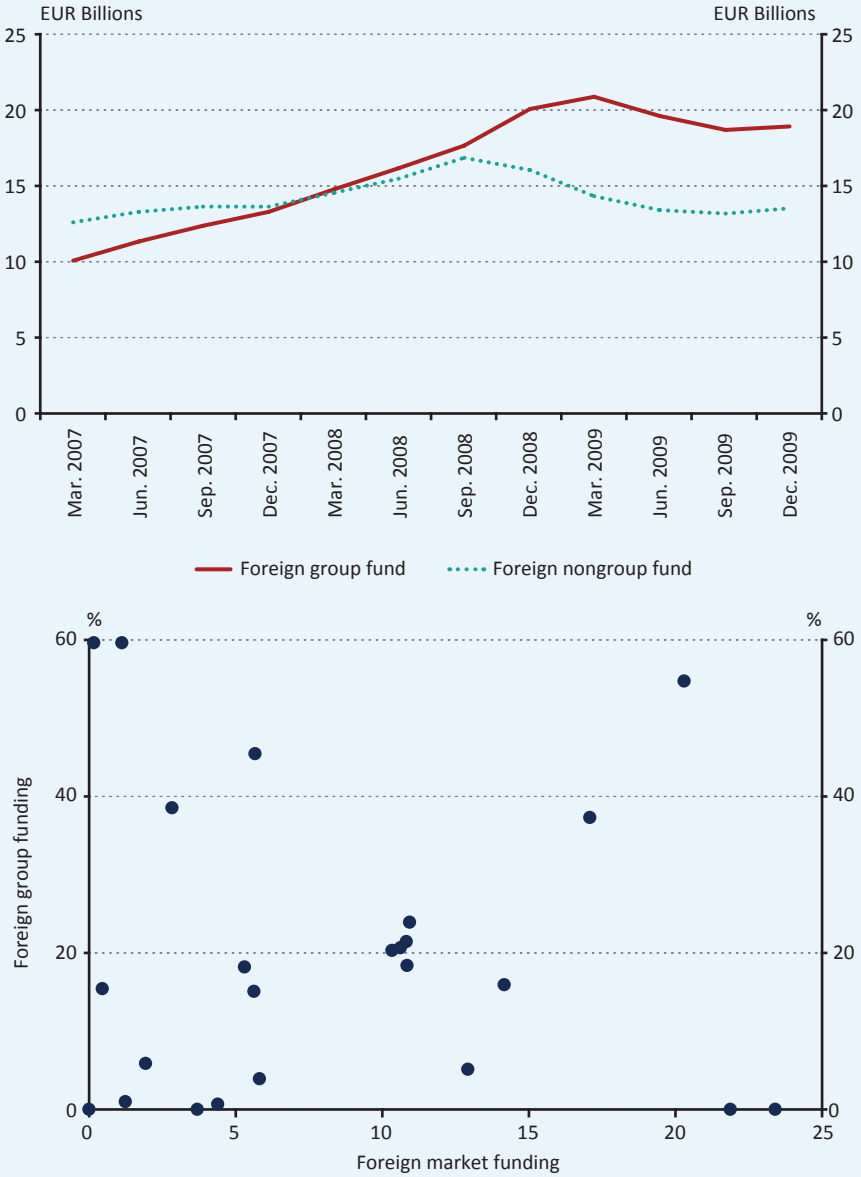
[5] This paper uses both empirical strategies to investigate the impact of loan supply shocks on productivity, and finds, that the effect is larger in the natural experiment, suggesting that normal and distress times are different. Access to finance becomes more important during financial distress.

[6] Obviously, the separation of group and non-group funding is relevant only in countries with significant presence of foreign owners.

2 Some stylized facts

Foreign funding kept increasing in the period preceding the crisis, climbing above 30% of total liabilities, and started declining after the Lehman event. Non-group funds decreased first, after reaching its peak around 17 Billion EUR (see Chart 1.) at the end of September 2008 and dropping by almost 3.5 Billion EUR by mid-2009. Consistent with the story documented in Banai et al. (2010) about the intervention of the parent banks, group funds kept increasing until the 1st quarter of 2009, and started declining after that. The exposure of banks was heterogenous (see Chart 1., lower panel): many of the banks either had large group funding OR large nongroup funding; while some relied on both and a few had no substantial reliance on external funds of any form.

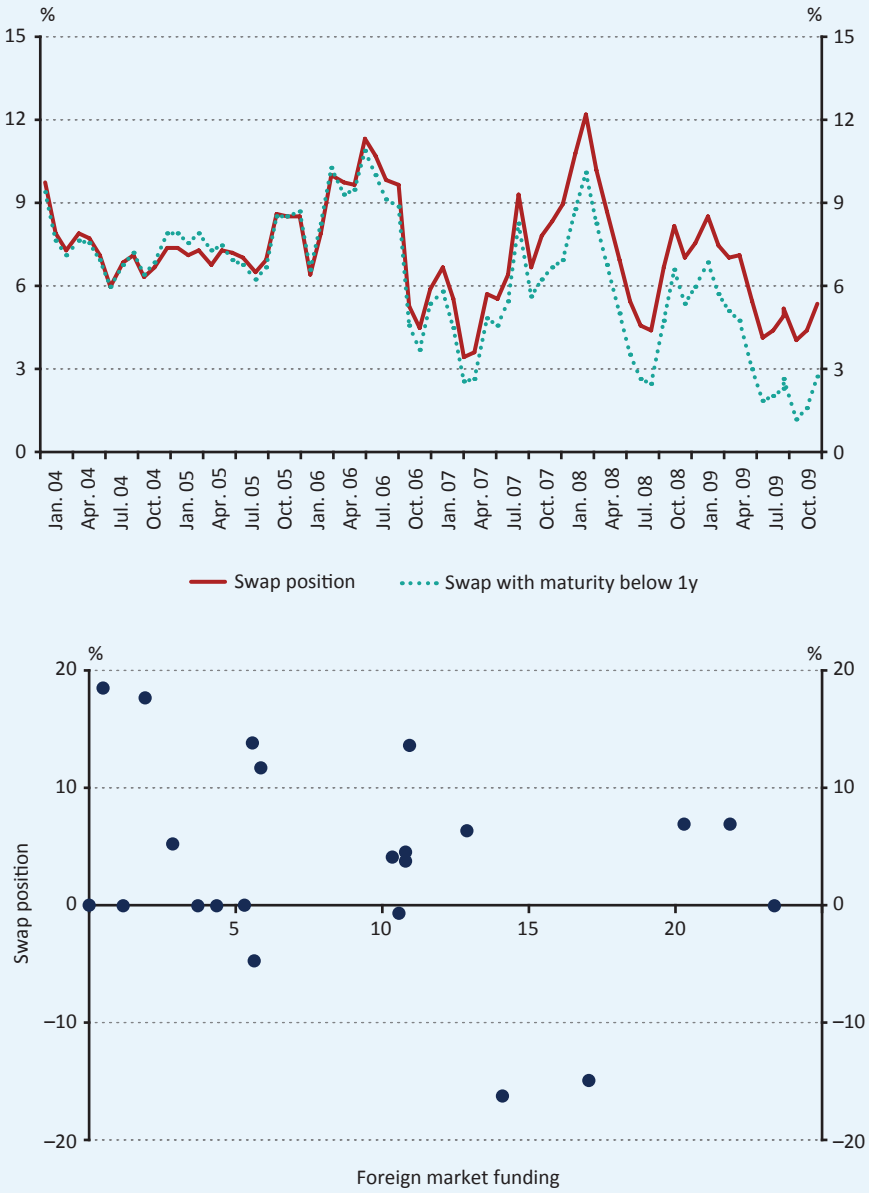
Chart 1
External funding in the banking sector; and exposure by banks in 2007 (lower panel), %



Source: MNB supervisory reports. Upper panel: total banking sector. Lower panel: only banks in the estimation sample; share to total assets; averages in 2007.

Regarding the foreign currency swap position, more than half of the banks had position on the swap market, most of them were long in HUF (short in FX). The swap position of the entire banking sector was very volatile before the crisis, moving between 4 and 12% of total banking sector assets (see Chart 2. upper panel). Most of swap contracts was short, with maturity below 1-year. The overall swap position of banks did not decline in 2008, as parent banks were willing to replace other falling out counterparts, and the stock of swap increased on the short run. Swap lines introduced by the MNB also eased market tension. Swap positions started declining sharply only from 2009 March, which is likely to reflect the balance sheet adjustment of banks (see Páles et al. 2010). Although the rollover risk was successfully eased, banks suffered losses due to their dependence on the swap market: swap spreads widened, reflecting the rise in domestic and foreign interest rate differential and in counterparty risk. The position of individual banks on the swap market was sizeable and heterogenous before the crisis. For some banks, the swap market served as a substitute to foreign funding (see Chart 2. lower panel): banks with the highest relative exposure on the swap market had rather low share of foreign non-group funding.

Chart 2
FX swap position to total assets, total banking sector (upper panel) and by banks (lower panel)



Source: MNB supervisory reports. Upper panel: total banking sector. Lower panel: the chart plots swap exposure against external non-group funding for banks in the final estimation sample; average in 2007.

Responses from the Senior Loan Officer Survey also underline, that liquidity problems indeed were important drivers of bank loan supply to corporate customers (see Appendix Table 1.). In the second half of 2008, on a net basis[7], 86.7% of banks thought that their liquidity position lowered their willingness to lend to firms; in 2009Q1 the same figure was 57.5%. At the same time, the role of the capital position was regarded indifferent.

Total outstanding lending in our sample[8] fell by 8.5% between the pre- and post-shock period. The average change of lending was -18.3% at the firm-bank level, and -10.8% at the firm level. Before the shock, about 25% of firms had links with more than one bank, the rest were single bank users. Although the former group took up only one fourth by number, its share in outstanding lending was roughly 56%, while its share in total number of firm-bank links was 43%. In the pre-crisis period, the average number of bank links was 1.49 in the total sample, and 2.39 among multi-bank users; both decreased slightly after the shock.

[7] This is the net of positive and negative answers.

[8] Here the estimation sample is used, instead of the information coming from supervisory report on total banking sector. This helps putting the estimation results into context. Moreover, the transactions in the sample are adjusted for exchange rate changes, which cannot be easily done for the data in the supervisory reports

3 Data

The following data sources are used to compile a matched bank-firm dataset: the Hungarian Central Credit Register (HCR), bank supervisory reports, a firm administrative dataset from the tax authority (NAV) and the firm registry. The credit register covers all transactions between credit institutions and firms with VAT id. The supervisory report submitted to the MNB (the central bank of Hungary) by all banks, branches and financial firms contains rich information on funding structure, portfolio composition or capital position. As to the firm data, a detailed balance sheet, profit and loss account, and other supplementary information on industrial classification, location or number of employees are available. Information to calculate age is collected from the firm registry. Firm data are of yearly frequency, the information on loan contracts are updated monthly, while banking reports are of monthly or quarterly frequency.

One of the challenges of linking the datasets comes from the availability and changes in the information content of the credit register. The first version of HCR (up to the middle of 2012) includes information on each contract and one can identify the firm but not the bank. In the new HCR (introduced in June 2012) the bank is known, but the MNB got access to the true firm and transaction id only from 2015. The two (old and new) HCR are matched by transaction id first. Because the two HCR cover different time periods and information is kept only for 5 years following the expiration of the loan, the match is partial. Where true transaction id is not available in both HCR various features of the transaction (amount, time of origination, expiry etc.) are used to improve the match. Altogether these methods helped identifying and linking banks and firms for more than 85% of the contracts and more than 80% of total outstanding values at 2007m9[9], while in 2008 and 2009 the match is better. As we go back in time, the coverage of the credit register and the success of matching starts falling dramatically. This has an inconvenient consequence: because of the quickly deteriorating coverage, one cannot go back further in time to do placebo to verify the goodness of the instruments of credit supply.

As the first version of the credit register included information on contractual but not on outstanding values, here the dataset compiled by Endresz et al. (2012) is used, where outstanding values are estimated. In general, linear capital payment is assumed, except in the case of credit lines, where an average utilization rate is used. This utilization rate is calculated for the entire banking sector by comparing the outstanding loan data reported in the bank supervisory reports with the contractual values reported in the HCR. This rate is time invariant, which ensures, that the increased drawdowns of credit lines, observed during the crisis, does not affect the calculated outstanding values. In a similar vein, because of the large depreciation of the domestic currency in the post-shock period it is crucial to filter out the impact of exchange rate changes.[10] In the case of foreign currency denominated loans the outstanding value is calculated throughout the life of the loan by using the exchange rate prevalent at the time of origination. So that the estimated outstanding values are not affected by changes in the exchange rate.

In search for bank supply instruments the following bank characteristics, which determine banks' exposure and response to the capital flight and swap market turbulences, are considered.

– Foreign group funds: share of foreign funds from the parent bank (or group members) in total assets. This can act either as a risk or a buffer, depending on whether a flight or bailout occurs.[11]

– Foreign nongroup funding: share of other, non-group foreign funds, which entails the risk of capital flight.

[9] That is the earliest date we go back in using the HCR.

[10] The forint depreciated in several waves, the largest swing in the post-shock period was above 20%.

[11] The behavior of foreign group funding may differ for Hungarian subsidiaries and mother banks. But this has no effect on our estimation, as almost all the group members in Hungary are subsidiaries of much larger foreign parent banks, and those which are not, had practically zero group funding from abroad.

– Swap position: net swap position to total assets, which captures the risk of rollover and rising costs due to increased spreads and margin requirements.

In case of foreign group finance two alternative indicators are used: (1) a dummy, which identifies banks who rely on group funding from abroad; (2) the actual share of group funds, to investigate if the impact varies with the size of funds already committed to the subsidiary.

In addition, we control for other bank characteristics, which may shape the respond to the supply shock: the capital buffer, the loan to deposit ratio and the quality of the portfolio (provisioning rate), defined as:

– Capital to risk-weighted assets, the regulatory capital adequacy ratio (CAR).

– Loan to deposit ratio.

– Total provisioning to gross value of rated assets.

Descriptives of bank characteristics for the 27 banks in the sample are reported in the Appendix. The averages and the variances indicate the size and the heterogeneity of banks' exposure. In the estimation all bank characteristics are normalized, so that the estimated parameters show the impact at 1 standard deviation away from the mean.

As the shock was triggered by the collapse of the Lehman Brothers, 2008m9 is set as the event date. The pre- and post-shock evolution of lending is examined over a 1-year window: for each bank – firm exposure the average outstanding value is calculated over the 12 months preceding/following 2008m9. We consider all loans and other contracts (leasing, credit lines, forfaiting etc.). Bank characteristics are lagged and calculated as the average during the 12 months preceding the pre-shock window. Firm's exposures to banks at 2007m9 are used as weights to define the instrument of loan supply[12] at the firm level – needed to estimate the impact on total loan and on real performance.

Only banks operating between 2006-2009 are included in the sample. Branches do not report CAR and foreign funding by source therefore they drop out automatically during the estimation. As to firms, only non-financial private firms[13] which operated between 2007-2009 are considered.

When firm characteristics (liquidity, leverage, sales growth, profitability, age, collateral, size) are controlled for, those values are taken from end of 2007. To deal with outliers, when relevant, the variables are generally winsorized at p1 and p99. In the case of bank characteristics, given the small number of banks, no general outlier filtering is done, except for CAR (some small banks have very large capital to risk weighted assets, because they have to comply with statutory minimum, while their size in terms of assets remains small) and LTD (some banks collect very few deposits leading to extremely high loan to deposit ratio).

[12] As the share of matched transactions falls deeply as we go back further in time, instead of using average exposure over a year, actual exposures at 2007m9 are used.

[13] The following industries are excluded: 84+, 64-66, and 19.

4 Methodology

Three questions are investigated. **First, a within firm estimation is conducted to identify the drivers and the impact of the funding shock on loan supply.** The largest challenge of identifying loan supply shocks is the separation of demand and supply. To do that, I follow Khwaja and Mian (2008). They exploit the within firm variation in lending and banks varying exposure to the funding shock to infer about the impact of loan supply. If we include solely firms, which have loans at several bank, in a diff-in-diff setup firms demand can be controlled for by firm fixed effects. It is assumed that firm demand changes proportionally in each existing bank link, and any within firm variation in lending is due to banks' ability and willingness to lend. It is also assumed that the supply shock, hitting a given bank, is not correlated with the demand shock faced by firms in the bank's portfolio.

The following model is estimated on the sample of multibank users to detect the impact of loan supply and to identify the sources of bank vulnerability to the funding shock:

$$Y_{ib} = \beta * X_b + \varepsilon_i + \mu_{ib} \qquad \text{(equation 1)}$$

where X_b is a vector of bank vulnerability indicators and other bank controls; controls for firm fixed effects. The left-hand side variable, Y_{ib} is defined in different ways:

– In the basic estimation the change in outstanding lending is modelled, which captures the intensive adjustment. The left-hand-side variable equals the log difference of average outstanding loans of firm *i* at bank *b* over the pre- and post-crisis 1-year' window:

$$dln(Y_{ib}) = ln\left(Loan_{post_{ib}}\right) - ln\left(Loan_{pre_{ib}}\right)$$

– In the second version the mid-point growth rate ala Davis et al. (1996) is used:

$$Y_{ib} = \frac{Loan_{ib,post} - Loan_{ib,pre}}{0.5 * \left(Loan_{ib,post} + Loan_{ib,pre}\right)}$$

The mid-point growth rate has several advantages to the log difference: (1) Even those firm-bank observations are included, where the value of lending is zero either in the pre- or post-crisis period. These are entries and exits, which have a growth rate of 2 and -2 respectively. (2) It is symmetric, increase and decrease by the same amount implies equal percentage change. (3) It can be approximated by the log difference. The size of the sample of Equation 1 is increased by around 25% when entries and exits are included too.

– To separate the extensive margin, the Y in equation 1 is redefined to capture exit and entry.

  ○ In case of exit Y is an indicator variable, which takes value 1, if the firm exits from the bank relationship: in the pre-shock period the firm had outstanding lending with a given bank j, but in the post-shock period its value falls to zero.

  ○ In a similar vein, entry is captured by an indicator variable, which equals 1 for a firm-bank pair, if the firm had zero exposure with the bank in the pre-shock period, but took loan following the shock. The control group of entrants includes firm-bank links with zero exposure in both the pre- and post-shock period[14].

[14] To define entries, the sample is artificially expanded to get a full panel.

– Finally, I examine whether the funding shock influenced banks' willingness to finance "expanding" firms. Here Y is an indicator variable, which equals 1, if the value of outstanding lending increased between the pre- and post-shock period.

I also experimented with flows – newly granted loans – and run regression on the change of log flows, and their mid-point growth rate. In this case, the sample is reduced significantly, especially for the log change version, as few firms took new loan from the same bank in both the pre- and post-shock periods. The size of the sample in the case of log change of new loans is just one third of that of outstanding lending.

In our sample roughly 25% of firms have multiple bank links, so that in the estimation we ignore many firms. One could question, if the results from estimation with multi-bank firms hold for the entire sample, which also includes firms with single-bank link. Firms might be different, or banks' vulnerability, the two groups are exposed to, might differ. Indeed, firms with single bank relationship have somewhat different characteristics than firms who have exposure to several banks (see Table 2.). Single bank users are typically smaller, younger, less productive, less likely to export or to be foreign owned, but their leverage is larger.[15]

Table 1
Firm characteristics by the number of bank links

	Leverage	Foreign owned	Export	Labor productivity	Employees	Sales	Age
single-bank firms	0.660	0.076	0.092	7.437	1.618	11.099	9.212
multiple-bank firms	0.674	0.087	0.142	7.984	2.444	12.327	10.637
t stat	-5.985	-5.478	-20.854	-29.772	-74.569	-84.768	-34.442

Source: own calculations. Note: end of 2007. Labor productivity, employees and sales are expressed in log.

At the same time, the average characteristics of banks in the two samples do not differ substantially (see Table 2. in the Appendix). Banks have similar average funding risks and other characteristics. The mean, the median and the variability of foreign fund share, loan to deposit ratio, swap exposure or capital adequacy are similar (except the median of foreign group funding).

To test the general validity of the results gained in the multi-bank sample, estimation is conducted for the entire sample, which includes all firms, even those with single bank link. As firm FE cannot be used, an alternative specification is estimated where cluster fixed effects based on industry and location are added to control for demand: two-digit NACE codes and two-digit postal codes capture the impact of industry and location. The cluster FEs are imperfect substitutes for firm FE. To see, how good they are at capturing demand, the estimation results with firm and cluster FE are compared for the multibank sample.

Following the basic estimation, **the heterogeneity of the impact is considered by examining whether the supply shock affected various groups of firms differently.** We are interested in whether banks differentiated among firms, punishing certain type (small, young, risky) more. This is done by adding interaction terms of bank funding vulnerability and firm characteristics to equation 1.

After identifying the drivers and impact of bank supply, I investigate **whether firms can switch to less exposed banks, or instead, substitution is limited, and their total loans are affected as well** (alike Paravisini et al. 2015). The supply shock is effective if not just the loan taken from a vulnerable bank, but the overall borrowing of the firm decreases.

The between estimation is done by using the following equation:

$$dln(TLoan_i) = \alpha + \beta 1 * X_i + \beta 2 * Firm_i + \beta 3 * (Ind_d * Loc_l) + \mu_i \qquad \text{(equation 2)}$$

[15] Regressing firm characteristics on industry fixed effects and a multiple bank dummy (not shown) yields similar conclusions.

where the left-hand-side variable is the log change of total loan of firm *i* between the post- and pre-crisis period. X_i is the vector of loan supply instruments. They capture the firm's exposure to the supply shock. Its elements are calculated as the weighted average of the funding vulnerability indicators – identified in the within estimation – of all the banks, the firms are exposed to. The weights equal the outstanding loan of the firm-bank pairs at 2007m9.

$$X_i = \frac{\sum Loan_{ib,2007} * X_b}{\sum Loan_{ib,2007}}$$

To control for demand, sector and location cluster fixed effects and other firm controls (real and financial performance, and other characteristics, such as age and size in 2007) are included in the model.

The last question considered is whether the supply shock had any impact on the real performance of firms, where performance is measured by investment (change in capital). To do that, Instrumental Variable (IV) regression is conducted, where the instruments (X_i) identified in step 1 and 2 are used and the second stage regression looks like the following:

$$dln(Z_i) = \alpha + \beta 1 * dln(TLoan)_i + \beta 2 * Firm_i + \beta 3 * (Ind_d * Loc_l) + \mu_i \qquad \text{(equation 3)}$$

where: $dln(Z_i)$ is the growth rate of the performance measure of firm *i* between 2009 and 2007. As 2008 end of year financial statements are already influenced by the crisis, a 2-year's window is used. In addition to the basic estimation, the heterogeneity of the impact is also examined. The real impact of the lending supply shock is expected to be larger for firms who have limited access to alternative financing. Heterogeneity is tested by interacting the lending variable and firm characteristics.

5 Estimation results

5.1 THE IMPACT ON LENDING

Estimation results of equation 1 show that the funding shock has indeed led to a lending squeeze. The larger the exposure to the funding shock, the bigger the decline in lending.

Let us discuss first the results on the **multibank firm** sample (see Table 2. model 1-2). Large non-group related foreign funding contributed to lower credit supply (model 1): a bank with foreign fund share of 1 standard deviation above the average lowered its lending by 12.1%point more than a bank with average exposure. The impact of swap position is 9%point. In contrast, group funding helped subsidiaries to tame the impact of the funding shock. Not just the presence of foreign owners mattered (model 2), but their pre-shock commitment as well (model 1). A one standard deviation higher than average use of foreign group funding resulted in 10.6%point higher lending. The estimation results are significant, not just statistically but economically. Given that in the sample of multi-bank firms the average (unconditional) growth rate of outstanding lending was -24.2%, we can claim, that the intensive adjustment of supply due to the funding shock was substantial.

Table 2
The impact of the funding shock on lending – within estimation

	Log change in oustanding lending						
	(0)	(1)	(2)	(3)	(4)	(5)	(6)
Sample:	multibank	multibank	multibank	multibank	multibank	all firms	all firms
foreign group funding	12.229***	10.640***		11.807***		10.186***	
	(2.742)	(2.507)		(2.257)		(1.733)	
foreign nongroup funding	-11.399***	-12.118***	-17.986***	-11.004***	-16.840***	-9.554***	-14.320***
	(3.311)	(2.584)	(3.585)	(2.671)	(3.137)	(2.049)	(2.563)
foreign group dummy			59.979***		62.257***		52.797***
			(15.581)		(13.391)		(11.698)
swap	-8.007**	-9.007***	-12.528***	-7.548***	-10.675***	-5.693**	-8.188**
	(3.088)	(2.838)	(3.925)	(2.479)	(3.661)	(2.112)	(3.192)
constant	-32.255***	-30.968***	-87.361***	-30.634***	-89.164***	-26.621***	-77.477***
	(3.350)	(2.867)	(14.798)	(2.837)	(12.534)	(2.004)	(11.278)
bank controls	yes	yes	yes	yes	yes	yes	yes
firm FE	no	yes	yes	no	no	no	no
group FE	no	no	no	yes	yes	yes	yes
Observations	15,879	15,879	15,879	20,805	20,805	52,183	52,183
R-squared	0.020	0.438	0.438	0.112	0.112	0.080	0.079

Note: All bank controls are normalized and multiplied by 100. The LHS variable is in %point (multiplied by 100). Standard errors are clustered at the bank level. Model 0 is an OLS estimation without any demand control. The number of observations differs in model 1-2 and model 3-4, as some of the firms defined as multibank users do not have multiple observations for the independent variable. For example if a firm had loans with 2 banks in the pre-shock period, but one of the loan is terminated by the post-shock period, the log change is defined only for 1 firm-bank link, and the firm will drop out from the FE estimation.

As Jimenez et al. (2020) argue, if one compares the multibank sample OLS and FE estimate (which is regarded the „true" beta), the difference informs about the correlation between demand and supply. If those are correlated the simple OLS estimates will be biased and the difference between the two estimates will be large. In our case however the two estimates (coming from model 0 and model 1) are rather similar, implying that the correlation between (the unobserved determinants of) demand and supply is low. That enhances the credibility of the identification strategy, which relied on the assumption that banks' exposure to the funding shock and their clients demand shock are uncorrelated.

When the sample is extended to also contain **firms with a single bank relationship** (see model 5-6), demand is controlled for by industry and location dummies instead of firm FE. The results for the full sample are very similar to those obtained in the multibank case.

The cluster FEs seem to be good proxy of credit demand. If one compares model 1-2 with model 3-4 – all are estimated in the sample of multibank firms, but the former two with firm FE and the latter two with cluster FE – the results are very similar.

As the banking sector in Hungary is concentrated and most contracts are with the largest banks, it is worth checking **whether the results are driven by a few large banks** or the supply shock is detected at smaller banks too. If one drops the contracts with the four largest banks, the sample roughly halves. The results for this subset of smaller banks are very similar to the ones gained for the full sample – see Table 3. in the Appendix. There are some differences though, for example in models with clustered FE (model 3-6) the impact of foreign non-group funding is much lower, but still negative and significant. Apparently both small and large banks were affected by the supply shock, and their response was similar at least in a qualitative sense.

The results are robust to **alternative growth rate definitions**. When the dependent variable is replaced by the mid-point growth rate, the results are very similar (see Table 4. in the Appendix), although the parameters of swap positions are insignificant in models with cluster FE (model 3-6). The estimated parameters differ in some cases, which can partly be related to the different growth rate concepts. First, the mid-point growth rate includes entries and exits (non-zero lending in either the pre- or post-shock period, but zero in the other), and so the estimation includes the impact on net entry as well. The other source of difference comes from the fact, that although for smaller changes the midpoint growth rate gives good approximation for the log change, for larger values they deviate. Thus, the distribution of growth rates also influences the estimation results and may make them deviate.

When the left-hand side variable is defined for **newly granted loans** (see Table 5. in the Appendix), the results are weaker. Swap exposure and group funding still exert large and significant effect, but the parameter of non-group foreign funding is neither significant, nor robust to changes in model specification.

According to the results, reported so far, banks who relied on external funding or on the swap market squeezed their lending more than their less vulnerable peers. In contrast, being part of a foreign group was beneficial for banks, by helping them curtail the impact of the funding shock and keep up the supply of loans. This is in line with the findings of Banai et al (2010). The impact is robust, applies to all firms, irrespective of having multiple or single bank links; found not just for the largest banks but also for smaller ones; detected both for outstanding stocks and new lending although results are weaker for the latter.

The next question investigated is to what extent banks were willing to finance expanding firms, catered new entrants or cut links entirely (exit). Accordingly, three alternative dependent variables are defined: (1) A dummy which signals an increase in outstanding exposure; (2) Exit, which occurs if in the pre-shock period firm *i* has lending with bank *j*, but following the shock the exposure falls to zero; (3) Entry, which capture cases, where firm *i* have exposure at bank *j* in the post-shock period, but none before the shock. The latter two measure the extensive adjustment[16].

[16] The definition of entry and exit has its limitation, given the partial match of the datasets (not all existing firm-bank transactions are included) and the short, 1-year window used to identify the pre- and post-shock period.

If we replace lending growth by the **increase in lending dummy**, the qualitative findings are the same: banks with vulnerable funding structure – with high foreign nongroup funding and swap position – were less likely to finance expanding firms. The availability of group finance had an exact opposite impact. The estimated sensitivities are not negligible if we compare them to the actual frequencies observed in the sample: lending stock increased in 31% of the bank-firm observations. Although the economic impacts are somewhat lower than those observed at the intensive margin.

Exit rate was also affected by the funding shock (see model 3-4 in Table 3.). Banks with large swap position or foreign fund were more likely to cut previously existing relationship, or just let loans depreciate without renewing; while the availability of group funding tamed the impact of the shock. As the unconditional exit rate was around 10% in the full sample and 13.3% in the multibank sample, the estimated parameters show a material economic impact. For example, if we compare two firm-bank links with low and high (1 s.d. above and below the average) foreign fund exposure, the difference between their exit rate is 3.6%point in the multibank sample, and 2.3%point in the full sample. Regarding the probability of **entry,** significant results are obtained only for the multibank sample, and the estimated sensitivities show that large dependence on foreign non-group funding and swap positions decreased the likelihood of lending to a new customer.

Table 3
The impact of the funding shock on the probability of increase in lending, exit and entry

	Increase in outstanding lending		Exit		Entry	
	(1)	(2)	(3)	(4)	(5)	(6)
Sample:	multibank	all firms	multibank	all firms	multibank	all firms
foreign group funding	4.914***	5.608***	-1.343**	-1.249***	-0.173	0.011
	(1.054)	(0.816)	(0.529)	(0.348)	(0.228)	(0.136)
foreign nongroup funding	-4.292***	-4.366***	1.784***	1.163**	-1.210***	-0.135
	(1.130)	(1.006)	(0.405)	(0.470)	(0.336)	(0.118)
swap	-2.678**	-2.534**	1.430*	0.393	-1.518***	-0.188
	(1.132)	(1.043)	(0.806)	(0.438)	(0.425)	(0.130)
constant	26.414***	26.651***	13.888***	10.754***	3.196***	0.404***
	(1.382)	(1.100)	(0.346)	(0.564)	(0.755)	(0.101)
bank controls	yes	yes	yes	yes	yes	yes
firm FE	yes	no	yes	no	no	no
group FE	no	yes	no	yes	yes	yes
Observations	24,623	62,303	26,402	65,340	409,285	1,686,148
R-squared	0.427	0.084	0.419	0.047	0.033	0.005

Note: All left- and right-hand-side variables are multiplied by 100. The indicator of increasing lending is assigned missing value for entries. Standard errors are clustered at the bank level.

Overall results on these alternative measures confirm the findings of the basic models regarding the impact of loan supply on lending. They underline that adjustment happened both at the intensive and extensive margin.

Finally, results regarding **the impact on total lending** is summarized. In the between estimation the change in firm's total loan is regressed on firms' exposure to the supply shock, which is calculated as the weighted average exposure to the funding shock through the partner banks.

According to the results firms were not able to substitute fully their falling loans at vulnerable banks. If a firm was on average exposed to banks with more funding risk, the firm's total outstanding lending fell as well. Regarding the size of the impact, if a firm (model 1 in Table 4.) was exposed to a supply shock via the foreign funding/swap position of its partner bank(s) of 1 standard deviation above the average, its total lending fell by 4.7%point / 4.5%point more than that of a firm with average exposure. Note, that foreign nongroup funding loses its significance in the multibank sample.

The differences between the within and between estimation results indicate that some substitution has taken place though. The estimated sensitivities coming from the between estimation are much smaller than the ones coming from the within estimation (reported in Table 3.), and the differences are larger in the multibank sample. This suggests that some multi-bank firms were able to substitute their falling loans at vulnerable banks by shifting to less exposed banks.

Nevertheless, the between and within parameters may differ due to other reasons as well. First, the potential correlation between supply and demand causes the OLS estimate to deviate from the true parameter. This makes the between estimates coming from an OLS model more biased than those from the within estimation with firm FE – as the model with firm FE is closer to the true model. However, we have seen above that the correlation between supply and demand is relatively low: the estimated within parameters of the OLS and FE models (see Table 2. model 0 and model 1) are similar for multibank users. If that is true for the bank-firm sample, the same should apply for the firm sample. See Jimenez et al. (2020) for more details. Second, the within and between estimates may also diverge if the distribution of bank and firm exposures differ. If that is the case, the parameters are calculated at a varying distance (of 1 s.d.) from the average exposure. But the differences in distribution are too small to explain the drop in the estimated parameters. Table 6. in the Appendix calculates the true parameters for the between estimation for multibank firms, using the formula of Jimenez et al. (2020). Even after correcting for potential correlation between demand and supply and the differences in the variance of firm and bank exposure, the between estimates remain significantly lower than the within estimates. This indicates that substitution indeed took place among multibank users.

Table 4
The impact of the supply shock on total lending – between estimation

	Log change in total lending			
	(1)	(2)	(3)	(4)
Sample:	all firms	all firms	multibank	multibank
foreign group funding - firm exposure	5.494***	5.408***	5.873***	5.350***
	(1.001)	(0.939)	(0.978)	(0.873)
foreign nongroup funding - firm exposure	-4.712***	-3.759***	-0.450	-0.675
	(0.890)	(0.817)	(1.241)	(1.311)
swap - firm exposure	-4.547***	-4.040***	-2.570***	-2.238**
	(0.789)	(0.773)	(0.800)	(0.932)
constant	-69.726***	-30.630***	8.726	-12.773***
	(10.205)	(0.407)	(9.745)	(0.421)
bank controls	yes	yes	yes	yes
firm group FE	yes	yes	yes	yes
firm controls	yes	no	yes	no
Observations	28,819	34,859	9,568	10,859
R-squared	0.107	0.091	0.149	0.133

Note: the exposure of firm is calculated as the weighted average of the exposure of the banks, whom the firm is exposed to. The weights equal the value of outstanding lending before the shock. Standard errors are clustered at industry and location level.

In model 1 and 3, in addition to cluster FEs, other firm characteristics are also controlled for. This helps disentangling firm and bank balance sheet effects. The effect of bank supply remains material and significant after adding firm controls.

5.2 HETEROGENEITY OF BANKS' RESPONSE

The question investigated next is, whether banks differentiated among their clients and punished certain type of firms: small, young, or risky more. Table 5. reports the estimation results for several models, in which bank vulnerability indicators are interacted with firm size: log total asset and log number of employees, age, and risk (probability of default[17]). We expect that the bank supply shock hit smaller, younger, or riskier firms harder. That is supported by the estimation if the interaction of foreign non-group and swap variable with the size or age of firm has positive sign (when the supply shock hits, larger/older firms' exposure at a given bank declines less than that of smaller/younger firms); and negative in case of risk (riskier firms suffer larger decline in lending). And exactly the opposite signs are expected for the interaction with foreign group funds.

The results suggest that banks favored larger firms, but the impact of age and risk is ambiguous. When firm characteristics are interacted with banks' exposure one by one, the size of the firm has a positive impact on lending: banks with significant exposure on the swap market lowered lending less to large firms. The impact of risk is ambiguous, as risky firms face larger fall in borrowing at banks with significant swap position, but also larger fall at banks with large buffer in the form of group funding. In the case of age, none of the interaction terms are significant.

Table 5
Heterogeneity by firm characteristics

	Log change in lending			
	(1)	(2)	(3)	(4)
foreign group funding	6.713**	7.194**	6.461*	5.791*
	(3.212)	(2.990)	(3.179)	(3.229)
foreign nongroup funding	-8.101***	-7.113***	-8.255***	-9.196***
	(1.153)	(1.191)	(1.075)	(1.181)
swap	-4.737**	-5.091**	-4.562**	-4.696**
	(2.137)	(1.959)	(2.127)	(2.017)
foreign group funding, squared	2.071	1.964	2.102	2.519
	(1.879)	(1.795)	(1.833)	(1.970)
foreign nongroup funding, squared	-3.875***	-4.188***	-3.654***	-3.524***
	(0.887)	(0.923)	(0.817)	(0.838)
swap, squared	1.527*	1.850**	1.205	0.598
	(0.814)	(0.813)	(0.760)	(0.872)
Interacted firm variables:	**log employee**	**log total asset**	**age**	**PD**
firm variable	-0.020*	-0.033***	-0.965***	-2.222***
	(0.010)	(0.010)	(0.133)	(0.175)
with foreign group funding	0.011	0.004	0.081	-0.580***
	(0.006)	(0.006)	(0.115)	(0.193)
with foreign nongroup funding	0.003	0.004	-0.183	-0.334**
	(0.014)	(0.013)	(0.145)	(0.137)
with swap	0.012**	0.012**	0.172	0.120
	(0.006)	(0.005)	(0.133)	(0.225)
bank controls	yes	yes	yes	yes
firm group FE	yes	yes	yes	yes
firm controls	yes	yes	yes	yes
Observations	50,984	52,013	52,183	41,598
R squared	0.084	0.084	0.084	0.089

Note: Estimation is conducted on the full sample. Bank variables are normalized, the interacted firm variables are demeaned. Thus, the parameter of each bank variable shows the impact at the firm with average characteristics (size, age, risk). Altogether 4 models' results are reported. All three bank variables are interacted with one firm characteristic. Standard errors are clustered at bank level.

[17] Predictions are made using the results of Bauer and Endresz (2016).

Note, that in these models foreign non-group funding affect lending in a nonlinear way, the squared term is highly significant.

The calculated differences by firm size are significant, but small. For example, in model 1 the only significant interaction with size equals 0.012. This small parameter implies a less than 1%point difference in fall of lending between a very large and very small firm (with employees of 3 s.d. above/below average) at a bank with large swap position.

As the sample contains many micro and small firms, the use of log employment or total assets to infer about heterogeneity might conceal actually large differences between large and small firms. Therefore, an alternative specification is estimated, where instead of log employment and total assets, a categorical variable is defined, which corresponds to the EU classification based on employment, total assets and turnover. Because of the small number of large firms in the sample, the medium and large categories are merged.

The estimation with size categories (see Table 6.) unveils much larger differences between firms of different size. When the size categories are interacted with bank exposures, micro firms are found to be affected the most by the supply shock. A large swap exposure (of 1 s.d. above average) causes a 7.3%point smaller fall in lending for medium and large firms relative to micro firms. A difference between small and micro firms in terms of fall in lending is 2.4%point.

Table 6
Heterogeneity by firm characteristics – size categories

	Log change in lending		
	(1)		
foreign group funding	6.065*		
	(3.403)		
foreign nongroup funding	-7.341***		
	(2.479)		
swap	-6.500**		
	(2.446)		
foreign group funding_squared	2.037		
	(1.826)		
foreign nongroup funding_squared	-4.046***		
	(0.888)		
swap_squared	1.951**		
	(0.813)		
Interacted firm variables:	**micro**	**small**	**large**
firm variable: size group	0	-5.762**	-6.863
		(2.134)	(4.905)
with foreign group funding	0	1.334	3.305
		(1.389)	(3.085)
with foreign nongroup funding	0	0.279	-1.288
		(3.063)	(7.281)
with swap	0	2.362**	7.346***
		(1.093)	(2.545)
bank controls	yes		
firm group FE	yes		
firm controls	yes		
Observations	52,183		
R squared	0.082		

Note: Estimation is conducted on the full sample. Bank variables are normalized. Thus, the parameter of each bank variable shows the impact on micro firms. All three bank variables are interacted with firm size categories. Standard errors are clustered at bank level.

Firms of different size tend to have varying financial or real characteristics. As the estimation contains other firm controls, the effect of these differences in profitability, availability of collateral or leverage is filtered out. What we calculate is the "pure" firm size effect.

5.3 AGGREGATE IMPACT

We have seen that the impact of the supply shock was economically significant. There was a material difference in lending fall depending on the vulnerability of the bank. But we are also interested in the macroeconomic importance of the shock and its effect: by how much total lending fell due to the funding shock? Or putting it another way: how lending would have evolved, had the banks been subject to lower funding risk? The challenge is, that we do not know what the counterfactual exposure of banks would have been. We can still come up with some back of the envelope estimation. In the first scenario it is assumed that banks' exposure to foreign funds and swap is half of the actual. This scenario implies a significant reduction in exposure, where funding risks remain still sizable: in the full sample the median value of group funding, non-group funding and swap exposure are 15.1, 10.9 and 6.7 respectively. Beware, as foreign group fund acted as a buffer, lowering its share will increase the fall in lending. In the second, more extreme scenario zero exposure is assumed for all banks. Practically we assume that banks replaced their foreign funding and swap with local, safe finance. All other bank controls are left unchanged.

To calculate the aggregate impact, in the first step model 1 in Table 4.[18] is used to predict the log change of outstanding lending for all the firms in the sample. This is done for the actual and the assumed (scenario) values of the funding risk variables. Then the predicted growth rates and pre-shock lending values are used to calculate the change in terms of aggregate lending. The difference between the actual and the assumed scenario provides a proxy for the aggregate impact of the funding shock via each source of funding risk or buffer.

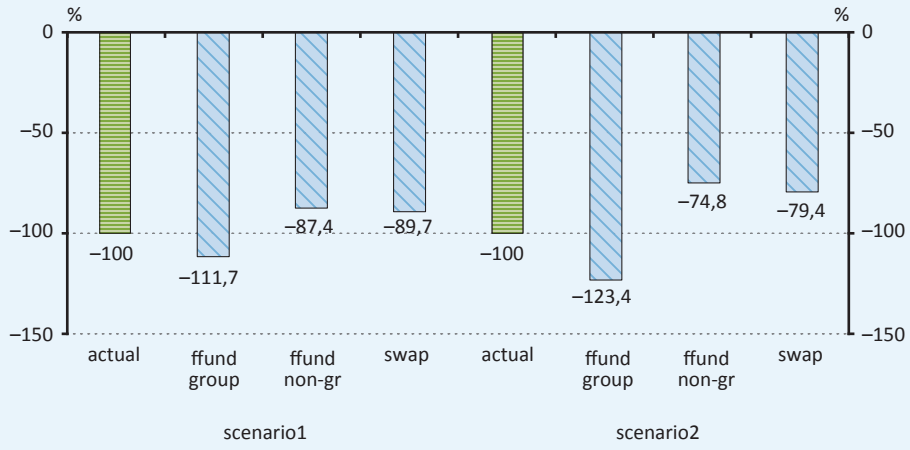
This is a crude approach, not just because of the arbitrary modification of banks' exposure, but also because we ignore multicollinearity between the right-hand-side variables, including the funding variables and other bank controls.

The results are reported in Chart 3. The green column is the baseline and shows the predicted fall in aggregate lending at the actual exposure of banks. The blue columns show the fall in aggregate lending for each scenario and for each funding variable. The green columns are all made equal -100%, to show the effect of each scenario in percentage point relative to the baseline. The bigger the difference between the green and blue column, the more influential the funding shock through the exposure examined.

The results show, that had the reliance on foreign non-group funds and swap positions been halved, the fall in aggregate lending would have been lowered by 23%. In the less likely case, where all exposures are eliminated (made equal zero), the aggregate fall is decreased by 45.8%. According to these calculations a significant part of the fall in lending was related to the funding shock banks were subject to.

[18] Because of technical reasons, I re-estimate model 1 on raw instead of normalized bank variables. The impact of scenario 2 cannot be calculated using the original models, as variables with all zero observations cannot be normalized. For the 1st scenario the two versions give very similar results.

Chart 3
Aggregate impact for two scenarios (scenario1 left, scenario2 right panel)



Note: In scenario 1 the exposure of banks is halved. In scenario 2 all exposures are eliminated, made equal to zero. The table shows the impact of lower vulnerability/buffer as a percentage of the predicted fall in aggregate lending at the actual exposure of banks.

5.4 THE IMPACT ON FIRMS' REAL PERFORMANCE

To investigate the real impact of the lending supply shock, 2SLS IV regression is conducted, where the previously identified drivers of loan supply are used as instruments. The supply shock might have heterogenous impact not just on lending, but also on the real performance. Small, young, or high-risk firms are likely to be liquidity constrained and to have limited access to alternative financing sources. If that is true, a given lending supply shock will have larger impact on them. It is supported by the estimation if the parameter of the interaction term with size and age is negative, while positive for PD.

The credit supply shock had a negative effect on net investment[19]. One percent fall in lending due to the supply shock caused 0.16-0.19%point lower net investment (model 1 and model 2). As the PD cannot be predicted for all firms in the sample, in model2 PD is dropped from firm controls, which increases the sample size and slightly changes the estimated parameters. If we take the average fall in firm-level borrowing, which is 11%, and assume that roughly 1/3 of it was due to supply (see chapter 5.3), its effect on net investment is -0.6%. This is a material impact, given that in the estimation sample of model 1 the average of net investment is -3.3%, while the median is – 5.1%.

When firm characteristics are interacted with the lending variable one by one, heterogeneity is found only for firm size (model 3). The negative parameter of the size interaction suggests that the lending shock was more influential for smaller firms. When all three interactions (size, age and risk) are included in the model, both age and risk become significant. In model 6 the supply shock does not influence net investment at firms with average age, size, and PD – the estimated parameter of the lending variable itself is not significant. But the impact becomes significant through the interaction terms and varies with the characteristics of the firm. Smaller and riskier firms are more affected by the changes in lending supply. The result on the effect of age is unintuitive: given the size and PD of the firm, older firms are found to be more affected by the shock. This can be related to the multicollinearity of these variables. Both size and risk changes with age, as young firms tend to be smaller and riskier. The instruments are strong according to the F statistics.

[19] Net investment is defined as the log change in capital, where capital is calculated with the Perpetual Inventory Methods. Capital is calculated on a long time series starting in 1995, in order to eliminate the impact of the assumption on the initial capital.

Table 7
The real impact of the supply shock

	Net investment					
	(1)	(2)	(3)	(4)	(5)	(6)
dlog lending	0.157*	0.188**	0.053	0.060	0.071	0.062
	(0.071)	(0.080)	(0.110)	(0.108)	(0.112)	(0.120)
dlog lending			0.000	-0.000	-0.000	0.001
			(0.001)	(0.001)	(0.001)	(0.001)
dlog lending			-0.122*			-0.251***
			(0.074)			(0.096)
dlog lending				-0.004		0.108**
				(0.033)		(0.049)
dlog lending					0.051	0.036**
					(0.087)	(0.016)
firm group FE	yes	yes	yes	yes	yes	yes
firm controls	yes	yes/no PD	yes	yes	yes	yes
Observations	28,647	32,967	28,647	28,647	28,647	28,647
F test: weak instrunents	20.16	56.23	41.83	35.81	38.76	37.48

Note: The dependent variable is expressed in percentage point and shows the change in capital between 2007 and 2009. Bank controls are normalized. Interacted firm variables are demeaned, so that the parameter of lending shows the impact of the supply shock at the firm with average size, age or PD. Each column corresponds to one estimation. As the inclusion of PD lowers the sample size, model 2 replicates model 1 but excluding PD. Standard errors are clustered at industry and location level.

6 Conclusion

At the end of 2008, the Hungarian banking sector faced with a severe liquidity crisis, due to the flight of foreign capital and problems on the swap market. The paper uses a matched firm-bank dataset and exploits the within firm variation of lending from banks with varying exposure to the funding shock to identify the drivers and the impact of the supply shock. The existence of firms with multiple bank links is utilized in a diff-in-diff framework where firm fixed effects are added to control for demand.

According to the evidence banks who had unhealthy funding structure before the crisis squeezed their lending more than their peers. While direct foreign funding and the use of swap lowered lending, the reliance on foreign group funds acted as a buffer. In the sample of continuing borrowers with multiple bank links a bank with large exposure on foreign funds (swap position) of 1 standard deviation above the average cut lending by 12%point (9%point) more. While banks with access to large parent funds provided 10%point more lending. This impact is economically significant given that the average fall in lending was about 25% among multibank users. The supply shock equally affected multiple and single banks users, and was rather widespread, not just driven by a few large banks.

The adjustment took place both at the intensive margin (continuing borrowers) and at the extensive margin. The probability of exit or failure to renew expiring loans was larger and the probability of granting loan to new customer was lower at banks with severe funding problems. Moreover, the probability of an increase in lending was also lower at banks more affected by the funding shock.

Firms were not able to fully compensate the fall in lending supply by switching to less exposed banks. Significant impact of the funding shock is detected in the between estimation as well. Firms with larger exposure to the funding shock via their link with vulnerable banks faced a steeper cut in their total lending. The calculated impact of large foreign market funding and swap position are -4.7% and -4.6% respectively. These sensitivities coming from the between estimation are lower than those from the between estimation, which implies that some substitution took place in the group of firms with multiple bank links.

The paper found evidence on banks differenting among firms by their size. Banks favored larger firms in the allocation of loans in response to the funding shock.

Back of the envelope estimations show, that the aggregate impact of the supply shock must have been significant. Had the exposure to the funding shock been more moderate (exposure to foreign market funds and swap halved), the fall in aggregate lending would have been 23% lower.

The supply shock led to a fall in lending which in turn had an impact on firms' real activity. One percentage fall in lending due to the supply shock lowered firms' capital (net investment) by 0.15%. The real impact was heterogenous, varied by the size and risk of firm, which suggests the existence of liquidity constraints for certain groups of companies.

7 Appendix

Definition of firm and bank variables	
profitability:	cash flow / total assets
leverage:	1 – equity / total assets
labor productivity:	RVA / employees
collat:	fixed assets / total assets
export:	1 if export share> 0.1
foreign:	1 if share of foreign owners >= 0.2
swap ratio:	net FX swap position / total assets
foreign nongroup fund ratio:	foreign non-group funds / total assets
foreign group fund ratio:	foreign funds from group members / total assets
loan to deposit ratio:	loans / deposits
CAR:	regulatory capital / risk weighted assets
provision ratio:	loan loss reserves (specific provisions) / gross value of rated assets

Table 1
Factors behind banks' willingness and ability to lend

Over the past period how did the following factors contribute to the change in your bank's willingness to grant loans or credit lines to enterprises? (net change indicator, positive: contributed to increase)

	2008 H2	2009 Q1	2009 Q2	2009 Q3
Changes in bank's current or expected capital position	-9.6%	0.0%	10.0%	29.2%
Changes in bank's current or expected liquidity	-86.7%	-57.5%	10.0%	22.5%
Economic outlook	-100.0%	-100.0%	-62.3%	-31.6%
Industry-specific problems	-100.0%	-100.0%	-62.3%	-50.9%
Competitive situation with other banks or non-banks	-8.9%	11.9%	22.6%	40.6%
Changes in risk tolerance	-88.9%	-88.9%	-7.,9%	-50.9%
Market share goals	-18.4%	0.0%	10.0%	-20.2%

Source: Senior Loan Officer Survey, MNB. Average of banks. Value -100% means, that all the banks regard the factor as a contributor to decreasing lending.

Table 2
Bank Characteristics (calculated on the bank-firm dataset)

		Foreign group funds	Foreign non-group funds	Swap	LtD	CAR	Provisioning
all firms	mean	13.53	11.54	8.63	148.02	10.59	2.01
	median	15.1	10.92	6.74	138.19	9.84	1.26
	s.d.	13.21	8.8	5.44	63.71	2.33	1.34
single bank firms	mean	13.78	11.67	7.72	157.42	10.75	2.13
	median	7.81	10.92	6.52	138.19	9.84	1.33
	s.d.	14.00	10.92	5.57	68.01	2.90	1.51
multi bank firms	mean	13.64	11.59	8.26	151.86	10.65	2.05
	median	15.10	10.92	6.73	138.19	9.84	1.26
	s.d.	13.54	8.89	5.51	65.66	2.58	1.42

Table 3
The impact of loan supply on lending – the 4 largest banks are dropped

	Log change in oustanding lending- for largest banks dropped					
	(1)	(2)	(3)	(4)	(5)	(6)
Sample:	multibank	multibank	multibank	multibank	all firms	all firms
foreign group funding	15.733***		14.116***		10.423***	
	(4.029)		(1.725)		(0.884)	
foreign nongroup funding	-13.947***	-14.701***	-7.322***	-7.977***	-4.180***	-5.034***
	(4.169)	(4.349)	(2.050)	(2.286)	(1.366)	(1.522)
foreign group dummy		58.635***		51.394***		42.166***
		(16.207)		(10.091)		(7.039)
swap	-8.884**	-14.120**	-6.524**	-10.880***	-5.519**	-9.263***
	(3.433)	(4.966)	(2.297)	(3.543)	(2.357)	(3.162)
constant	-22.004***	-70.968***	-21.015***	-63.801***	-15.871***	-52.458***
	(2.037)	(14.042)	(1.792)	(8.134)	(1.587)	(5.747)
bank controls	yes	yes	yes	yes	yes	yes
firm FE	yes	yes	no	no	no	no
group FE	no	no	yes	yes	yes	yes
Observations	4,591	4,591	10,159	10,159	24,744	24,744
R-squared	0.460	0.459	0.137	0.136	0.090	0.089

Table 4
The impact of loan supply on lending – mid-point growth rate

	Mid-point growth rate in lending					
	(1)	(2)	(3)	(4)	(5)	(6)
Sample:	multibank	multibank	multibank	multibank	all firms	all firms
foreign group funding	9.696***		10.632***		10.726***	
	(3.293)		(3.757)		(2.845)	
foreign nongroup funding	-7.442***	-11.594***	-6.647**	-10.146**	-6.307***	-9.782***
	(2.196)	(3.685)	(2.684)	(3.976)	(1.771)	(2.762)
foreign group dummy		46.373**		42.735*		41.686**
		(20.205)		(20.793)		(16.220)
swap	-9.796**	-11.654**	-6.530	-7.613	-4.393	-5.297
	(4.369)	(5.516)	(4.923)	(6.144)	(3.801)	(5.112)
constant	-22.267***	-65.834***	-23.495***	-63.518***	-18.834***	-58.823***
	(2.483)	(18.238)	(2.854)	(18.630)	(2.684)	(14.738)
bank controls	yes	yes	yes	yes	yes	yes
firm FE	yes	yes	no	no	no	no
group FE	no	no	yes	yes	yes	yes
Observations	26,402	26,402	27,762	27,762	65,340	65,340
R-squared	0.403	0.403	0.089	0.087	0.063	0.061

Table 5
The impact of loan supply on new lending

	Log change in new lending					
	(1)	(2)	(3)	(4)	(5)	(6)
Sample:	multibank	multibank	multibank	multibank	all firms	all firms
foreign group funding	12.291**		9.728***		8.217***	
	(5.794)		(2.107)		(1.849)	
foreign nongroup funding	1.978	-3.696	1.591	-2.389	0.077	-3.623
	(6.893)	(6.076)	(4.057)	(4.203)	(2.819)	(2.877)
foreign group dummy		80.032**		38.848**		36.189**
		(31.494)		(16.117)		(15.397)
swap	-13.376**	-15.993**	-9.430**	-9.740**	-7.535**	-8.185**
	(6.344)	(6.382)	(4.257)	(4.682)	(2.817)	(3.179)
constant	-10.435***	-86.462***	-17.313***	-54.220***	-13.105***	-48.286***
	(3.165)	(29.179)	(2.261)	(14.963)	(1.557)	(15.212)
bank controls	yes	yes	yes	yes	yes	yes
firm FE	yes	yes	no	no	no	no
group FE	no	no	yes	yes	yes	yes
Observations	1,559	1,559	5,926	5,926	15,496	15,496
R-squared	0.486	0.486	0.172	0.172	0.107	0.107

Table 6
Calculating the "true" parameters for the between estimation

	within estimation			between estimation		
	OLS	**group FE**	**firm FE**	**OLS**	**group FE**	**TRUE**
foreign group funding	0.871***	0.844***	0.758***	0.445***	0.450***	0.230
	(0.195)	(0.179)	(0.179)	(0.105)	(0.116)	
foreign market funding	-1.260***	-1.236***	-1.339***	-0.408***	-0.410**	-0.512
	(0.366)	(0.313)	(0.286)	(0.151)	(0.163)	
swap	-1.414**	-1.489***	-1.591***	-0.807***	-0.969***	-1.074
	(0.545)	(0.477)	(0.501)	(0.258)	(0.271)	

Notes: The "true" parameters for the between estimation are calculated following Jimenez et al (2020), using the following formula:

$$\beta^{between} = \beta_{OLS}^{between} - \left(\beta_{OLS}^{within} - \beta_{FE}^{within}\right) * \left(\frac{Var_i}{Var_j}\right),$$

where Var_i and Var_j are the variance of banks' and firms' exposure (in the bank-firm and firm sample). For this calculation variables are not normalized. Only firms with multibank links are included.

8 References

Amador, J. and A. J. Nagengast (2016) *The effect of bank shocks on firm-level and aggregate investment*. ECB Working Paper Series No 1914

Amiti, M. and D. E. Weinsten (2018) *How Much Do Idiosyncratic Bank Shocks Affect Investment? Evidence from Matched Bank-Firm Loan Data*. Journal of Political Economy, 2018, vol. 126, no.2

Banai, A. (2016) *Drivers of bank lending in Hungary – roles of bank-specific and macro factors.* Phd dissertation, chapter 5. In Hungarian: A banki hitelezést meghatározó tényezők – középpontban a bankok helyzete és a makrokörnyezet. Közgazdasági Szemle, Vol LXIII. February 2016.

Bauer P. and M. Endresz (2016) *Modelling bankruptcy using Hungarian firm-level data.* MNB Occasional Paper 122.

Bottero, M., S. Lenzu and F. Mezzanotti (2019) *Sovereign debt exposure and the bank lending channel: impact on credit supply and the real economy.* Mimeo. Earlier version: Banca d'Italia Temi di Discussione 2015. No. 1032.

Bripi F., D. Loschiavo and D. Revelli (2017) *Services trade and credit frictions: evidence from matched bank-firm data.* Banca d'Italia Temi di Discussione No 1110

Buera, F. and S. Karmakar (2018) *Real effects of financial distress: the role of heterogeneity.* Banco de Portugal WP 6.

Cingano, F., F. Manaresi and E. Sette (2016) *Does Credit Crunch Investment Down? New Evidence on the Real Effects of the Bank-Lending Channel.* The Review of Financial Studies v 29 n 10

Davis, S. J., J. C. Haltiwanger, and S. Schuh. (1996) *Job Creation and Destruction*. Cambridge MA: MIT Press.

Endresz M., Gy. Gyöngyösi and P. Harasztosi (2012) *Currency mismatch and the sub-prime crisis: firm-level stylised facts from Hungary.* MNB WP 2012/08

Jimenez, G., A. Mian, J.-L. Pedro and J. Saurina (2020): *The real effect of the bank lending channel.* Journal fof Monetary Economics January 2020

De Jonghe, O., H. Dewachter, K. Mulier, S. Ongena and G. Schepens (2019) *Some borrowers are more equal than others: bank funding shocks and credit allocation.* ECB WP No 2230

Khwaja A.I. and A. Mian (2008) *Tracing the Impact of Bank Liquidity Shocks: Evidence from an Emerging Market.* American Economic Review 2008, 98:4

Liberti J. M. and J. Sturgess (2017) *The Anatomy of a Credit Supply Shock. Evidence from an Internal Credit Market*. Journal of Financial and Quantitative Analysis

Manaresi F. and N. Pierri (2019) *Credit Supply and Productivity Growth*. IMF WP/19/107

Páles J., Zs. Kuti and Cs. Csávás (2010) *A devizaswapok szerepe a hazai bankrendszerben és a swap piac válság alatti működésének vizsgálata.* MNB Tanulmányok 90.

Paravisini, D., V. Rappoport, P. Schnabl and D. Wolfenzon (2015) *Dissecting the Effect of Credit Supply on Trade. Evidence from a Matched Credit-Export Data.* Review of Economic Studies 82.

Temesváry, A. and A. Banai (2017) *The drivers of foreign bank lending in Central and Eastern Europe: The roles of parent, subsidiary and host market traits*. Journal of International Money and Finance 79.

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September 2020

Print: Prospektus Kft.

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