Essays in Empirical Banking and Financial Stability

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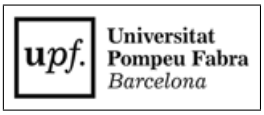

To my parents.

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Abstract

In the first two chapters of this thesis, I study the effects of financial stability policies on bank behavior. Thus, in the first chapter, I analyze whether liquidity provision mechanisms may have unintended redistributive consequences for the credit markets. I show that by accepting certain assets as collateral, the central bank can significantly alter bank competition and, therefore, prices in the primary markets of asset. The second chapter analyzes the efficacy of a central bank policy of hedger of last resort. It demonstrates that by absorbing on its balance sheet part of the FX risks, the central bank can affect funding costs of the domestic credit institutions and, by doing so, support bank loan supply. The last chapter presents evidence on the importance of asset encumbrance for credit risks of banks. It documents that while in normal circumstances encumbrance is associated with smaller credit risk premiums, it can be heavily priced in for financially-troubled banks.

Resum

En els dos primers capítols d'aquesta tesi, estudio els efectes de les polítiques d'estabilitat financera sobre el comportament dels bancs. Així, en el primer capítol, analitzo si els mecanismes de subministrament de liquiditat poden tenir conseqüències redistributives no desitjades per als mercats de crèdit. Mostro que, mitjançant l'acceptació de certs actius com a garantia, el banc central pot alterar substancialment la competència bancària i, per tant, els preus als mercats d'actius primaris. El segon capítol analitza l'eficàcia de la política de cobertura d'últim recurs d'un banc central. Demostra que, absorbint en el seu balanç una part dels riscos associats als mercats de divises, el banc central pot influir sobre els costos de finançament de les entitats de crèdit domèstiques i, en fer-ho, recolzar el subministrament de préstecs bancaris. L'últim capítol presenta evidències sobre la importància del gravamen dels actius per als riscos crediticis dels bancs. Documenta que, si bé en circumstàncies normals el gravamen està associat a primes de risc de crèdit més petites, pot encarir-se molt per als bancs amb problemes financers.

Preface

Banking and financial regulation is a fascinating area of economic studies. Understanding mechanisms underlying financial intermediation is crucial for crisis management, yet the field is full of unsettled discussions. In this thesis, I try to contribute to the economics of banking by providing empirical evidence on the effects of financial stability policies and the determinants of bank credit.

In the first chapter, I analyze whether the central bank policies of liquidity provision are neutral for the underlying collateral markets. Because of data availability and difficulties in identification, academic discussion of the regulator collateral frameworks hardly leaves the theoretic domain. This chapter provides an empirical evidence suggesting that the liquidity provision policy may affect the primary markets of collateralizable assets and redistribute the funding risks among the ultimate borrowers. To demonstrate this, I trace the outcomes of the collateral policy amendment that took place in Russia in 2015. Using difference-in-difference setup, I document that the borrowers earned an interest rate discount as long as their liabilities were pledgeable under the updated refinancing program. To isolate the credit supply role, I show that it is the liquidity-constrained banks who became more central in the market competition and offered noticeably lower interest rates to the collateralizable claims. The effect is robust to a wide range of tests, including a control for unobserved heterogeneity at the loan contract level. These results suggest that, while designed to ensure financial stability and, at the same time, preserve central bank independence, liquidity provision mechanisms may have significant redistributive implications.

The second chapter relies on a joint project with Rodrigo Gonzalez, José Luis Peydró, and Andrea Polo where we investigate the role of a central bank in the provision of hedging against FX risks. Experience of the emerging markets has demonstrated that foreign debts of domestic commercial banks may become costly in times of local currency devaluation or high FX rate volatility. Whether these costs arise from the re-evaluation of bank liabilities or expensive hedging, they may impede the credit supply and, in the extreme circumstances, require central bank intervention. While in a standard setup the regulator may try to interfere the spot FX markets, it can also act as a "hedger of last resort" and provide the necessary insurance against high FX risks via derivate instruments. The chapter is devoted to the analysis of the efficacy of this policy in Brazil, where the central bank implemented a massive derivative market intervention in the aftermath of the Bernanke Tapering speech. We use corporate credit register of Bank of Brazil to show that local banks with larger exposure to the FX risks reduced their credit supply in the aftermath of the US monetary shock. We further match this data with the employer-employee dataset from Ministry of Labor and Employment to estimate the transmission of credit supply shocks to the real sector. Finally, we show that the FX exposure had a smaller effect on the bank loan provision after the central bank committed to absorbing part of the risk by intervening in the FX derivatives. This result suggests that the policy can serve as a useful tool in decreasing local

economy exposure to the global financial conditions.

The last chapter investigates the connection of asset encumbrance and bank credit risks. It is based on a paper written jointly with Albert Banal-Estañol and Enrique Benito. Asset encumbrance refers to the existence of bank balance sheet assets being subject to arrangements that restrict the bank's ability to transfer or realize them freely. It has recently become a much-discussed issue, and policy-makers have been actively addressing what some consider to be excessive levels of asset encumbrance. Despite its importance, the phenomenon remains poorly understood. We build a novel dataset of asset encumbrance metrics based on information provided in the banks' public disclosures for the very first time throughout 2015. Using different metrics, we provide descriptive evidence of asset encumbrance levels by country, credit quality, and business model. Our empirical results point to the existence of a negative association between CDS premia and encumbrance of bank's assets. That is, on average encumbrance is perceived to be beneficial. We then identify bank characteristics that play a mediating role in this relationship. Encumbrance appears to have more information content about institutions with low credit ratings. For banks that have high exposures to the central bank, high leverage ratio, or are located in southern Europe, asset encumbrance is less beneficial and could even be detrimental in absolute terms. While the analysis of the first two chapters aims at estimating causal relationships, due to identification challenges the last part of the thesis follows a more descriptive approach. Nevertheless, it provides a first empirical evidence for the highly debated topic and can serve as a solid starting point for further research.

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Chapter 1

CENTRAL BANK LIQUIDITY PROVISION AND SEGMENTATION OF COLLATERAL MARKETS

1.1 Introduction

Liquidity provision mechanisms operated by the central banks are at the core of financial stability and monetary policy implementation. In most modern economies injection of high-powered money into the financial system occurs fully or partially via central bank lending to commercial banks against eligible collateral assets. Aimed at maintaining the money rate close to the required levels, liquidity injections directly affect the aggregate amount of central bank money as well as its distribution across the market participants.

It is generally accepted that segmented money markets can severely harm banks supply of credit to the real sector. Viewed from this perspective, central bank collateral framework that allows efficient distribution of liquidity in the money markets is an important part of monetary and financial stability policy. What is less understood, though, is the reaction of the markets of pledgeable assets on the shifts in the collateral frameworks, which itself is an important factor to consider when forming collateral policy.

In spite of its importance to monetary systems, collateral framework analysis frequently stays outside of academic attention. The scarcity of the required data as well as the general difficulty of empirical identification of the relevant effects are, presumably, the main reasons for a lack of applied research in this field. Relative opacity and versatility of existing collateral frameworks present additional problems for empirical studies.

In this paper, I try to address this challenge by tracing the consequences of collateral policy change that took place Russia in February 2015. Faced with

shrinking collateral base comprised of marketable securities, the Bank of Russia (BoR) announced a list of entities — regional and local governments — whose non-marketable debts were said to constitute eligible collateral in the refinancing operations. I show that the policy induced significant fragmentation of the underlying credit markets and drove a wedge between the borrowers of different eligibility status. To demonstrate this, I first use difference-in-difference setup and show that the BoR decision created a gap in the costs of credit of the two types of borrowers. In contrast to the non-eligible claims, collateralizable debts received an additional 0.7pp discount after the introduction of the policy.

Second, I provide further evidence that the above-mentioned interest rate gap is not driven by confounding factors, in particular, changes in the borrower credit risks. To do this I explore the details of the institutional setup that allow me to observe the interest rates offered by *all* the lenders competing for the *same* loan contract. Accounting for unobservable loan heterogeneity, I demonstrate that in the eligible collateral segment the most attractive loan conditions were offered by the banks that strongly depended on the central bank funding or had high rates of marketable collateral utilization.

I next recast the analysis of the credit market segmentation in terms of commonality of borrowers of the competing banks. This allows me to quantify the collateral policy effects on market competition from the perspective of network analysis. I show that short-in-liquidity lenders became more central to the competition in the eligible collateral segment as funding constraints crowded out the traditional factors of bank sorting. Effectively, the collateral framework reallocated competition across the market segments and acted as a redistribution mechanism leaving part of the credit risks on the regulator balance sheet and allowing eligible borrowers to enjoy an interest rate subsidy.

These findings contribute to the literature on assets liquidity and on the effects of interventions in the financial markets. In the theory of money, the recent developments of the new monetarist approach by Lagos and Wright provide search-theoretic foundations of the liquidity premium attached to the assets performing functions of money in trade (Kiyotaki and Wright (1993), Lagos and Rocheteau (2009)). In this framework asset liquidity ("moneyness") arises endogenously as a response to the underlying search frictions (Nosal and Rocheteau (2011)). The liquidity premium is larger for the assets that provide easier access to the means of debt settlement — central bank money in the context of this paper.

Liquidity provision during a systemic crisis is one of the central topics of theoretical banking. Bhattacharya et al. (1985) point out that liquidity provision is a public good and, thus, can be subject to under-provision by the private sector. Central bank interventions favoring illiquid collateral may further exacerbate the free-rider problem and, as a result, affect the allocation efficiency of the economy. Rochet and Vives ((Rochet, 2009, Ch. 2)) recast Bagehot principle in a model of bank runs within a "global game" approach and show that solvency and liquidity regulation can solve coordination failure — a fundamental driver of bank fragility. Emergency liquidity provision can complement these measures to minimize the so-

cial costs of the liquidity crisis. Freixas, Parigi, and Rochet ((Rochet, 2009, Ch. 3)) find that the lender of last resort may be important to the economy even in the absence of contagion risks, albeit, this conclusion depends on the monitoring role of the banks and the quality of market discipline. Bindseil (2013) in a simple model relates liquidity provision to asset fire sales and notes that central bank collateral framework acts as a monetary policy tool, especially when the regulator faces the zero lower bound.

There is a vast literature on the effects of bank collateral and liquidity constraints on the real sector (Bernanke and Gertler (1989), Kiyotaki and Moore (1997), Khwaja and Mian (2008), Iyer et al. (2013) to name a few), as well as on the spillovers of money market shocks to other financial markets (Nyborg and Östberg (2014), Brunnermeier and Pedersen (2009)). Bindseil et al. (2009) and BIS (2013) provide a comprehensive overview of central bank risk management practices, in particular, on collateral policy. However, with a few exceptions, the empirical literature on the effect of liquidity provision on the collateral markets is rather scarce.

Nyborg (2017) presents a detailed description of the ECB collateral framework and argues that it may impair market discipline and encourage overproduction of illiquid assets. Fecht et al. (2016) document existence of systemic arbitrage whereby weaker banks shift part of their credit risk exposure to the central bank by borrowing from it against low-quality collateral. Perhaps, the closest paper in terms of the questions I try to address is by Van Bekkum et al. (2016) where authors examine a change in the ECB collateral policy and document its impact on bank risk-taking in the Netherlands. I contribute to their discussion by exploring granularity of the data that allows me to isolate the importance credit supply. I further argue that the predominance of price or quantity effect is likely to be highly dependent on the elasticity of credit demand. Given that the latter is rather insensitive to the interest rate, the largest effects are likely to be observed in the rate differential and not on the quantity side (over-production of collateralizable assets).

The view that collateral frameworks may distort private markets is not without criticism. Thus, Bindseil and Laeven (2017) argue that this view "is misguided, and misses the bigger picture of the role of the lender of last resort". They argue that since the central bank is never liquidity constrained it should act as a natural counterparty to banks in crisis times. To protect the central bank from credit risks, the lending must be sufficiently collateralized. Even though this liquidity insurance may distort the incentives of banks to store liquidity *ex-ante*, these costs may be mitigated with an adequate regulation and disincentives to the central bank credit.

In this paper, I document another, in a way, a more basic effect of the collateral policy. Even if liquidity regulation is optimal *ex-ante*, it may have redistributive consequences *ex-post*, when markets value some assets more than the others because of their collateralizability in the central bank refinancing operations. Relatedly, the collateral framework may affect bank sorting in different segments of the credit market and, thus, funnel bank liquidity risks on a small number of pledgeable issuers. If the latter include entities in a weak financial position (for example, because of the political reasons as in the case of Greece and the EU), the collateral

policy may force matching of constrained-in-liquidity lenders with high credit risk borrowers and, thus, generate additional systemic risks.

The rest of the paper is organized as follows. In section 1.2 I describe institutional setting and discuss identification strategy. Section 1.3 is devoted to data description with the details of data construction provided in Appendix 1.A. The main results are presented in Section 1.4. Section 1.5 concludes.

1.2 Institutional Setting and Identification

Until 2015 the Russian banking sector heavily relied on foreign funding. The largest russian banks would try to exploit unusually low interest rates in the European markets and attract credit abroad. Over the next few months, the funding structure changed dramatically with the Bank of Russia becoming the center of financial activity.

The reason was not coming from the financial sector itself. Pursuing its geopolitical interests, the Russian government was faced with an ever-increasing political and economic isolation. Soon after an unfortunate escalation of the political tension in July 2014, the country's leading economic partners — including the EU and the US governments — imposed and reinforced a series of sanctions on the local economic agents. The sanctions, among other things, included a prohibition to "buy or sell new bonds, equity or similar financial instruments with a maturity exceeding 30 days, issued by five major state-owned Russian banks", as well as a ban on provision of "loans [of the same maturity] to the entities described above" (EU (2016)). Although the Russian banking sector traditionally was a net exporter of capital and, thus, in principle could finance its debt repayments by selling off its foreign assets, the uncertainty about *immediate* refinancing needs spurred counterparty risks and brought forward expectations of the BoR as the main intermediary in the refinancing process.

The BoR assumed an even more important role in the second half of 2014 when the price of oil — the main export good of the Russian economy — collapsed to the levels unseen since the 2008–2009 crisis. Faced with an increased risk of ruble depreciation, BoR abandoned its policy of managed FX rate float (that, essentially, capped daily volatility in FX markets without targeting any particular level of the exchange rate), and left the local currency in the regime of free float. During the year 2014 ruble lost about half of its value against the US dollar — a noticeable contribution to the banks' refinancing needs directly linked to their dollar denominated debts.

By the end of the year, the BoR was using all available mechanisms of liquidity provision to address country's quaking money markets. First, in a series of adjustments of its collateral framework, the BoR inflated the collateral base of marketable securities; this was done both on the extensive margin — by including new securities in the list of assets eligible for refinancing under standard repo arrangements, as well as on the intensive one — by dwarfing the haircuts. Having

a considerable amount of foreign reserves, the Bank also set up FX repo mechanisms to lend the much-needed dollar liquidity to commercial banks on the short- and medium-term basis. The FX liquidity risks were partially transferred to the Bank's balance sheet via FX swaps. Finally, the Bank opened up (though, never used in practice) unsecured lending programs. Fig. 1.C.1 plots some of the macro variables illustrating the economic conditions of that period.

Expansion of liquidity supply by the Central Bank put an immense pressure on the collateral function of marketable securities. The fragility of money markets can be illustrated with a case of Rosneft, the country's largest oil extracting and refining company, issuing bonds with the face value of $11.5bn. in the midst of December run on the ruble. The deal was announced and completely booked on the same day, and the next day the BoR included the newly issued bonds in the eligible collateral list. The opacity of the deal and the fear that the new collateral would be available to a very limited set of market players fostered more panic in the wholesale and retail FX markets. BoR replied by drastically increasing the key rate from 10.5% to 17% over the following night, which cut the market value of pledgeable securities even further. The country met its winter holidays with arid money markets.

Repo refinancing against marketable securities was not the only mechanism employed by the BoR. Warning market participants in its annual Financial Stability Review that the rate of collateral utilization could hit 80% in 2015, the Bank announced an expansion of the program of lending against *non-marketable* claims[1]. The latter included claims on state entities, as well as claims on the largest corporates that met the credit quality requirements established by the Bank. These claims generally fell into two categories: direct credit claims on the above-mentioned organizations, as well as claims on other nonfinancial firms guaranteed by the eligible entities. Under this mechanisms, the liquidity was distributed via regular auctions as well as auxiliary irregular auctions and permanent access liquidity arrangements. While the aim of the latter was to insure the market against the risks of systemic illiquidity, the former was used primarily to meet the demands of mid-term funding. By doing this BoR aimed to increase the efficacy of its main overnight refinancing operations, i.e. to keep the money market rate close to the key rate and to ensure free access to liquidity across all segments of money markets.

The Bank formulated and clarified its view on the collateral framework in its decree OD-406 issued on the February 24th, 2015 (CBR (2015)); the decree amended the earlier version of the law regulating liquidity provision. The document lists organizations — municipal and regional governments — whose debts were allowed to be pledged in the BoR under the refinancing arrangements backed by non-marketable assets. Originally the list contained sixty-five entities: 14 cities, 2 federal level cities, and 49 regions. The list was subsequently amended in July 2015 with another six organizations (1 city and 5 regions) (see Appendix 1.B for

[1]The Bank did accept gold and other precious metals as collateral, but the share of the loans backed in this way was small.

the list of eligible issuers). The framework stipulated that any claim on these organizations (direct credit claims or guarantees to third parties) were pledgeable in the BoR with no extra significant checks and requirements, while claims on other non-eligible borrowers were to be thoroughly scrutinized for associated risks before any decision was taken on collateralizability of these contracts. While this did not completely exclude the chances of non-eligible debts being used in refinancing, in practice this was likely to create substantial costs and risks of not obtaining access to the central bank funds. Therefore, I compare the credit market outcomes for these two groups of borrowers labeled as "eligible" and "non-eligible" issuers.

State entities of all levels in Russia are obliged to acquire goods and services via a procurement system which makes all contract details and related competition outcomes available for a general public. Most of the contracts are allocated via auction or related mechanisms. Provision of credit by commercial banks is considered to be one of these services and it is allocated via English type auctions. Importantly, it is unlikely that the the collateral policy shift affected the *demanded* quantity of credit. Local and regional governments in Russia rely on private credit markets to finance their short- and mid-term deficits. The federal government policy of increasing social support funneled a large chunk of expenses on the local budgets; however, this was not accompanied by a commeasurable increase in the federal subsidies. The resulting local budget deficit generated a steady inelastic demand for external finance[2].

I employ the difference-in-difference setup to trace the effects of the collateral framework amendment on the regional and municipal public credit markets. I first analyze the overall market outcomes by estimating a model of the form

$$y_i = \beta d\{t \in P\} + \delta d\{t \in P, b \in E\} + x_{bt}\gamma + \theta_b + \epsilon_i, \tag{1.1}$$

where i indexes the credit contracts, $b = b(i)$ is a mapping of contracts to borrowers with E denoting a subset of issuers whose debts constitute eligible collateral in BoR, $t = t(i)$ is a mapping of contracts to their scheduled bidding dates with P denoting a set of auction dates ranging from the effective date of collateral amendment (February 26th, 2015) until the end of 2015 (the end of sample), θ_b is borrower fixed effect, and ϵ_i is unobserved error component of the credit market outcome y_i; $d\{\cdot\}$ indicates the true value of its argument. Variable indexing is thought to highlight the structure of the data that is different from a typical panel data setup normally employed in the studies of policy effects (i.e. I do not observe bidding for the same contract i in multiple time periods but rather bidding for a set of contracts of the same borrower $b = b(i)$ throughout the sample period; also, occasionally a borrower may post several contracts on the same date t, so that the

[2]The contract level credit data is, in principle, available for the analysis (see the next section for a description of the public credit data and Appendix 1.A for the details of its construction). Unfortunately, no disaggregated or structured data is available neither for the guarantees issued by the local governments nor for private credit markets, so I do not include these collateral segments in the analysis.

set of $t = t(i)$ with $i \in \{i : b(i) = b\}$ does not necessarily span multiple dates).

As I mentioned before, the BoR expanded the collateral base further in July 2015. I do not rely on this policy shift in the identification strategy due to a small number of the second wave contracts allocated during all three subsets of the auction dates. More importantly, it is very likely that the second wave amendment was expected by market participants long before it became effective, which, in its turn, could affect the competition in soon-to-be pledgeable debts *ex-ante*. Inclusion of these contracts in either "treatment" or "control" group would contaminate any of them and bias the estimate of the policy effect towards zero.

As in any difference-in-difference application, I am interested in the δ coefficient that is thought to capture policy effects. I mostly focus on the price of credit (maturity-adjusted interest rates) determined in the bidding process of each contract. The winning and second bid interest rates serve as direct indicators of the liquidity premium that market assigns to collateralizable assets. When estimating δ via non-structural approach, I need to condition on competition of the lenders that was intense enough to (partially) reveal their valuations.

For the sake of completeness I note that I do not treat as controls auction characteristics, in particular, the reserve rate. Any theoretical auction model considers reserve rates to be endogenous and, in the simplest case, derives it as a solution to a nonlinear equation in the reserve value and distribution of buyer valuations. While the reserve rate clearly affects the number of auction participants and, as a consequence, the outcome price, it is assumed to be set up in the maximization of expected revenue (minimization of expected costs) and, thus, not predetermined with respect to auction outcomes.

To account for potential differences in the outcomes across heterogeneous contracts I include in the regression a vector of observables x_{bt} capturing borrower-related controls and general macroeconomic conditions. Perhaps, the most important reason to include controls is to try to account for differences in y_is stemming from factors confounded with "treatment" assignment. Thus, it is reasonable to assume that the BoR as an extremely risk-averse institution included in the eligible collateral list only the issuers that had the lowest credit risks. The estimated δ, in this case, may capture the *changes* in the credit risk spread between the safe and less secure credit claims, i.e. widening credit risk premium which could happen independently on the Bank's policy decision. The concern is mitigated, at least partially, if the controls are informative on the borrower's creditworthiness.

Furthermore, I employ borrower fixed effects estimation to account for unobservable borrower-level heterogeneity. Some borrowers may be structurally less risky due to the strength of their local economies, or because of their role and importance in the budgetary system of Russia. Yet another issuer may implicitly rely on the guarantees provided by the federal government. Finally, one may raise concerns that, when extending the collateral base, the BoR was implicitly targeting some banks based on their already existing claims on the public sector. Fixed effect estimator is consistent to the extent the decision of BoR on the eligibility list was based on these rather time-invariant features of the issuers.

Nevertheless, to push identification one step further we focus on the within-contract variation of the competition outcomes:

$$\begin{aligned} y_{il} = \alpha r_l + \beta_p d\{t \in P\} r_{lt} + \beta_e d\{b \in E\} r_{lt} \\ + \delta d\{t \in P, b \in E\} r_{lt} + x_{lt}\gamma + \phi_i + u_{il}, \end{aligned} \tag{1.2}$$

where l indexes lenders, x_{lt} is a row vector of bank controls, and ϕ_i is a contract fixed effect. The bank-level variable r_{lt} is thought to capture the liquidity or collateral constraint of bank l at the auction period $t = t(i)$. Then the tripple interaction coefficient δ shows whether the constrained banks bid differently for the contracts that open an easy access to the central bank funds than in the debts of non-eligible borrowers (net of a similar difference in the pre-amendment period).

Introducing the contract fixed effect ϕ_i in the triple difference equation (1.2) eliminates any component of variation common to all potential lenders of a given contract i. This, arguably, mitigates most of the concerns about borrower-specific changes in creditworthiness that might be correlated with its inclusion in the eligible collateral list. That is, the contract fixed effects estimator is consistent if, conditional on the observables x_l, the liquidity constraint measure r_l is not correlated with bank-specific valuations of credit risk premium.

I augment the above-mentioned approach with the analysis of bank sorting in the collateral markets. While the previous analysis is focused on the differences in bank behavior within an auction conditional on their participation, it remains salient about the selection of banks into particular market segments. Constrained in liquidity banks may exhibit similar preferences for eligible collateral and, thus, sort into specific borrower markets more frequently than the unconstrained ones. If this selection is strong, sorting of specific lenders into some segments of the markets may severely affect redistribution of the borrower-lender match surplus. That is, since liquidity value may re-channel competitive pressure towards the eligible debts markets, the unconstrained lenders would be forced to put aside a part of their surplus in order to outbid the constrained-in-liquidity banks. Although this competition would directly benefit the borrowers, the outcomes are quite likely to be the opposite in the markets of non-eligible collateral. In short, collateralizability may serve as an attractor for short-in-liquidity lenders, and by reallocating their competition it may also redistribute the economic surplus.

To formalize the idea of bank sorting within the difference-in-difference approach, I turn to a bank pair setup and estimate a model of the form

$$y_{lks} = \beta_s r_{lk} + x_{lk}\gamma_s + \alpha_{ls} + \alpha_{ks} + e_{lks}, \tag{1.3}$$

where l and k index a pair of banks, $r_{lk} = r(r_l, r_k)$ and $x_{lk} = x(x_l, x_k)$ are dyad-level measures of liquidity constraints and control variables, both symmetric in their arguments, and αs and e are bank fixed effects and an unobserved pair error. Index s runs over all potential combinations of the product of $d\{t \in P\}$ and $d\{b \in E\}$, i.e. s splits observations into four groups by the timing of the auctions

and their collateral eligibility tag.

Since it is multiple bidder competition that allows the borrower to share the economic surplus, I am mainly interested in the *joint* participation of lenders in bidding for similar debtors. Hence, I define the outcome variable y_{lks} to be equal to 1 if banks l and k compete for at least one common borrower in a subperiod-segment s, and 0 otherwise. The quantity of interest is the double difference of βs, i.e.

$$\Delta_t \Delta_c \beta = \beta(t \in P, b \in E) - \beta(t \in P, b \notin E) \\ - (\beta(t \notin P, b \in E) - \beta(t \notin P, b \notin E)).$$

This double difference contrasts the relationship between liquidity positions and bank sorting within the two segments of the markets (eligible and non-eligible claims), and compares this difference to a similar quantity of the pre-amendment period.

As before, the causal interpretation of $\Delta_t \Delta_c \beta$ hinges on the assumption of conditional mean independence of e_{lks}. To ensure that this assumption is realistic, I include a set observables in the model and leave their effects across the subsamples s unconstrained. Furthermore, I eliminate unobservable s-specific heterogeneity at the level of bank pair components by including bank-l and bank-k fixed effects.

The importance of unobserved heterogeneity can be clearly seen in the context of competition "networks". Thus, one can stack y_{lks} together in one matrix Y_s, which, from the point of view of the networks theory, constitutes an adjacency matrix of a network of banks with each edge indicating lenders intention to compete for similar borrowers[3]. The fixed effects α_{ls} and α_{ks} allow for non-trivial network configurations where some banks tend to be more centric, i.e. compete more frequently with the rest, while other lenders participate in the market only occasionally. These unobserved components would directly affect the connectivity degree of each bank (row or column totals of Y_s), while the distribution of connectivity within each row/column of Y_s is attributed to the observed r_{lk} and x_{lk}. The factors determining the probability of $y_{lks} = 1$ can be interpreted as the drivers of banks' tendency to sort in a segment s. By aligning the sorting factros with the shift in the collateral framework, one can trace the impact of the latter on the lenders' credit supply and competition.

1.3 Data Description

I collect, structure and merge the data coming from three different sources: the Russian Procurement Information System, the bank balance sheet data files and macroeconomic statistics of the Central Bank of Russia, and municipal and regional database of the Russian Federation State Statistics Service. With the ex-

[3]This network of banks is itself a modified projection of bipartite network of lenders and borrowers onto the network of the former. The unmodified projection would assign the number of common borrowers to y_{lks} — I use this definition as the robustness check.

ception of the data coming from the Central Bank, none of these databases are provided in the format readily available for statistical analysis; I devote Appendix 1.A to a detailed description of the data construction and cleaning.

The main dataset is built using the Procurement Information System data files. The procurement law in Russia instructs the public borrowers — financial departments of regional and municipal governments — to attract credit funds via auctions. With a few exceptions, these auctions are held in the English-type open format, where bidders compete along the only admitted margin: the interest rate[4].

The competition process consists of three steps:

1. Announcement of the auction, including full disclosure of loan contract specification: the demanded volume of credit, maturity, repayment schedule, and the maximum interest rate (reserve rate) allowed by the borrower. The reserve rate is determined by reference to analogous auctions that have been held in the past or to the ongoing credit market rates. Although the law offers general guidance on the reserve rate determination, the final decision is at the borrower's discretion.

2. Applications collection and admission. At this step, the potential lenders apply for bidding by sending to the auction organizer the necessary documentation. The organizer checks the documents for consistency and, in case all the requirements are satisfied, confirms bank's participation. The application procedure ends by the date prespecified at Step 1 when the organizer announces the intermediate results (the number of admitted applicants) without disclosing the identities of potential lenders.

3. Bidding and contract allocation. The actual auction is held on a date specified in its documentation if more than one potential lenders were admitted for bidding. At this stage, banks are allowed to offer interest rates one after another in a decreasing order (potentially multiple times), with all the bids being open to the participants. The winner is determined in the event when during a fixed time interval no competitor is willing to outbid the last offered rate. After the ultimate bids have been checked by the organizer, the winner and other participants of the auction are de-anonymized in the final protocol. The bidding normally takes minutes, while the whole process from auction announcement to contract allocation takes slightly less than a month.

The allocation process may stop at any stage before it reaches Step 3. Hence, occasionally, no bidders apply for an announced auction, in which case the borrower may review the loan conditions and try to attract lenders in the next round. In another typical outcome, the process stops at Step 2, when at most one lender applies

[4]Tröge (2013) analyses bank competition from the auction-theoretic perspective, in particular, lender bidding strategy with common value component. I argue, however, that conditional on observables independent private values is a reasonable assumption in the context of this paper due to the public nature of the ultimate borrowers.

and passes the checks. In that case, the contract is allocated to the only lender at the reserve rate. Since in this paper I focus on pricing, I mostly consider auctions with at least one potential lender and only briefly analyze the contracts that did not manage to attract any banks. These three types of outcomes span more than 96% of the auction results in 2014–2015[5].

The Procurement Information System started to disseminate the auction documentation in a machine readable format in the middle of 2014. However, not the all electronic platforms hosting the auction process were able to comply with the new data dissemination standard until the end of 2014. To extend the sample to the beginning of 2014, as well as to cover auction outcomes that were not reported under the new data standards, I collect the unformatted protocols manually. Furthermore, even under the new format, auction documentation does not provide structured data on the contract characteristics. The related data field specified in the structured format is the reserve (maximum) price. However, it is always reported in absolute monetary terms which makes it impossible to deduce the actual interest rates without knowing loan volumes and maturities. To fill in this gap I collect the information on reserve rates, loan volumes and maturities from contract specifications manually. To ensure integrity of the data, I cross-check the final data set with a sample of auctions collected by a private consulting firm and find no important differences.

The other two import sources of information are the data files of the Central Bank of Russia and the Russian Federation State Statistics Service. The BoR publishes disaggregated bank balance sheets on a monthly basis, with each bank file covering more than seven hundred accounts split by the currency value, beginning- and end-of-period stocks, as well as monthly credit and debit flows. I aggregate this data following a scheme similar to the one used by the BoR (See Appendix 1.A for details). I match banks data with the auctions outcomes by the lender tax ids.

The information on borrowers finance is provided by the Russian Federation State Statistics Service. The relevant data is contained in two databases — Socio-Economic Conditions of Subjects of the Russian Federation (regional data), and Database of Municipal Entities. The variables that I focus on are thought to capture borrower's credit risk, hence I collect the data on budgets income and deficit, as well as on dependence on other budgets in their income structure. Unfortunately, other potentially relevant variables are not well represented in the database. Appendix 1.A describes the steps I take to clean the borrower's data file.

In sections 1.4.1 and 1.4.2, the main dependent variable is the interest rate offered by banks when competing for the auctions. The raw auctions data provides absolute monetary values of reserve prices and bids; after amending this dataset

[5]The other potential outcomes include: one or many applicants at Stage 2 with none of them passing the documentation checks (no contract allocation); multiple bidders at the Stage 3 with none of them posting any offers (the contract is allocated to the first applied bank); multiple bidders at the Stage 3 with none of them passing the results checks (no contract allocation); auction cancellation by the organizer; refusal of the winner to sign the contract etc.

with hand collected contract characteristics I calculate the bids in the form of interest rates. I adjust the reserve and final bid rates for the term premium by subtracting the risk-free yield of similar maturity available to the market participants in the market for federal government bonds. This adjustment eliminates approximately 30% of the variation in bids related to changes in the economy-wide term structure of interest rates. Hence, I focus the analysis on the adjusted interest rates premiums, similar to risk adjustment in the stock pricing literature.

The within-auction analysis of section 1.4.2 relies on a properly defined measure of bank liquidity constraints (r_l in eq. (1.2)). To proceed, I define r_l to be the ratio of bank funding provided by the BoR to the total money market funds attracted by the lender (denoted as "cCB funds" in the output tables[6]). Central bank funds represent bank's total borrowing from the BoR under different refinancing mechanisms; the denominator sums all the money-market liabilities of the bank to other banks (mostly repo and unsecured borrowing) and to the BoR. I argue that the composition of bank's short term borrowing tilted to the central bank funds represents a good measure of liquidity constraint as it provides a clear signal of a bank shortage of privately supplied liquidity.

As a robustness exercise, I use an alternative definition of r_l based on the structure of bank's liquid assets. Namely, I use a ratio of bank's securities encumbered under its repo borrowings to the total value of securities on bank's balance sheet. Presumably, this measure is less precise as not all securities held by a bank can be collateralized in the private or central bank markets of liquidity. Also, the disclosed information is not granular enough to separate the encumbered part of some types of the assets. Other variable definitions are provided in Table 1.1.

Table 1.1: Variable definitions

Notation	Description
*d*Post	An indicator variable equal to one for auctions with the scheduled bidding date after the 26th of February 2015, and zero otherwise
*d*Pledge	An indicator variable equal to one for borrowers whose debts are pledgeable in the Bank of Russia, and zero otherwise
*c*Reserve rate (unadj.)	The maximum interest rate allowed by the borrower in a loan contract
*c*Reserve rate	The reserve rate net of the risk-free rate of the corresponding maturity
*c*Interest rate (unadj.)	An interest rate offered by a lender for a particular loan contract
*c*Interest rate	An interest rate net of the risk-free rate of the corresponding maturity

[6]I use prefix *c* to denote continous variables and *d* for indicators.

Table 1.1: Variable definitions (continued)

Notation	Description
*c*Face value	Loan volume required by the borrower, mln. RUB
*c*Maturity	Loan maturity required by the borrower, years
*d*Guarantee	An indicator variable equal to one for auctions requiring a third party guarantee of lender's liability to provide credit
*c*Budget income	Logarithm of budget income per person (thsd. RUB) corresponding to the budget represented by the borrower
*c*Budget proficit	The ratio of the borrower's budget proficit to its total income
*c*Budget dependence	The ratio of total subsidies, subventions, and transfers from other budgets to the borrower's budget income
*d*Region	An indicator variable equal to one if the borrower is a regional government, and zero if it is a municipal or city government
*c*CB funds	The ratio of bank's liabilities to the Central Bank of Russia to the total interbank borrowing of the bank
*c*Repo	The ratio of the value of securities encumbered under bank's repo agreements to the total value of security holdings of the bank
*c*Bank size	Logarithm of bank's total assets
*c*Capital	The ratio of bank capital to its total assets
*c*State credit	The ratio of bank's credit claims on the local and federal governments and state-owned firms to its total credit claims on organizations
*c*NPL	The share of non-performing loans in total credit claims of a bank
*c*Liquid assets	The share of liquid assets (reserves in the central bank, money and its equivalents, correspondent accounts) in bank's total assets
*d*State owned	An indicator variable of the state-owned banks
*c*SIFI	An indicator variable equal to one for systemically important financial institutions (as classified by the Bank of Russia), and zero otherwise
*d*Local	An indicator variable equal to one for banks that compete for borrowers of at most one region
*c*Mosprime	Interbank money market rate on unsecured lending between high credit quality banks, pp
*c*CDS Russia	CDS premium on the public debt issued by the Russian Federation, pp

Table 1.1: Variable definitions (continued)

Notation	Description
*c*USD shortage	The spread between the interest rate implied in the cross-currency swaps and the interbank money rate RUONIA, pp
*c*RUB/USD volatility	The realized volatility of the annualized daily RUB/USD rate changes, pp

All macro variables are averaged over the last 15 days preceeding to the auction bidding date.
All bank balance sheet variables are as of the beginning of the month of auction bidding date.

The final dataset is comprised of 6623 loan contracts issued by 929 borrowers. Upon a closer inspection of the data, however, I note that not all the contracts announced by a borrower reflect different credit demand conditions. That is, some borrowers would post for sale several contracts with identical characteristics and scheduled bidding date, i.e. they would split the requested amount of credit funds into a few auctions. This loan tranching is done mostly due to statutory limits, or, in case of large-scale borrowings, in an attempt to reduce banks exposure to a particular debtor.

To be more precise, I define a master contract (package) to be a set of contracts with identical values of borrower id, scheduled bidding date, reserve rate and loan maturity. With this definition 74% of 3410 master contracts in the data are *not* split into multiple auctions, i.e. they are represented by a single contract. The rest are divided into tranches with a median master contract offered in 3 auctions, and the largest package containing 44 contracts. Importantly, auction outcomes exhibit very low variation within the same master package. For instance, only 62 out of 870 multi-tranched master contracts have at least one contract unsold while the others attracting some lenders. Similarly, only 13% of multi-tranched packages are sold to multiple lenders. I argue that, from the estimation perspective, low outcome variation within contract packages is akin to including multiple duplicates of the same observation, which may give disproportionally large weight to the borrowers that divide their demands into multiple tranches.

To adjust for the multiplicity of contracts I proceed by weighting observations when running estimation or reporting summary statistics. I set the weights to be inversely proportional to the number of contracts in each master package. An alternative approach would be to use unweighted data. I estimate the baseline regressions under this aggregation scheme: this does not change the point estimates significantly. I opt for the weighted case as it balances contribution of each master contract within treatment and control groups; if anything, the reported estimates are slightly more conservative under weighting (see section 1.4 for the results).

The descriptive statistics of contract characteristics are reported in Table 1.2. Out of all contracts in the sample, 74% end up attracting at least one lender; almost half of these successful auctions result in a competition between multiple banks. A

typical reserve rate offers about 6% premium to the risk-free rate, and successful auctions tend to admit slightly higher reserve rates. An average borrower sells 7.1 contracts (median 2) and meets 2.3 banks competing for its debts. The banks are way more concentrated: an average institution of 79 banks ever participating in the market competes for 104 contracts, while the median one bids only for 8. This is a fair reflection of a more general concentration of credit markets in Russia. Similarly, borrower characteristics reflect a general tendency of local governments having budget deficits (−0.02) and being strongly dependent on the subsidies from higher-level budgets (0.48).

Table 1.2: Summary statistics of contracts, borrowers and lenders

	Mean	Median	SD	Min	Max
Sample of contracts, $N = 6623$					
*c*Reserve rate (unadj.)	15.09	14.18	3.98	3.00	36.00
*c*Reserve rate	5.76	5.12	3.22	−4.92	27.51
*c*Face value	176.16	30.00	414.36	0.10	10768.20
*c*Maturity	1.65	1.00	0.97	0.08	9.92
*d*Guarantee	0.17	0.00	0.37	0.00	1.00
Subsample of contracts with 1+ bidders, $N = 4796$					
*c*Reserve rate (unadj.)	15.21	14.50	3.79	7.98	36.00
*c*Reserve rate	6.10	5.40	2.88	−3.90	27.51
*c*Face value	169.11	39.00	339.52	0.30	5000.00
*c*Maturity	1.62	1.00	0.96	0.25	9.92
*d*Guarantee	0.16	0.00	0.36	0.00	1.00
Subsample of contracts with 2+ bidders, $N = 2269$					
*c*Reserve rate (unadj.)	15.87	15.83	3.56	8.90	27.75
*c*Reserve rate	6.72	6.57	2.61	1.45	16.28
*c*Face value	168.32	50.00	286.97	0.40	4000.00
*c*Maturity	1.47	1.00	0.80	0.25	5.50
*d*Guarantee	0.13	0.00	0.34	0.00	1.00
Sample of borrowers, $N = 929$					
*c*Number of contracts	7.13	2.00	16.31	1.00	186.00
*c*Number of banks	2.28	2.00	1.86	0.00	14.00
*c*Number of winning banks	1.56	1.00	1.17	0.00	7.00
*c*Budget income	9.13	9.65	1.70	3.38	12.22
*c*Budget proficit	−0.02	−0.02	0.09	−0.47	0.34
*c*Budget dependence	0.48	0.51	0.23	0.00	1.00
*d*Region	0.08	0.00	0.26	0.00	1.00
Sample of banks, $N = 79$					
*c*Number of contracts	104.01	8.00	417.68	1.00	3307.00

Table 1.2: Summary statistics of contracts, borrowers and lenders (continued)

	Mean	Median	SD	Min	Max
*c*Number of borrowers	26.85	3.00	87.48	1.00	594.00
*c*Number of won borrowers	18.39	2.00	69.53	0.00	546.00
*c*CB funds	0.28	0.19	0.31	0.00	1.00
*c*Repo	0.12	0.00	0.19	0.00	0.80
*c*Bank size	10.30	9.79	2.14	6.92	16.80
*c*Capital	0.13	0.12	0.07	0.04	0.48
*c*State credit	0.07	0.03	0.11	0.00	0.57
*c*NPL	0.06	0.05	0.05	0.00	0.29
*c*Liquid assets	0.13	0.11	0.09	0.03	0.64
*d*State owned	0.13	0.00	0.33	0.00	1.00
*d*SIFI	0.08	0.00	0.27	0.00	1.00
*d*Local	0.54	1.00	0.50	0.00	1.00

Table 1.3, top panel, reports summaries for the subsample of contracts used to estimate eq. (1.1). With average 2.4 banks competing for the same contract, borrowers receive 2.3% of additional surplus in their interest rate payments. Second-to-minimum bids loose around 20bp to the winners — an indication that lenders do not tend to win the auctions by lowering their bids too discontinuously. A similar summary of the sample of bids used in the estimation of eq. (1.2) is provided in bottom panel of Table 1.3.

Table 1.3: Summary statistics of the samples used in estimation

	Mean	Median	SD	Min	Max
Subsample of contracts with 2+ bidders, $N = 2269$:					
*c*1st Interest rate (unadj.)	13.52	13.41	2.53	7.87	26.07
*c*1st Interest rate	4.37	4.05	1.63	0.78	13.84
*c*2nd Interest rate (unadj.)	13.72	13.69	2.52	7.92	26.07
*c*2nd Interest rate	4.55	4.25	1.63	0.84	13.84
*c*Number of bidders	2.39	2.00	0.98	0.00	6.00
*c*Budget income	8.91	9.74	2.18	3.49	12.17
*c*Budget proficit	−0.03	−0.03	0.08	−0.47	0.34
*c*Budget dependence	0.44	0.47	0.21	0.00	0.89
*d*Region	0.14	0.00	0.35	0.00	1.00
*c*Mosprime	11.07	11.59	1.98	6.00	17.56
*c*CDS Russia	3.21	3.40	0.61	1.76	5.83
*c*USD shortage	−0.05	−0.08	0.34	−1.85	1.05
*c*RUB/USD volatility	17.55	16.39	9.25	4.92	60.42

Table 1.3: Summary statistics of the samples used in estimation (continued)

	Mean	Median	SD	Min	Max
Subsample of bids for contracts with 2+ bidders, $N = 6041$:					
*c*Interest rate (unadj.)	13.86	13.84	2.51	7.87	26.07
*c*Interest rate	4.64	4.43	1.66	0.78	13.84
*c*CB funds	0.58	0.65	0.32	0.00	1.00
*c*Repo	0.34	0.20	0.33	0.00	0.99
*c*Bank size	13.77	13.08	2.55	6.89	16.95
*c*Capital	0.10	0.10	0.03	0.01	0.52
*c*State credit	0.21	0.09	0.22	0.00	0.70
*c*NPL	0.06	0.05	0.05	0.00	0.41
*c*Liquid assets	0.08	0.07	0.05	0.03	0.70
*d*State owned	0.43	0.00	0.50	0.00	1.00
*d*SIFI	0.39	0.00	0.49	0.00	1.00
*d*Local	0.03	0.00	0.17	0.00	1.00

Note that the dependent variable has relatively small variation — an important factor to take into account when estimating economic significance of the effects.

1.4 Results

1.4.1 Difference-in-difference estimation

In this section I present the first results on credit contract pricing and its dependence on collateral eligibility. Fig. 1.C.2 illustrates the point on the interest rate spread attributed to the policy. During the pre-amendment period the differential of bank valuations of eligible and non-eligble contracts was slighthly below zero and frequently taped the positive territory. Collateral policy amendment, however, widened the spread by approximately 0.7pp and pushed it further to the negative zone. The following regressions capture this spread dynamics in a difference-in-difference setup.

Table 1.4 reports OLS and fixed effects estimates of the eq. (1.1) for a subsample of contracts that attracted more than one lender. The dependent variable is the winning bid, i.e. the actual interest rate assigned to the contract. The four columns demonstrate the robustness of the main effect when controlling for different sources of observable and unobservable heterogeneity.

I intend to be conservative when doing inference by allowing non-zero correlation of the error term across multiple observations. The Russian budgetary system is hierarchical: municipal budget incomes may rely on the transfers from the higher level budget of the region where the municipality is located. Also, smaller cities may be subject to similar economic shocks common to all municipalities of a larger

geographic areas. To account for this dependence I cluster the standard errors by geographical region[7]. This clustering allows for the errors to be correlated across time, borrowers and contracts as long as observations belong to the same region.

Column 1, effectively, compares the average outcome variable across the four subsamples. The coefficient on the interaction of *d*Post and *d*Pledge is negative and statistically significant at conventional levels. The estimated effect is around -0.5%. The model as simple as this one explains 19% of variation in the interest rates.

Adding macro economic control doubles the explained variation and increases the precision of the main effect estimate. Economically and statistically, the most important macro control is the money market rate, with the estimated elasticity of 0.7. According to these results, the policy generated a gap between the two segments of the collateral market with the eligible collateral claims priced at 0.7pp discount — a noticeable effect relative to both average (4.4%) and standard deviation (1.6%) of the adjusted rates.

This result is robust to the inclusion of borrower-level controls, with higher income, smaller deficits and external dependence contributing to lower cost of credit; regions are charged the interest rate that is, on average, 2pp lower than the ones of the municipalities. The budgetary data, however, is quite noisy, hence, its contribution to the explained variation is relatively small. Allowing for unobservable borrower-level heterogeneity potentially correlated with eligibility status (column 4) does not change the estimate[8]. This specification relies on the subsample of borrowers participating in the credit market with at least two contracts (hence, reduction of the effective sample size). Restricting the subsample even further to the set of borrowers with at least one contract in each of the pre- and post-amendment periods affects the estimated effect on the order of tenths of a basis point; hence, I do not report it.

Table 1.5, with the similar structure, reports estimates of the eq. (1.1) but with the second-to-minimum bid as the dependent variable. While the previous table describes final *prices*, it provides rather indirect evidence on the *valuations* (required interest rates) of the lenders. The winner's bid is an upper bound of the bank's valuation: I do not get to observe the minimum rate required by the bank since no competitors are willing to outbid the winner. In a way, valuations of the winners are censored (Paarsch et al. (2006)).

The second-to-minimum bid is less subject to this censoring issue: the fact that a bank was ranked as the second indicates that its required rate is not higher than its final bid and, at the same time, not lower than the bid of the winner. In a simple clock model of an English auction with independent private values (Milgrom and Weber (1982)), the optimal bidder's strategy with continuous price is to drop out from the competition as soon as the price reaches bidder's valuation. From this per-

[7] Population of an average region in Russia is around 1.7 million people.

[8] Budget statistics has very low within-borrower variation; as a consequence, borrower fixed effect estimates of the coefficients on these variables are not very stable.

Table 1.4: Winning bids of auctions with multiple participants.

	Winning bid			
	(1)	(2)	(3)	(4)
*d*Post	1.60***	−0.69**	−0.67**	−1.14***
	(0.09)	(0.26)	(0.27)	(0.33)
*d*Pledge	−0.24	−0.24	0.18	
	(0.17)	(0.16)	(0.19)	
*d*Post × *d*Pledge	−0.54**	−0.71***	−0.77***	−0.71***
	(0.22)	(0.17)	(0.16)	(0.15)
*c*Mosprime		0.71***	0.68***	0.73***
		(0.06)	(0.05)	(0.06)
*c*CDS Russia		−0.17	−0.14	0.02
		(0.16)	(0.16)	(0.21)
*c*USD shortage		−0.26*	−0.23*	−0.16
		(0.14)	(0.13)	(0.16)
*c*RUB/USD volatility		−0.01**	−0.01*	−0.01
		(0.01)	(0.01)	(0.01)
*c*Budget income			−0.27***	0.59**
			(0.08)	(0.24)
*c*Budget dependence			0.84*	0.41
			(0.49)	(0.88)
*c*Budget proficit			−0.81*	−1.10
			(0.41)	(1.15)
*d*Region			−2.00***	
			(0.45)	
Constant	3.31***	5.00***	4.93***	
	(0.14)	(0.21)	(0.19)	
Borrower FE	*n*	*n*	*n*	*y*
R^2	0.19	0.38	0.41	0.66
# observations	2269	2269	2269	2038
# regions	72	72	72	69

The table reports OLS and FE estimates of versions of the eq. (1.1). The dependent variable is the winning interest rate net of the risk-free rate of the corresponding maturity. *d*Post is equal to one for auctions with bidding scheduled after the 26th February 2015 and zero otherwise. *d*Pledge is equal to one for the borrowers whose debts are pledgeable in the Bank of Russia, and zero otherwise. See Table 1.1 for other variable definitions. All control variables are demeaned. Sample includes all auctions that have at least two participants in 2014–2015. Standard errors (in parenthesis) are clustered by borrower's region. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

spective, the non-winning bids are exactly equal to the valuations of the bidders. In reality, however, the prices do not change continuously but rather adjust discretely when bidders update their offers; the actual valuations then are likely to be in the interval bounded by bidders last offer and the bid of the winning lender. As the second-to-minimum bids are the closest ones to the winning prices, the estimated effects in Table 1.5 can be thought of as an upper bound, while those of Table 1.4 — a lower bound on the market value of funding liquidity (this is conecptually close to the incomplete data estimator of Haile and Tamer (2003)).

The second-to-minimum bid results are qualitatively similar to the winning bid outcomes. The point estimates of the valuation interval bounds are close to each other spanning, roughly, 5bp. Given sampling uncertainty, it is safe to claim that the previous estimate 0.7pp remains a good indicator of the value of funding liquidity. Taking into account that the BoR was charging extra 25bp to the key rate on its loans backed by non-marketable assets (or even more at times when competition for central bank funds was high), the total cost of banks liquidity constraint (the interest rate the banks were willing to forego in order to obtain central bank funding) was likely about 1%.

To derive the above estimates, I rely on the subsample of auctions with multiple banks competition. With no model structure behind, this was necessary to unveil valuations hidden in the observed prices: in an alternative outcome where only one bank offers a loan the observed rate is the reserve rate announced by the borrower. Auction theory suggests that even in the simplest setup the reserve price is a nonlinear function of seller's reserve value and the distribution of buyer's valuations. Thus, when simultaneously considering single and multiple bank outcomes in one simple linear model, one should be aware that the results characterize the observed prices rather than unobservable valuations. I report the estimates of the eq. (1.1) for the full sample of successful auctions in Table 1.6. Economically and statistically the results are close to the ones discussed above.

I perform a series of robustness checks to ensure the stability of the results. Thus, I estimate the baseline regressions with no weights applied to the master contracts (see discussion in the section 1.3): this does not affect statistical significance and, if anything, it slightly increases the estimated policy effect. I also amend baseline specification with (winning) lender fixed effects — this does not alter the estimates in any significant way (see Table 1.C.1).

As a part of robustness check, I also include the second dimension of errors clustering. Namely, I allow the errors to be correlated if the auctions take place during the same calendar week even if the borrowers do not belong to the same region. Similarly, one can make inference robust to a potential correlation of errors among the winning banks. Furthermore, I include additional macro economic controls (the rate of absorption of interbank credit by the core banks, the ruble depreciation rate) and, arguably, exogenous contract characteristics (required credit volumes and maturity), as well as lender-borrower fixed effects in the baseline specification. None of this changes the previous results in any significant manner.

Table 1.5: Second-to-minimum bids of auctions with multiple participants

	Second bid			
	(1)	(2)	(3)	(4)
*d*Post	1.74***	−0.46*	−0.44*	−0.98***
	(0.10)	(0.24)	(0.24)	(0.32)
*d*Pledge	−0.29*	−0.30**	0.16	
	(0.15)	(0.13)	(0.18)	
*d*Post × *d*Pledge	−0.51**	−0.65***	−0.72***	−0.61***
	(0.22)	(0.17)	(0.17)	(0.16)
*c*Mosprime		0.67***	0.65***	0.71***
		(0.06)	(0.05)	(0.06)
*c*CDS Russia		−0.14	−0.12	−0.01
		(0.16)	(0.16)	(0.18)
*c*USD shortage		−0.34**	−0.31**	−0.28*
		(0.15)	(0.15)	(0.16)
*c*RUB/USD volatility		−0.01	−0.01	−0.01
		(0.01)	(0.01)	(0.01)
*c*Budget income			−0.24**	0.32*
			(0.10)	(0.16)
*c*Budget dependence			0.77	0.51
			(0.49)	(1.19)
*c*Budget proficit			−0.56	0.34
			(0.42)	(1.08)
*d*Region			−1.87***	
			(0.51)	
Constant	3.35***	5.04***	4.95***	
	(0.12)	(0.20)	(0.18)	
Borrower FE	*n*	*n*	*n*	*y*
R^2	0.22	0.40	0.42	0.67
# observations	2188	2188	2188	1957
# regions	72	72	72	68

The table reports OLS and FE estimates of versions of the eq. (1.1). The dependent variable is the second to lowest interest rate net of the risk-free rate of the corresponding maturity. *d*Post is equal to one for auctions with bidding scheduled after the 26th February 2015 and zero otherwise. *d*Pledge is equal to one for the borrowers whose debts are pledgeable in the Bank of Russia, and zero otherwise. All control variables are demeaned. See Table 1.1 for other variable definitions. Sample includes all auctions that have at least two participants in 2014–2015. Standard errors (in parenthesis) are clustered by borrower's region.* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 1.6: Winning bids of all auctions

	Winning bid			
	(1)	(2)	(3)	(4)
*d*Post	2.02***	−0.83**	−0.77**	−1.16***
	(0.16)	(0.36)	(0.36)	(0.34)
*d*Pledge	−0.54***	−0.66***	−0.03	
	(0.16)	(0.14)	(0.19)	
*d*Post × *d*Pledge	−0.68**	−0.73***	−0.84***	−0.98***
	(0.26)	(0.21)	(0.21)	(0.21)
*c*Mosprime		0.68***	0.67***	0.74***
		(0.10)	(0.10)	(0.10)
*c*CDS Russia		0.53***	0.54***	0.69***
		(0.19)	(0.19)	(0.22)
*c*USD shortage		0.36***	0.36***	0.37***
		(0.11)	(0.10)	(0.12)
*c*RUB/USD volatility		−0.04***	−0.04***	−0.04***
		(0.01)	(0.01)	(0.01)
*c*Budget income			−0.33***	−0.02
			(0.10)	(0.21)
*c*Budget dependence			1.07**	−0.16
			(0.47)	(0.81)
*c*Budget proficit			−0.76	−0.33
			(0.67)	(0.77)
*d*Region			−2.48***	
			(0.53)	
Constant	4.07***	5.62***	5.49***	
	(0.13)	(0.17)	(0.17)	
Borrower FE	*n*	*n*	*n*	*y*
R^2	0.16	0.29	0.31	0.60
# observations	4796	4796	4796	4473
# regions	78	78	78	76

The table reports OLS and FE estimates of versions of the eq. (1.1). The dependent variable is the winning interest rate net of the risk-free rate of the corresponding maturity. *d*Post is equal to one for auctions with bidding scheduled after the 26th February 2015 and zero otherwise. *d*Pledge is equal to one for the borrowers whose debts are pledgeable in the Bank of Russia, and zero otherwise. See Table 1.1 for other variable definitions. All control variables are demeaned. Sample includes all auctions that have at least one participant in 2014–2015. Standard errors (in parenthesis) are clustered by borrower's region.* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

1.4.2 Within-contract estimation

Even though the results of the Section 1.4.1 indicate that the BoR policy of collateral amendment was followed by an increase in the spread of interest rates of eligible and non-eligible borrowers, one can still argue that the effect was potentially driven by the changes in credit risk premiums associated with the corresponding borrower types. In this section, I try to minimize these concerns by using within-contract variation and demonstrating that those were offers of constrained-in-liquidity banks that were likely to push the interest rates of the collateralizable contracts down to the levels unattainable to the non-eligible claims. Following the discussion of the relation between hidden values and observed prices, I interpret the results of this section in terms of the actual market outcomes and not so much as a model of (some moments of) the distribution of bank valuations.

The OLS and fixed effects estimates of the eq. (1.2) are reported in Table 1.7. I focus on the triple interaction coefficient where the two indicator variables *d*Post and *d*Pledge are interacted with a continuous proxy of bank liquidity constraint *c*CB funds. The latter is defined as a share of central bank funds in the total interbank borrowing of a lender. I allow this variable to be time-dependent: *c*CB funds is as of the beginning of a month corresponding to auction bidding date. Since *c*CB funds is a bank-level variable, I introduce the second dimension of potential non-zero correlation of the errors, namely, I calculate standard errors under two-way clustering by borrower's region and lender id. This allows the inference to be robust to a non-zero correlation of observations corresponding to the same bank even if the lender is competing for borrowers of different regions.

In all specifications reported in Table 1.7 the triple interaction coefficient is negative and statistically significant at conventional levels. The negative coefficient indicates that, in comparison with the pre-amendment period, banks dependent on central bank funding offer lower interest rates to the eligible borrowers in contrast with the lenders unconstrained in their private money market funds. This behavior is relevant economically: an increase of one standard deviation in central bank funding corresponds to a discount of 0.4pp in posted bids, with the full potential effect estimated to be around -1.4pp.

Importantly, these results are robust to controlling for unobservable contract-specific heterogeneity common to all auction participants. Thus, in column 3 I add contract fixed effects so that only within-contract variation is used in the estimation of the model parameters. This variation accounts for 36% of the total variation of the observed bids. The fixed effects estimator is not without drawbacks: because of nesting of contracts in borrowers, it does not allow to identify the average effect of the collateral amendment policy. However, to the extent that credit risk premium for a particular contract is identical across all banks (or does not vary systematically with bank liquidity positions), the fixed effect estimator allows to analyze whether funding constraint is an important driver of bank competition beyond credit risk considerations.

In column 4, I add bank fixed effects to account for unobservable time-invariant

Table 1.7: Within auction bidding vs. central bank funding

	(1)	(2)	(3)	(4)
*d*Post	1.80***	1.64***		
	(0.27)	(0.23)		
*d*Pledge	−0.29**	−0.24		
	(0.14)	(0.15)		
*d*Post × *d*Pledge	−0.53**	−0.53**		
	(0.21)	(0.21)		
*c*CB funds	−0.13	0.69	0.12	0.01
	(0.17)	(0.49)	(0.12)	(0.12)
*c*CB funds ×				
*d*Post	0.91	0.90	0.22	0.20
	(0.66)	(0.60)	(0.20)	(0.19)
*d*Pledge	0.45**	0.35	0.21*	0.27
	(0.20)	(0.36)	(0.12)	(0.18)
*d*Post × *d*Pledge	−1.08***	−1.37***	−0.73**	−0.88***
	(0.33)	(0.50)	(0.35)	(0.30)
Bank controls	*n*	*y*	*y*	*y*
Contract FE	*n*	*n*	*y*	*y*
Lender FE	*n*	*n*	*n*	*y*
R^2	0.22	0.28	0.89	0.91
# observations	5685	5685	5611	5591
# contracts	2268	2268	2194	2187
# regions	72	72	72	71
# lenders	74	74	74	61

The table reports OLS and FE estimates of versions of eq. (1.2). The dependent variable is the interest rate offered by a bank for a particular contract, net of the risk-free rate of the corresponding maturity. *d*Post is equal to one for auctions with bidding scheduled after the 26th of February, 2015, and zero otherwise. *d*Pledge is equal to one for borrowers whose debts are pledgeable in the Bank of Russia, and zero otherwise. *c*CB funds denotes the share of bank's funding from the Bank of Russia in its total money markets liabilities. All regressions in columns 2–4 include additional control variables: *c*Bank size, *c*Capital, *c*State credit, *c*NPL, *c*Liquid assets, and (in columns 2–3) *d*State owned, *d*SIFI, *d*Local (not reported). See Table 1.1 for other variable definitions. All treatment and control variables are demeaned. Sample includes all auctions that have at least two participants in 2014–2015. Constant is omitted from the outputs. Standard errors (in parenthesis) are two-way clustered by borrower's region and lender. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

characteristics of the lenders that may potentially be correlated with their dependence on the central bank funds — the estimated effect is roughly the same under this specification.

Lower bids in the eligible collateral markets offered by liquidity constrained banks are likely to affect the distribution of the winning lenders. To test this hypothesis, I run a similar set of specifications but with a winning indicator variable as the dependent variable. Table 1.8 reports results for the OLS and fixed effect estimation of the eq. (1.2) with y_{li} equal to one if a bank l is a winner in the auction i and zero otherwise. I confirm that, in comparison with the similar contrast in the pre-amendment period, short-in-liquidity banks tend to win the auctions more frequently when they compete for eligible borrowers. The precision of the estimated effect is increasing as more variation is absorbed to account for unobservable heterogeneity; according to the baseline specification, banks half funded by the BoR in their interbank borrowings are 27% more likely to win the auctions in comparison with those lenders who have zero funding from the regulator (net of the same contrast in the pre-amendment period).

To assess the robustness of these results I first employ a different proxy of liquidity constraint. Thus, I use the variable *c*Repo — the share of encumbered securities in the total securities holdings of a bank — as a proxy for collateral utilization. Unfortunately, accounting standards in Russia do not allow to distinguish the part of the securities that is encumbered in the private money markets from the one involved in the refinancing operations of the BoR. Thus, I expect the collateral utilization *c*Repo to be a noisier alternative of the liquidity constraint.

The corresponding results on pricing and winning probabilities are reported in Tables 1.C.2 and 1.C.3. The estimates confirm my previous conclusions on the importance of liquidity demand in interest rate determination: constrained in collateral banks offer lower rates to the eligible borrowers after the BoR "turns on" this collateralizability by its policy decision. The distribution of the winning lenders has a pattern similar to the one discussed above, albeit, with a slightly lower precision of the estimated effect.

In a series of further robustness checks, I rerun the analysis with the liquidity measures fixed at the levels of the end of 2014 — the period when the collateral amendment had not been introduced yet. The corresponding outputs are reported in Table 1.C.4: economically and statistically they are almost identical to the baseline results. I also control for additional bank characteristics (share of retail funds in the total liabilities of a bank, an indicator for banks under the EU and US financial sanctions), use no weighting of observations, or allow for more heterogeneous effects of bank controls — the triple interaction coefficient preserves the economic relevance and remains statistically significant at conventional levels.

1.4.3 Common borrowers and market segmentation

The previous sections focused on pricing of credit contracts and remained salient about selection of banks into particular market segments. Sorting of specific lenders

Table 1.8: Probability of winning an auction vs. central bank funding

	(1)	(2)	(3)	(4)
*d*Post	−0.11*	−0.03		
	(0.06)	(0.04)		
*d*Pledge	−0.02*	−0.05***		
	(0.01)	(0.01)		
*d*Post × *d*Pledge	0.03	0.02		
	(0.02)	(0.02)		
*c*CB funds	0.24**	0.14	0.17	0.19*
	(0.12)	(0.11)	(0.14)	(0.10)
*c*CB funds ×				
*d*Post	−0.21	−0.09	−0.14	−0.14
	(0.17)	(0.11)	(0.13)	(0.14)
*d*Pledge	−0.03	−0.05	−0.13	−0.38
	(0.12)	(0.13)	(0.20)	(0.24)
*d*Post × *d*Pledge	0.23*	0.30*	0.54**	0.74***
	(0.13)	(0.16)	(0.24)	(0.20)
Bank controls	*n*	*y*	*y*	*y*
Contract FE	*n*	*n*	*y*	*y*
Lender FE	*n*	*n*	*n*	*y*
R^2	0.02	0.08	0.14	0.23
# observations	5685	5685	5611	5591
# contracts	2268	2268	2194	2187
# regions	72	72	72	71
# lenders	74	74	74	61

The table reports OLS and FE estimates of versions of eq. (1.2). The dependent variable is an indicator equal to one if a bank is a winner in a particular auction, and zero otherwise. *d*Post is equal to one for auctions with bidding scheduled after the 26th of February, 2015, and zero otherwise. *d*Pledge is equal to one for borrowers whose debts are pledgeable in the Bank of Russia, and zero otherwise. *c*CB funds denotes the share of bank's funding from the Bank of Russia in its total money markets liabilities. All regressions in columns 2–4 include additional control variables: *c*Bank size, *c*Capital, *c*State credit, *c*NPL, *c*Liquid assets, and (in columns 2–3) *d*State owned, *d*SIFI, *d*Local (not reported). See Table 1.1 for other variable definitions. All treatment and control variables are demeaned. Sample includes all auctions that have at least two participants in 2014–2015. Constant is omitted from the outputs. Standard errors (in parenthesis) are two-way clustered by borrower's region and lender. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

into eligible assets induced by the central bank collateral policy can have its own consequences. Hence, the summary statistics suggests that it is *joint* competition of at least two banks for a similar contract that results in surplus sharing. Thus, to the extent the regulator policy re-channels competition across the market segments, it is likely to affect the split of borrower-lender match surplus both in the eligible and non-eligible assets segments. Furthermore, by actually matching the eligible borrowers with short-in-liquidity banks, the policy may concentrate bank funding risks in a smaller segment of collateral markets, potentially exposing it to additional systemic risks. In this section I analyze the degree of collateral market segmentation that might be caused by the BoR policy decision.

To do this, I move to the bank pair setup and estimate versions of the eq. (1.3), i.e. I model joint participation of bank-l and bank-k in a market segemnt s. The dyadic setup is attractive as it allows to consider market competition from the point of view of network analysis. One can stack y_{lks} in a matrix Y_s that can be thought of as an adjacency matrix of a bank competition network. The elements of this matrix indicate "closeness" of banks to each other in terms of their attempts to compete for *similar* borrowers. By contrasting factors that matter for competition for common borrowers across market subsegments and sample periods, one can identify the drivers of market segmentation induced by the BoR collateral framework

I report the corresponding estimates of the eq. (1.3) in Tables 1.9 and 1.10. Given the data structure, I calculate the standard errors under dyadic clustering (Cameron and Miller (2014)). This makes inference robust to non-zero error correlation between any bank pairs that have at least one bank in common (including correlation over time and market segments). As a byproduct of this calculation I also estimate the VCV of point estiamtes under two-way clustering (by bank-l and bank-k). The dyadic clustering is way more conservative with the resulting standard errors being at least twice as large as the ones calculated under the two-way clustering approach; this is well in line with simulation results of Aronow et al. (2015).

Both tables indicate that the dependence on the central bank funding acts as an important factor of bank sorting into eligible collateral markets when this collateralizability is annonced by the regulator. Thus, after the policy amendment, a pair of banks with each bank owing half of its interbank liabilities to BoR is estimated to compete by 10pp more frequently for the eligible borrowers in contrast with a pair of banks where at least one competitor is free from the central bank funding. In the other segment and pre-amendment subperiods, the importance of the liquidity constraint is economically and statistically close to zero; as the estimated effect preserves its magnitude and statistical precision after the double differncing, it can be directly attributed to the shifts in collateral policy.

This result is robust to the inclusion of pair-components fixed effects specific to each of the four subsamples. Among other factors driving joint selection of banks into eligible collateral markets one can mention liquidity of their balance sheets as well as lender's systemic importance. Importantly, banks specialization in provi-

Table 1.9: Competition for common borrowers (OLS)

cPledge	0		1		$\Delta_t \Delta_c \beta$
dPost	0	1	0	1	
cCB funds	0.01	−0.02	0.02	0.20**	0.20**
	(0.02)	(0.05)	(0.02)	(0.09)	(0.08)
cState credit	0.44*	1.34***	0.35*	0.76**	−0.48**
	(0.23)	(0.49)	(0.19)	(0.33)	(0.21)

The table reports OLS estimates of a version of the eq. (1.3) without bank fixed effects. The dependent variable is an indicator equal to one if both banks in a bank pair compete for at least one common borrower, and zero otherwise. dPost is equal to one for auctions with bidding scheduled after the 26th February 2015 and zero otherwise. dPledge is equal to one for the borrowers whose debts are pledgeable in the Bank of Russia, and zero otherwise. All regressions include additional column-specific control variables: cBank size, cCapital, cNPL, cLiquid assets, dState owned, dSIFI, dLocal (not reported). Pair-level explanatory variables are calculated as a geometric mean of the corresponding bank-level variables (cBank size is calculcated as an arithmentic mean of the logarithm of assets of the banks). Bank-level variables are averaged by the pre- and post-amendment periods before calculating the bank-pair statistics. See Table 1.1 for bank level variable definitions. Sample includes all potential bank-pairs. Total number of observations is 12168, number of dyads is 3081, total number of banks is 79 in the pre-amendment period and 78 in the post-period. Standard errors (in parenthesis) are calculated under dyadic clustering. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

sion of credit to the governments and state-owned companies plays a noticeably smaller role in the eligible collateral segment (when compared to the markets of non-eligible claims and net of the similar contracts in the pre-amendment period). In other words, lenders specialised in public credit are less likely to jointly compete in eligible collateral markets than in the other segment. This acts in favor of the hypothesis that the collateral framework may act as a bank sorting factor which can, in principle, reduce the relevance of the traditional determinants of credit supply.

To assess robustness of these results I first employ a different assumption on the kind of banks that can in principle compete with each other. Thus, instead of using all potential bank pairs in estimation, I rerun the analysis on the subsample of bank pairs comprised of those lenders that compete at least in one common region during the years 2014–2015. Arguably, due to geographical spread of Russia, smaller banks in one region may be excluded from the competition with the local banks of the other parts of the country. The estimated effects under this sample restriction are presented in Tables 1.C.5 and 1.C.6: if anything, it makes the economic significance of the liqudity constraint even larger.

As another robustness check I employ commonality of contracts rather than commonality of borrowers as the dependent variable. The resulting adjacency matrix is sparser as banks may compete for the same borrower but not for the same credit contract. This does not change the economic and statistical relevance of the analysed effects in any significant manner. Furthermore, I try Graham's tetrad logit estimator (Graham (2017)) and obtain conceptually similar results. Next, instead

Table 1.10: Competition for common borrowers (FE)

cPledge	0		1		$\Delta_t \Delta_c \beta$
dPost	0	1	0	1	
cCB funds	−0.00	−0.02	0.01	0.19**	0.20**
	(0.03)	(0.06)	(0.03)	(0.08)	(0.09)
cState credit	0.46**	1.26***	0.33	0.68*	−0.45**
	(0.23)	(0.48)	(0.20)	(0.35)	(0.22)

The table reports FE estimates of the eq. (1.3). The dependent variable is an indicator equal to one if both banks in a bank pair compete for at least one common borrower, and zero otherwise. dPost is equal to one for auctions with bidding scheduled after the 26th February 2015 and zero otherwise. dPledge is equal to one for the borrowers whose debts are pledgeable in the Bank of Russia, and zero otherwise. Pair-level explanatory variables are calculated as a geometric mean of the corresponding bank-level variables (cBank size is calculcated as an arithmentic mean of the logarithm of assets of the banks). Bank-level variables are averaged by the pre- and post-amendment periods before calculating the bank-pair statistics. All regressions include additional column-specific control variables: cBank size, cCapital, cNPL, cLiquid assets, dState owned, dSIFI, dLocal (not reported). See Table 1.1 for bank level variable definitions. Sample includes all potential bank-pairs. Total number of observations is 12168, number of dyads is 3081, total number of banks is 79 in the pre-amendment period and 78 in the post-period. Standard errors (in parenthesis) are calculated under dyadic clustering. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

of using an indicator of having some borrowers in common as the dependent variable, I employ an actual (normalized) quantity of common borrowers between the two banks. The results are qualitatively analogous to the ones reported before.

Finally, I follow a similar estimation strategy in the analysis of bank network centrality, where the latter is measured as normalized connectivity degree of the nodes of adjacency matrices Y_s. The resulting bank-level estimates are presented in Table 1.11. The outputs are in line with the previous conclusions suggesting that short-in-liquidity banks are more central to the eligible collateral markets in terms of competition with the rest of the lenders; the estimated economic effect of a standard deviation in central bank funding is around 0.3 standard deviations of degree connectivity. This is likely to be a consequence of the BoR policy decision as I do not observe a similar pattern neither in the other segment of the credit market nor in the pre-amendment period.

1.5 Conclusions

The BoR policy of liquidity provision achieved its aim. Money markets recuperated soon after the December 2014 collapse; the mid-term funding needs were satisfied with the BoR additional refinancing arrangements and — later in 2015 and 2016 — with the Treasury deposits. Stable money markets allowed the regulator to concentrate on its monetary policy and strengthening of bank capital.

The measures that were undertaken by the BoR, however, were more costly

Table 1.11: Degree connectivity of banks competition

cPledge	0		1		$\Delta_t \Delta_c \beta$
dPost	0	1	0	1	
cCB funds	−0.02	−0.02	−0.00	0.06**	0.06**
	(0.01)	(0.04)	(0.01)	(0.03)	(0.03)
cState credit	0.18**	0.12	0.11	−0.05	−0.10
	(0.09)	(0.11)	(0.07)	(0.06)	(0.06)

The table reports difference-in-difference estimates of the dependence of nomralized connectivity degree of banks on their characteristics. Degree connectivity is calculated for each matrix Y_{lks}, where y_{lks} is equal to one if banks l and k compete at least for one common borrower in a subperiod-segment s and zero otherwise, $s \in P \times E$. dPost is equal to one for auctions with bidding scheduled after the 26th February 2015 and zero otherwise. dPledge is equal to one for the borrowers whose debts are pledgeable in the Bank of Russia, and zero otherwise. Bank-level variables are as of the end of 2014. All regressions include additional column-specific control variables: cBank size, cCapital, cNPL, cLiquid assets, dState owned, dSIFI, dLocal (not reported) See Table 1.1 for bank-level variable definitions. Robust standard errors are in parenthesis. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

for some economic agents than for the others. In this paper, I analyze one type of these costs, namely, segmentation of the market of public credit fostered by the supervisor collateral framework. I show that by labeling assets with "eligible collateral" tag the central bank rechanneled credit supply of the lenders that valued liquidity most. This created additional competitive pressure in the eligible assets segment and, eventually, a wedge in the interest rates paid by the two types of borrowers. Arguably, a part of this interest rate spread, however small, can be explained in terms of redistribution of funding risks coming with weaker lenders. In more general terms, the Bank collateral policy acted as a tax on credit supply to the non-eligible borrowers and subsidized the supply of credit to the eligible ones.

This paper is not aimed to support the claim that these were the largest costs faced by the Russian economy, or that the costs did not justify the ultimate aim of liquidity provision — ensuring financial stability. I rather want to highlight that the monetary authority actions may cause redistributive consequences and that one would require a credible cooperation with the fiscal office to partially neutralize them by politically-feasible tools.

Collateral framework, at its core, is a risk-management system, and as such is aimed to protect the central bank from excessive credit risks and preserve its capital. Historically this was a clearly justified measure that shielded the central clearing houses — ancestors of most modern central banks — from unnecessary risks. The academic discussion of the economic nature of modern central bank capital is less decisive. If there is any agreement on why central banks need capital, then it is in the assertion of its ultimate importance to the monetary authority independence. In the context of this paper, a higher dependence of commercial banks on the finance of local authorities can be thought of some form of price of

the central bank independence from the federal government. Whether this cost can be minimized in the environment of an endogenous collateral base is an interesting topic for further research.

Appendix

1.A Data construction

The data used in this paper comes from three sources: the Russian Procurement Information System, the bank balance sheet data files and macroeconomic statistics of the Central Bank of Russia, and municipal and regional database of the Russian Federation State Statistics Service. I use Python in data preparation as it provides a wide range of tools and packages for handling data.

1.A.1 The Russian Procurement Information System data files

The original procurement data is distributed via FTP[9] and structured in a system of XML files comprising in total more than 72 GB of archived data for the years 2014–2015.

To prepare the auction data, I first extract auction characteristics from the notification files and filter the contracts that contain the roots of the words "credit" or "loan" (in Russian) in their short textual description or are tagged with the "Financial intermediation industry" label (7675 files). I further check manually the filtered results and drop a few contracts that were mistakenly classified as credit auctions. I next collect all XML protocols on canceled notifications and filter them out from the list of credit auction notifications. In case if a notification was subsequently modified, I use its last valid version. I define "Customer Registration Number" and not the "Buyer Registration Number" as the borrower id as some contracts may be announced and auctioned by entities other than the final customers. After cleaning and dropping duplicates, the set of contracts contains 7218 files.

To collect the auction outcomes, I filter XML protocols by the purchase numbers corresponding to the credit contracts. Each of the three auction stages described in Section 1.3 is thought to have its own protocol (XML file) containing a structured description of the outcome. As in the case with auction notifications, I drop duplicates and canceled protocols and, if they had been modified earlier, I use the last valid versions of the files. The official data contains 7643 protocols documenting Stage 1 outcomes (2255 additional protocols for cases of single bidder applications), 5858 protocols on Stage 2, and 5659 Stage 3 protocols (with 27

[9] `ftp://zakupki.gov.ru/`

additional files on single participant outcome). The Stage 2 and 3 protocols are matched by tuples of purchase number and journal number, with the latter identifying the bidders within the auctions. I amend this data with manually collected protocols that are missing from the official source due to transition in data dissemination standards (1787 records on 1262 contracts). I then group the auction outcomes into broad categories "No bidders", "One bidder", "Many bidders" and "Other/Not matched" comprising, correspondingly, 1880, 2555, 2369 and 320/94 contracts. The main three groups are defined by the failed auction flag in the Stage 1 protocol (no bidders), the presence of the single bidder protocol or corresponding failure flag in the Stage 2 file (one bidder), the presence of all three stages protocols and absence of any failure flags (many bidders).

The final step of auction data preparation includes a collection of loan contract characteristics. Each auction is linked to a set of documentation files in MS Word, Excel or PDF formats. These documents are not provided in a machine-readable format; and the information is not structured enough to be programmatically parsed. Hence, I collect the information on reserve rates, loan volumes, and maturities manually. In cases when reserve rate is not explicitly mentioned, I calculate it from the data on credit volume, maturity and absolute monetary value of interest payments using simple interest rate formula. To verify the validity of collected data, I cross-check it with a sample of auctions collected by a private consulting firm[10]. Since in some cases, there is not enough information to deduce the reserve rates, or auction documentation is missing whatsoever, the final set of auctions contains 6804 contracts (including non-standard auction outcomes).

1.A.2 The Bank Balance Sheet files

The BoR publishes disaggregated bank balance sheets and income statements on a monthly basis, with each bank file covering hundreds of accounts[11]. I aggregate this data following a scheme analogous to the one used by the BoR with adjustments standard in the Russian banking analytics practice[12]. This section describes bank aggregates used to construct lender characteristics in Table 1.1. Values in parenthesis indicate account number according to the Russian Bank Accounting Standards.

*c*CB Funds:

- Bank liabilities to the BoR: sum of
  - short-term liabilities (31201, 31202, 31203, 31210, 31213, 31214, 31215, 31216),
  - mid-term liabilities (31204, 31205, 31217, 31218),
  - long-term liabilities (31206, 31207, 31212, 31219, 31220, 31221, 31222),

[10] `http://trp.tomsk.ru`
[11] `http://cbr.ru/credit/forms.asp`
[12] `http://kuap.ru/methodics/`

  - overdue debts (31701, 31704, 31801, 31804),
  - other funding from BoR (32901).

- Bank total borrowing in the interbank market: sum of
  - bank liabilities to the BoR (as above),
  - all liabilities to the resident and non-resident banks (accounts starting with 313 or 314, 20313, 20314, 32901).

*c*Repo:

- Bank securities encumbered under repo agreements: sum of
  - encumbered bonds (50113, 50115, 50118, 50218, 50318),
  - encumbered stocks (50611, 50613, 50618, 50718),
- Bank total security holdings:
  - holdings of bonds and stocks (sum of active accounts starting with 50), notes (51) and mutual funds (60106, 60118),
  - net of provisions and re-evaluations (50114, 50213, 50219, 50312, 50319, 50507, 51210, 51310, 51410, 51510, 51610, 51710, 51810, 51910, 50719, 50809, 50120, 50220, 50620, 50720).

*c*Bank size: bank total assets calculated as the sum of all active accounts of balance sheet Section A net of provisions and re-evaluations.

*c*Capital:

- Bank accounting capital: sum of
  - main capital (10207, 10208, (10501), (10502), 10601, 10602, 10603, 10604, (10605), 10609, (10610), 10611, 10612, (10613), 10614, 10621, 10701, 10702, 10703, 10704, (11101)),
  - profit from previous years (10801, (10901), 70302, (70402), (70502), 70701, 70702, 70703, 70704, 70705, (70706), (70707), (70708), (70709), (70710), (70711), 70713, (70714), 70715, (70716), 70801, (70802), (70712)),
  - current year profit (61306, (61406), 70301, (70401), (70501), 70601, 70602, 70603, 70604, 70605, (70606), (70607), (70608), (70609), (70610), (70611), 70613, (70614), 70615, (70616), (70612))
  - future period expenditures (61301, 61302, 61303, 61304, (61401), (61403))

*c*State credit:

- Credit to state-owned companies and state entities: sum of accounts starting with 44 or 46, net of provisions (44115, 44215, 44315, 44415, 44515, 44615, 44715, 44815, 44915, 45015, 46008, 46108, 46208, 46308, 46408, 46508, 46608, 46708, 46808, 46908)

- Total credit to organizations: sum of
  - credit to state-owned companies and state entities net of provisions (as above)
  - credit to resident and non-resident private companies (accounts starting with 45 or 47) net of provisions (45115, 45215, 45315, 47008, 47108, 47208, 45615, 47308)

*c*NPL:

- Non-performing loans: sum of
  - non-performing loans to organizations (45811, 45812, 45813, 45911, 45912, 45913, 40310, 40311, 45816, 45916, 45801, 45802, 45803, 45804, 45805, 45806, 45807, 45808, 45809, 45810, 45901, 45902, 45903, 45904, 45905, 45906, 45907, 45908, 45909, 45910)
  - non-performing personal loans (45815, 45817, 45915, 45917)
- Total credit claims: sum of
  - credit to resident and non-resident private companies net of provisions (as above)
  - credit to state-owned companies and state entities net of provisions (as above)
  - personal credit (accounts starting with 455, 457, 45815, 45817, 45915, 45917) net of provisions (45515, 45715)
  - net of provision on non-performing loans (45818, 45918)

*c*Liquid assets:

- Liquid assets: sum of
  - money and money equivalents (20202, 20203, 20209, 20210, 20206, 20207, 20208, 20302, 20303, 20305, 20308, 20311, 20312, 20315, 20316, 20317, 20318, 20319, 20320, 20401, 20402, 20403)
  - accounts in the Central Bank (30102, 30104, 30106, 30224)
  - correspondent accounts in other banks (30114, 30119, 30110, 30118, 30125)
  - money in payments (30213, 30215, 30221, 30228, 30233, 30235, 30402, 30409, 30413, 30416, 30417, 30418, 30419, 30424, 30425, 30426) and stock exchange (47404)
  - net of provisions (20321, 30126, 30226, 30410, 30607)
- Bank total assets (as above)

*d*SIFI: systemically important institutions as defined in the BoR order 3737-Y[13].

1.A.3 The Russian Federation State Statistics Service

The two datasets used to construct borrower characteristics are the municipal and regional databases of the Russian Federation State Statistics Service. The regional data is collected in a series of publications on Socio-Economic Conditions of the Regions available at the Service website[14]. I merge regional level data with the auction data set by region name.

The municipal level data is provided in the Database of Municipality Characteristics[15], however, it is not available for a bulk download. To overcome this issue, I write a simple program to collect the necessary data from the Service website. For municipalities of the regions that did not have properly functioning pages on the Service website, I collect the information manually from the web pages of their regional offices.

The full original database does not contain all the budget characteristics for all the municipalities active in the credit market. That is, for some small borrowers the required information is present only in the aggregated form, where aggregation is done over a set of municipalities grouped into larger districts. The share of missing data is small with the number of borrower-years with empty records not exceeding 30 (out of 1519 records of the original data). To overcome this issue I impute the missing data from the average characteristics of higher-level districts. If, furthermore, a municipality is present in the data only in 2013 and not in 2014, I use the 2013 values as the proxy for the next year budget characteristics (11 values in total). Finally, I merge the Statistics Service data with the auction data set by borrower municipality id (OKTMO).

1.B List of issuers whose liabilities constitute eligible collateral

The first wave:

City of Moscow (not in the sample), Moscow region, Saint-Petersburg, Khanty-Mansi Autonomous Okrug–Yugra, Tatarstan Republic, Kazan, Mordovia, Bashkortostan, Tumen region, Samara region, Samara, Kemerovskaya oblast, Izhevsk, Republic of Komi, Murmanskaya oblast, Sverdlovskaya oblast, Yamalo-Nenets Autonomous Okrug, Kransondarsky Krai, Republic of Saha (Yakutia), Lipeckaya oblast, Republic of Karelia, Irkutskaya oblast, Nizhegorodskaya oblast, Krasnoyarksy Krai, Vologodskaya oblast, Kaluzhskaya oblast, Magadanskaya oblast,

[13] http://www.cbr.ru/press/PR/?file=20102015_100129ik2015-10-20T10_01_03.htm

[14] http://www.gks.ru/free_doc/new_site/region_stat/sep_region.html

[15] http://www.gks.ru/free_doc/new_site/bd_munst/munst.htm

Nizhny Novgorod, Novosibirsk, Novosibirskaya oblast, Tomskaya oblast, Tomsk, Tverskaya oblast, Kirovskaya oblast, Leningradskaya oblast (not in the sample), Surgut (not in the sample), Voronezhskaya oblast, Omskaya oblast, Orenburgskaya oblast, Astrahanskaya oblast (not in the sample), Omsk, Republic of Chuvashiya, Tambovskaya oblast, Ufa, Belgorodskaya oblast, Altaisky Kray (not in the sample), Udmurtiya Republic, Yaroslavskaya oblast, Ulyanovskaya oblast, Tulskaya oblast, Dzerzhinsk, Kostromskaya oblast, Republic of Mariy-El, Volzhsky, Volgograd, Volgogradskaya oblast, Stavropolsky Krai, Penzensakaya oblast, Republic of Hakasia, Ryazanskaya oblast, Krasnoyarsk.

The second wave:

Kurskaya oblast, Chelyabinskaya oblast, Smolenskaya oblast, Krasnodar, Vladi-mir-skaya oblast, Permsky Krai, Primorsky Krai, Rostovskaya oblast, Sahalinskaya oblast, Kostroma.

1.C Graphs and robustness checks

Figure 1.C.1: Macroeconomic conditions of collateral framework amendment

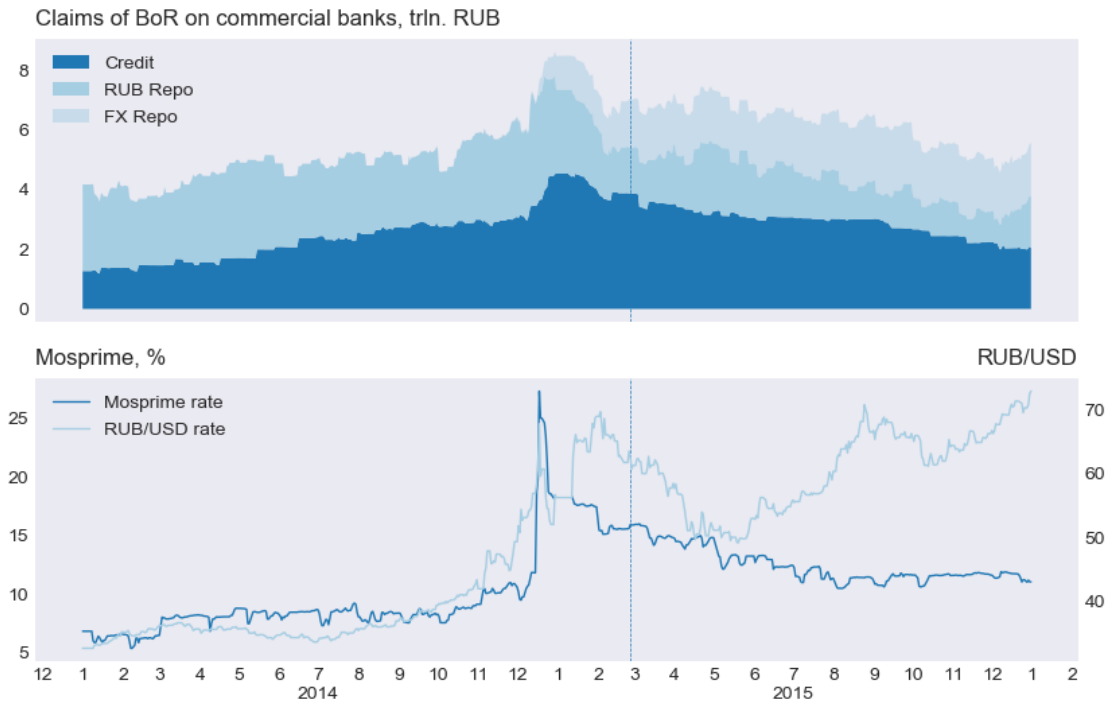
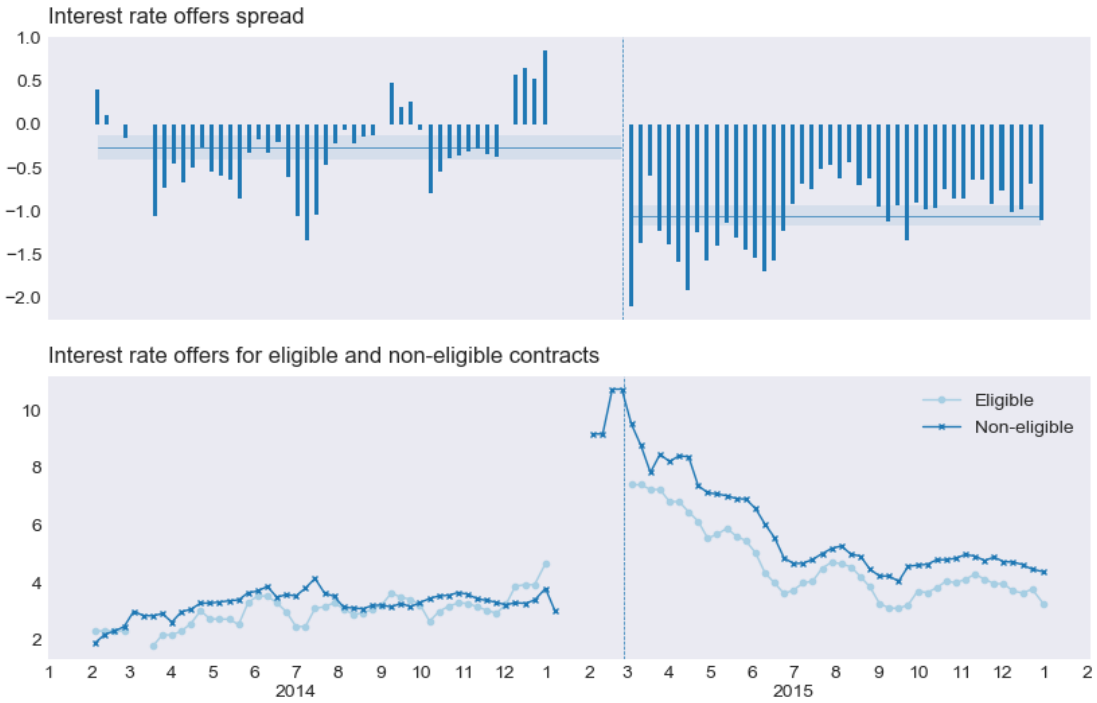


Figure 1.C.2: Interest rate offers by borrower type



Four-week moving average second-to-minimum bids grouped by contract eligibility status (the bottom panel), and the spread between the two groups with pre- and post-amendment sample means (the top panel). Subsample of contracts with at least two potential lenders. The dotted vertical line indicates the date of collateral policy amendment.

Table 1.C.1: Auxiliary difference-in-difference estimations

	Winning bid		Second bid	
	(1)	(2)	(3)	(4)
*d*Post	-1.76^{***}	-1.16^{***}	-1.35^{***}	-1.13^{***}
	(0.39)	(0.33)	(0.36)	(0.27)
*d*Post × *d*Pledge	-0.77^{***}	-0.78^{***}	-0.72^{***}	-0.52^{***}
	(0.20)	(0.17)	(0.21)	(0.16)
*c*Mosprime	0.78^{***}	0.70^{***}	0.75^{***}	0.65^{***}
	(0.06)	(0.05)	(0.07)	(0.05)
*c*CDS Russia	0.21	0.10	−0.00	0.10
	(0.35)	(0.18)	(0.27)	(0.17)
*c*USD shortage	0.09	-0.28^{*}	−0.04	-0.34^{**}
	(0.15)	(0.16)	(0.14)	(0.15)
*c*RUB/USD volatility	-0.01^{*}	-0.02^{**}	−0.01	−0.01
	(0.01)	(0.01)	(0.01)	(0.01)
*c*Budget income	0.82^{**}	0.54^{**}	0.52^{**}	0.25^{*}
	(0.31)	(0.25)	(0.25)	(0.15)
*c*Budget dependence	0.81	0.75	0.57	0.52
	(0.94)	(0.99)	(1.57)	(1.26)
*c*Budget proficit	−1.37	−1.32	0.56	1.18
	(1.35)	(1.01)	(1.18)	(1.01)
Weighted	*n*	*y*	*n*	*y*
Borrower FE	*y*	*y*	*y*	*y*
Winning lender FE	*n*	*y*	*n*	*y*
R^2	0.67	0.69	0.70	0.73
# observations	2038	2024	1957	1938
# regions	69	69	68	68

The table reports OLS and FE estimates of versions of the eq. (1.1). The dependent variable is the interest rate net of the risk-free rate of the corresponding maturity *d*Post is equal to one for auctions with bidding scheduled after the 26th February 2015 and zero otherwise. *d*Pledge is equal to one for the borrowers whose debts are pledgeable in the Bank of Russia, and zero otherwise. See Table 1.1 for other variable definitions. All control variables are demeaned. Sample includes all auctions that have at least two participants in 2014–2015. Standard errors (in parenthesis) are clustered by borrower's region. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 1.C.2: Within auction bidding vs. securities encumbrance

	(1)	(2)	(3)	(4)
*d*Post	1.77***	1.96***		
	(0.15)	(0.24)		
*d*Pledge	−0.32**	−0.31**		
	(0.14)	(0.14)		
*d*Post × *d*Pledge	−0.52***	−0.56***		
	(0.17)	(0.19)		
*c*Repo	−0.43**	0.05	−0.05	−0.15
	(0.19)	(0.35)	(0.13)	(0.21)
*c*Repo ×				
*d*Post	1.78***	2.18***	0.79***	0.02
	(0.30)	(0.50)	(0.21)	(0.32)
*d*Pledge	0.32	0.20	0.27*	0.08
	(0.20)	(0.41)	(0.15)	(0.25)
*d*Post × *d*Pledge	−1.05***	−1.11***	−0.98***	−0.76***
	(0.18)	(0.32)	(0.28)	(0.25)
Bank controls	*n*	*y*	*y*	*y*
Contract FE	*n*	*n*	*y*	*y*
Lender FE	*n*	*n*	*n*	*y*
R^2	0.26	0.29	0.89	0.91
# observations	5685	5685	5611	5591
# contracts	2268	2268	2194	2187
# regions	72	72	72	71
# lenders	74	74	74	61

The table reports OLS and FE estimates of versions of eq. (1.2). The dependent variable is the interest rate offered by a bank for a particular contract, net of the risk-free rate of the corresponding maturity. *d*Post is equal to one for auctions with bidding scheduled after the 26th of February, 2015, and zero otherwise. *d*Pledge is equal to one for borrowers whose debts are pledgeable in the Bank of Russia, and zero otherwise. *c*Repo denotes the share of bank's securities encumbered under repo funding in its total securities holdings. All regressions in columns 2–4 include additional control variables: *c*Bank size, *c*Capital, *c*State credit, *c*NPL, *c*Liquid assets, and (in columns 2–3) *d*State owned, *d*SIFI, *d*Local (not reported). See Table 1.1 for other variable definitions. All treatment and control variables are demeaned. Sample includes all auctions that have at least two participants in 2014–2015. Constant is omitted from the outputs. Standard errors (in parenthesis) are two-way clustered by borrower's region and lender. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 1.C.3: Probability of winning an auction vs. securities encumbrance

	(1)	(2)	(3)	(4)
*d*Post	−0.10***	−0.05		
	(0.02)	(0.05)		
*d*Pledge	0.01	−0.02		
	(0.04)	(0.03)		
*d*Post × *d*Pledge	0.01	0.01		
	(0.03)	(0.04)		
*c*Repo	0.16	0.12	0.30	0.38*
	(0.11)	(0.10)	(0.20)	(0.20)
*c*Repo ×				
*d*Post	−0.50***	−0.32***	−0.59***	−0.38*
	(0.16)	(0.10)	(0.19)	(0.23)
*d*Pledge	−0.14	−0.17	−0.54	−0.59
	(0.24)	(0.23)	(0.42)	(0.43)
*d*Post × *d*Pledge	0.29	0.39	0.78*	0.80*
	(0.24)	(0.24)	(0.42)	(0.42)
Bank controls	*n*	*y*	*y*	*y*
Contract FE	*n*	*n*	*y*	*y*
Lender FE	*n*	*n*	*n*	*y*
R^2	0.05	0.08	0.14	0.23
# observations	5685	5685	5611	5591
# contracts	2268	2268	2194	2187
# regions	72	72	72	71
# lenders	74	74	74	61

The table reports OLS and FE estimates of versions of eq. (1.2). The dependent variable is an indicator equal to one if a bank is a winner in a particular auction, and zero otherwise. *d*Post is equal to one for auctions with bidding scheduled after the 26th of February, 2015, and zero otherwise. *d*Pledge is equal to one for borrowers whose debts are pledgeable in the Bank of Russia, and zero otherwise. *c*Repo denotes the share of bank's securities encumbered under repo funding in its total securities holdings. All regressions in columns 2–4 include additional control variables: *c*Bank size, *c*Capital, *c*State credit, *c*NPL, *c*Liquid assets, and (in columns 2–3) *d*State owned, *d*SIFI, *d*Local (not reported). See Table 1.1 for other variable definitions. All treatment and control variables are demeaned. Sample includes all auctions that have at least two participants in 2014–2015. Constant is omitted from the outputs. Standard errors (in parenthesis) are two-way clustered by borrower's region and lender. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 1.C.4: Auxiliary triple difference estimations

	*c*Interest rate		*d*Winner	
	(1)	(2)	(3)	(4)
*c*CB funds ×				
*d*Pledge	0.13		−0.31	
	(0.17)		(0.31)	
*d*Post	0.15		0.07	
	(0.17)		(0.19)	
*d*Post × *d*Pledge	−1.01***		0.75***	
	(0.32)		(0.24)	
*c*Repo ×				
*d*Pledge		−0.01		−0.33
		(0.30)		(0.42)
*d*Post		−0.10		−0.01
		(0.19)		(0.26)
*d*Post × *d*Pledge		−0.95***		0.74**
		(0.30)		(0.36)
Bank controls	*y*	*y*	*y*	*y*
Contract FE	*y*	*y*	*y*	*y*
Lender FE	*y*	*y*	*y*	*y*
R^2	0.91	0.91	0.23	0.23
# observations	5591	5591	5591	5591
# contracts	2187	2187	2187	2187
# regions	71	71	71	71
# lenders	61	61	61	61

The table reports FE estimates of versions of eq. (1.2). *d*Post is equal to one for auctions with bidding scheduled after the 26th of February, 2015, and zero otherwise. *d*Pledge is equal to one for borrowers whose debts are pledgeable in the Bank of Russia, and zero otherwise. In all columns, bank treatment variables (*c*CB funds and *c*Repo) are as of the end of 2014. All regressions in columns 1–4 include additional control variables: *c*Bank size, *c*Capital, *c*State credit, *c*NPL, *c*Liquid assets (not reported). See Table 1.1 for other variable definitions. All treatment and control variables are demeaned. Sample includes all auctions that have at least two participants in 2014–2015. Standard errors (in parenthesis) are two-way clustered by borrower's region and lender. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 1.C.5: Competition for common borrowers, subsample of bank-pairs (OLS)

*c*Pledge	0		1		$\Delta_t \Delta_c \beta$
*d*Post	0	1	0	1	
*c*CB funds	0.00	−0.03	0.04	0.30**	0.29**
	(0.03)	(0.08)	(0.04)	(0.12)	(0.12)
*c*State credit	0.59**	1.46***	1.01***	1.21***	−0.67***
	(0.28)	(0.46)	(0.30)	(0.42)	(0.23)

The table reports OLS estimates of a version of the eq. (1.3) without bank fixed effects. The dependent variable is an indicator equal to one if both banks in a bank pair compete for at least one common borrower, and zero otherwise. *d*Post is equal to one for auctions with bidding scheduled after the 26th February 2015 and zero otherwise. *d*Pledge is equal to one for the borrowers whose debts are pledgeable in the Bank of Russia, and zero otherwise. All regressions include additional column-specific control variables: *c*Bank size, *c*Capital, *c*NPL, *c*Liquid assets, *d*State owned, *d*SIFI, *d*Local (not reported). Pair-level explanatory variables are calculated as a geometric mean of the corresponding bank-level variables (*c*Bank size is calculcated as an arithmentic mean of the logarithm of assets of the banks). Bank-level variables are averaged by the pre- and post-amendment periods before calculating the bank-pair statistics. See Table 1.1 for bank level variable definitions. Sample includes bank-pairs comprised of banks that compete at least once in the same geographical region during 2014–2015. All explanatory variables are centered within each subsample defined by combinations of *d*Pledge and *d*Post. Total number of observations is 5464, number of dyads is 2552, total number of banks is 79 in the pre-amendment period and 78 in the post-period. Standard errors (in parenthesis) are calculated under dyadic clustering. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 1.C.6: Competition for common borrowers, subsample of bank-pairs (FE)

*c*Pledge	0		1		$\Delta_t \Delta_c \beta$
*d*Post	0	1	0	1	
*c*CB funds	0.00	−0.04	0.04	0.31**	0.32**
	(0.05)	(0.08)	(0.07)	(0.13)	(0.13)
*c*State credit	0.72**	1.56***	1.12***	1.22**	−0.74**
	(0.35)	(0.50)	(0.39)	(0.48)	(0.30)

The table reports FE estimates of the eq. (1.3). The dependent variable is an indicator equal to one if both banks in a bank pair compete for at least one common borrower, and zero otherwise. *d*Post is equal to one for auctions with bidding scheduled after the 26th February 2015 and zero otherwise. *d*Pledge is equal to one for the borrowers whose debts are pledgeable in the Bank of Russia, and zero otherwise. Pair-level explanatory variables are calculated as a geometric mean of the corresponding bank-level variables (*c*Bank size is calculcated as an arithmentic mean of the logarithm of assets of the banks). Bank-level variables are averaged by the pre- and post-amendment periods before calculating the bank-pair statistics. All regressions include additional column-specific control variables: *c*Bank size, *c*Capital, *c*NPL, *c*Liquid assets, *d*State owned, *d*SIFI, *d*Local (not reported). See Table 1.1 for bank level variable definitions. Sample includes bank-pairs comprised of banks that compete at least once in the same geographical region during 2014–2015. All explanatory variables are centered within each subsample defined by combinations of *d*Pledge and *d*Post. Total number of observations is 5464, number of dyads is 2552, total number of banks is 79 in the pre-amendment period and 78 in the post-period. Standard errors (in parenthesis) are calculated under dyadic clustering. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Chapter 2

HEDGER OF LAST RESORT: CAN CENTRAL BANK PROTECT LOCAL CREDIT MARKETS FROM GLOBAL FINANCIAL SHOCKS? EVIDENCE FROM BRAZIL

Joint with Rodrigo Barbone Gonzalez, José Luis Peydró and Andrea Polo.

2.1 Introduction

The recent developments in monetary policy of the developed economies raised new concerns about their effects on the emerging markets. Understanding particular transmission mechanisms, quantifying their effects and working out policy actions aimed to reduce the social costs of the shocks spillovers is of particular interest both for the academics and policymakers. In this paper, we analyze whether banks' foreign liabilities matter for transmission of the US monetary policy to the local economy of emerging markets. Specifically, we investigate the lending behavior of domestic banks in Brazil with different exposure to the external financial shocks. As the latter may trigger massive capital outflows and exchange rate adjustments, the local banks may face higher funding costs both because of the lower supply of foreign capital and due to increased prices of FX risks hedging. We provide empirical evidence suggesting that hedging is a significant source of costs for the local financial institutions and that the domestic monetary authority may partially moderate them by intervening in the FX markets.

First, as a quasi-natural experiment, we look at the announcement of US Quan-

titative Easing tapering by the Chairman of the Federal Reserve in 2013. On May 22, Ben Bernanke raised the possibility of tapering its security purchases in his testimony before the Joint Economic Committee of the U.S. Congress. The unconventional monetary policies undertaken by the Fed in the aftermath of the Global Financial Crisis massively reduced the interest rates in advanced economies and incentivized investors to expand to emerging markets in search for yield. This trend reversed on May 22, 2013. While the expansionary policies by the Fed were not expected to last forever, the "tapering" speech did surprise the markets. Between May 22 and end-June, on average, in emerging markets bond spreads rose 1%, and equities fell 7% (Mishra et al. (2014)). The speech by Ben Bernanke had significant spillovers regarding currency rates dynamics. Thus, currencies across emerging markets depreciated, on average, by 3% and in some countries, the FX depreciation was massive (Brazil 12.5%, India 9.9%, South Africa 8.9%, Turkey 7.6%, Russia 4.6% (Eichengreen and Gupta (2015))).

Three months after the Bernanke speech, the Central Bank of Brazil (BCB) announced a program of extensive interventions in the FX derivatives markets. According to the program, BCB was to provide relatively cheap hedging against Brazilian Real (BRL) depreciation by selling FX forwards at a discount to the ongoing market prices. The intervention aimed primarily at decreasing the hedging costs of the global financial intermediaries and, thus, incentivizing them to supply much-need dollar liquidity to the on-shore FX markets. We show that local commercial banks with larger exposure to the FX shock decreased their lending disproportionally more than non-exposed banks in the aftermath of Bernanke speech and that the BCB policy could partially mitigate this effect.

Second, we match the credit data with firm employment statistics and quantify transmission of the credit supply shocks to the labor markets. We find that worsened credit conditions affected negatively credit demand of the firms that relied on the foreign-funded banks. Finally, apart from the shock of May 2013 we also examine the FX rate effects on local banks credit in a full panel dataset from 2008 to 2015. The time variation of macroeconomic variables allows us to model them explicitly. Hence, we can quantify the importance of FX rate fluctuations for the local credit markets conditional on the changes in US monetary policy rate.

For identification, we analyze three matched datasets from Brazil: a register of credit flows from foreign counterparties to Brazilian commercial banks; a credit register (with exhaustive bank-firm credit relationships) from the Central Bank of Brazil and an employer-employee dataset from the Ministry of Labor and Employment. In our cross-section and panel analysis, we address potential confounded credit demand shifts by exploring the granularity of the credit data and controlling for unobservable credit heterogeneity at, correspondingly, the firm and firm-quarter level (Khwaja and Mian (2008)).

We contribute to the literature on bank lending channel in emerging markets and its dependence on the global financial conditions (Kalemli-Ozcan et al. (2013), Baskaya et al. (2017), Cetorelli and Goldberg (2011), De Haas and Van Horen (2012), Cerutti et al. (2017b), Schnabl (2012)). By focusing on domestic insti-

tutions, we also contribute to the literature on the impact of US monetary policy on emerging economies: Morais et al. (2015) provide micro-level evidence for the transmission via foreign banks, here we investigate the role of local institutions which typically constitute the largest part of the banking sector. We document the relevance of the currency movements to the credit supply, even conditionally on the US interest rates and other global and local macroeconomic characteristics. In Bruno and Shin (2015) local banks do not play any significant role as they are assumed to be fully hedged. In this paper, we show that since matching books is costly, banks can be sensitive to large exchange rate fluctuations. Finally, we provide micro-level evidence on the impact of FX interventions of central banks. Cerutti et al. (2017a) show that interventions in the exchange rates are one of the most common macroprudential policies in emerging markets. Here we provide empirical evidence that interventions in the FX derivatives markets can be effective in so far as they reduce the exposure of the market participants to the FX risks.

The chapter proceeds as follows. Section 2.2 provides institutional details. Section 2.3 describes the data. Section 2.4 discusses the results, and Section 2.5 concludes.

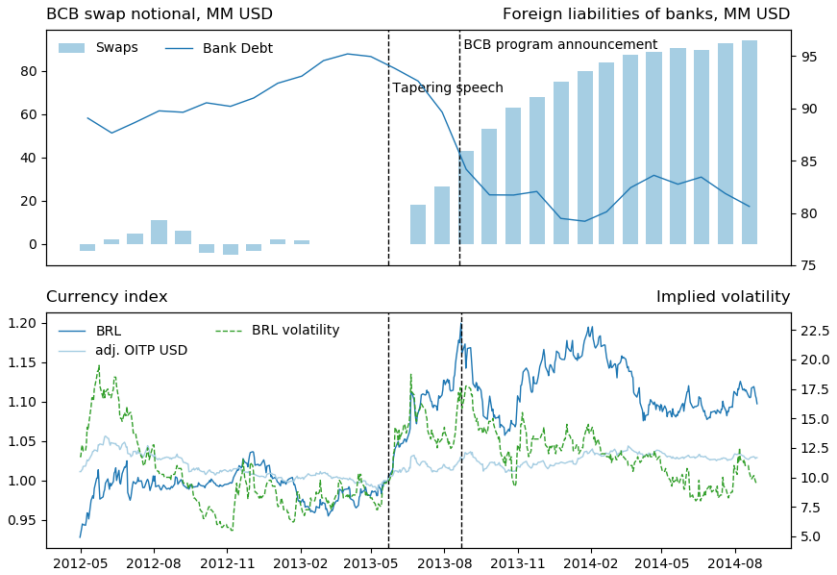
2.2 FX interventions in derivative markets

In May 2013, after a prolonged period of the unconventional monetary policy, the back then chairman of the Federal Reserve Ben Bernanke in his Congressional speech noted that the monetary authority might consider tapering the QE if warranted by the data. The speech immediately launched a rollercoaster in the US and global financial markets as it was thought to signal tightening US monetary policy in a near future. Faced with higher opportunity costs, in the following next few months after the speech the developing economies witnessed massive capital outflows. In most cases, with capital leaving the countries, local currency depreciation was steep and followed by Central Banks' interventions. The intervention program carried by BCB was the largest of its kind with over USD 86MM of dollars offered between May 2013 and April 2014.

In Brazil, the first interventions started in early June 2013 with the unannounced sales of currency "swaps"; by the end of June, the BCB also offered currency repo lines. However, the initial policy steps were not effective: capital outflows continued, and by the end of June BRL lost more than 12% of its value against the US Dollar. Three months after the Bernanke speech, on the 22nd of August, a formal program was announced where the BCB committed to daily sales of USD 500M of swaps from Monday to Thursday and an additional USD 1MM every Friday on repo lines. Markets welcomed the regulator promise: the policy led to an appreciation of the currency. Chamon et al. (2017) present evidence of a 10 to 19% appreciation of BRL attributed to the BCB intervention. Later in 2013, depreciation resumed and, on December, 18, BCB announced the second round of interventions. In the second wave, BCB auctioned USD 200M daily in swaps and

repo auctions only by demand. The impact of this policy was more modest with an upper bound of the estimated effect around 5% of appreciation (Chamon et al. (2017)). Figure 2.1 illustrates the macroeconomic conditions in Brazil around the analyzed period.

Figure 2.1: Macroeconomic conditions in Brazil around the Tapering speech.



While interventions in FX markets via derivatives are common among many countries, the Brazilian policy environment is unique. First, due to historical reasons, the country's FX derivates markets are way more developed than the spot ones[1]. In addition to the standard option contracts, the market participants may employ a relatively wide range of hedging instruments of FX risks. The most relevant tools comprise the BCB swaps auctioned on Brazil's main centralized venue, BM&F Bovespa, altogether with FX futures and on-shore USD interest rates (known as "Cupom Cambial"). Relatedly, the BCB swaps are settled in BRL as opposed to the typical USD settlement of the non-deliverable forwards. As such, the policy does not require an exchange of actual foreign currency and, thus, preserves the level of BCB reserves, albeit, by exposing the investors to (typically negligible) convertibility risks.

In its core, the BCB interventions were aimed to confront excess volatility and devaluation by providing a cheap insurance against the BRL depreciation. In words of Márcio Garcia, "The forex interventions are not meant to establish a floor for the exchange rate, but to provide the needed liquidity for the depreciation to take

[1] Garcia et al. (2014a) show that higher liquidity allows for price discovery to take place in the futures markets.

place without excess volatility and overshooting — which may entail unnecessary economic costs" (Garcia (2013)). The policy instrument was designed to provide the investors with hedging similar to the one that could be obtained by buying the USD on the spot and holding it until the maturity of the swaps. Hence, the policy targeted those investors who demanded FX instruments for hedging or speculative purposes, and not the market participants who used the currency for actual settlement. The former include institutions with needs of addressing their balance sheet exposures (e.g., banks that continually roll over foreign debt). To the extent convertibility risks were negligible, the BCB forwards were nearly perfect substitutes of the actual USD balances.

Contractually, the BCB FX swap agreements were structured in such a way that, at maturity, the Bank would pay to its counterparty the realized variation in the BRL/USD exchange rate. In return, the Bank was to receive the spread between the local money market rate (SELIC) and the on-shore dollar rate (Cupom Cambial) adjuster for the contract discount.[2]. By offering the swaps for sale, the BCB assumed a short position in USD and, hence, was to incur losses — by renumerating the counterparties — if BRL depreciated over the contract period. The reserve price of the auctioned contracts was set to depend on the past spot FX rates, thus, providing the hedge consumers with an additional margin over the market price on days of BRL depreciation. In other words, the BCB agreed to absorb part of the FX risks on its balance sheet at prices favorable for the cross-border dollar intermediaries. In a way, the Bank paid the commercial institutions a fee to bring spot USD to Brazil and help to finance its current account deficit (Garcia et al. (2014b)).

The policy could affect the local commercial banks in several ways. In broad terms, the Tapering Tantrum increased the funding costs of the domestic banks, both directly — by raising the opportunity costs of investing in Brazil and decreasing supply for foreign capital, and indirectly — by pushing up the hedging costs of cross-border dollar intermediation. Since prudential regulation in Brazil imposes additional charges on large unmatched FX positions (those that exceed 5% of regulatory capital), the banks had high demand to hedge their foreign liabilities. The on-balance-sheet hedge via foreign denominated securities would be costly due to large interest rate differential; additionally, FX-denominated lending was limited to the trade credit and as such comprised a rather negligible part of the total assets of most of the commercial banks. As a result, the institutions were to hedge their FX exposures predominantly off-balance sheet in derivatives markets, and the BCB, effectively, promised to subsidize them in doing this.

The hedging costs were likely to be relevant not only for the local commercial institutions but also for the global financial intermediaries of dollar liquidity. To the extent the Bank policy offered attractive hedging subsidies, it could soften the USD supply shock of the global investment banks and, hence, alleviate dollar liquidity shortages of the domestic institutions. In a way, one can think of the BCB's policy

[2]As opposed to the conventional cross-currency swaps, the BCB contracts did not involve an exchange of the notional amounts.

as of a coordination tool resolving uncertainty about capital outflow timing. In a dynamic setup, the scale of operations could further indicate BCB's commitment to sharing the risks of the FX rate adjustments in the future periods. As such, the policy could affect not only the current refinancing costs but also expectations about banks' future costs of funding.

With significant net short FX exposures, BRL depreciation could have a direct effect on banks' capital as they were to account for losses stemming from adverse FX rate movements. To the extent bank capital requirements were binding, this could create additional pressure on funding costs. Most of the institutions with unmatched FX positions were involved in investment banking and are not included in our sample of commercial banks. However, this could still matter for the commercial lenders if the undercapitalized balance sheets of the investment banks negatively affected their participation in derivatives markets. Furthermore, even in the absence of direct accounting costs, massive devaluations may lead to rapid expansion of the bank balance sheets and rebalancing of the lenders' assets if the macroeconomic shocks significantly raise the costs of funds.

By refilling the markets with FX risks insurance, a central bank acts, effectively, as a hedger of last resort. This policy goes in parallel with its standard function of lender of last resort whereby the regulator aims at mitigating systemic risks by lending to the financial system in times of aggregate liquidity shocks. As an insurance mechanism, the FX derivative interventions can distort banks' *ex-ante* incentives to rely upon risky funding. Analogously to liquidity provision, prudential regulation can, in principle, mitigate this effect and, conditional on adverse outcomes, the regulator's actions of the ultimate provision of hedging services may help to minimize the costs of excessive volatility. In our analysis, we do not consider the *ex-ante* effects of the interventions in FX derivative markets, but rather estimate its *ex-post* efficacy of protecting domestic credit markets from global financial shocks.

2.3 Data Description

In our analysis, we match three data sets: the registry of corporate loans administered by the Bank of Brazil, regulatory database on foreign borrowing by local financial institutions, and employment registry of the Brazilian Ministry of Labor and Employment. We augment this data with bank balance sheet variables, as well as with macroeconomic statistics provided by the Bank of Brazil. Our final panel sample spans all calendar quarters from 2008 until the middle of 2015.

Financial regulation in Brazil instructs every financial institution to submit comprehensive information on issued credit at the level of a separate loan. The files describe basic characteristics of the underlying credit contracts, including committed and actual credit volumes, interest rates, maturity, loan types and borrower tax ids, as well as information on loan performance. We aggregate loan level credit volumes at the firm-bank level and calculate credit exposure as the total credit (ac-

tual credit claims and committed but unused credit lines) provided by a lender to a particular firm. We perform this aggregation at the bank holding company level in order to mitigate any concerns about credit supply dependence of banks with common management strategy. We further trace the quarterly dynamics of this exposure over the whole sample period for each bank-firm pair present in the database. Due to computational reasons, we sample the data from the original database by a firm (i.e. we collect a random sample of firms ever present in the full registry and build their credit histories from all the banks that ever lend to these borrowers). Our sample covers 30% of all the firms that have credit from at least one bank in at least one quarter during the sample period.

As we focus on credit supply in local currency, we drop firm-bank observations with at least one credit contract denominated in currencies other than Brazilian Real. In our sample, as of the end of April 2013, less than 0.5% of firms have liabilities to banks denominated in a foreign currency. According the BCB statistics, economy-wide about 8% of bank credit is provided not in BRL. However, most of these credit claims are directly related to trade finance: only 0.8% of total bank loans non-related to trade purposes is in a foreign currency. Furthermore, most of the USD-denominated trade finance is concentrated in one of the largest banks. Hence, it is safe to assume that other banks do not have significant shares of loans denominated in currencies other than BRL.

We also exclude from the analysis non-profit organizations and financial firms, as well as loans that were not originated by depository institutions. Since we aim to account for unobservable credit demand characteristics by using fixed effect estimator, we further restrict the sample to include firms with at least two lenders in a given quarter. Importantly, we exclude from the main analysis credit claims of foreign banks. With the exception of the two largest institutions, most foreign lenders in Brazil are involved in investment banking rather than in commercial activity. By excluding all the non-Brazilian institutions we aim to highlight that the final estimates are specific to the local financial institutions rather than driven by the foreign lenders. As of the end of April 2013, the claims of local commercial banks included in our baseline sample comprise more than 77% of economy credit; the largest foreign banks involved in the commercial activity account for additional 13%, with the remaining part attributed to other foreign, investment and non-depositary institutions. In our baseline regressions we employ the sample of loans issued by the local commercial banks and, as an additional exercise, we analyze firm substitution between the three sources of credit.

Our main dependent variable is log growth rates of firm-bank credit exposures winsorized at 1% and 99% percentiles. We quantify our main bank-level treatment variable using the data on foreign borrowing of local credit institutions. The original data file comprises contract-level data on bonds and loans issued by the domestic banks with the corresponding credit claims acquired by the foreign investors. To calculate total foreign liabilities of a bank group, we drop all funds coming not from noncommercial non-financial organizations and sum up the remaining balances. We further recast the foreign funds variable in terms of BRL

using end-of-quarter exchange rates (more than 93% of bank foreign debt is in USD). Our main bank exposure variable is calculated as a ratio of its foreign funds as defined above to the lender's total liabilities.

The foreign funds variable is thought to capture the exposure of a bank to time-varying FX risks and hedging costs. In general, part of the short FX exposure may be offset on balance sheet via security holdings or credit claims denominated in the corresponding foreign currency. Local Brazilian banks, however, have very small direct FX exposure on their asset side: most of the euro bonds intermediation is concentrated among investment banks, while credit denominated in the foreign currencies is predominantly used to finance trade and as such comprises a small share of bank loan portfolio. As a consequence, most of the net short positions are hedged off-balance sheet in the derivatives markets of FX futures and options. Hence, the level of foreign liabilities can be treated as a good proxy for hedging demand.

We amend the regression analysis by accounting for observable credit supply drivers potentially confounded with bank foreign debt. Hence, we include a list of control variables comprised of bank size (log of bank assets), capital (bank capital to its total assets), NPL (share of non-performing loans in the total credit portfolio of a bank) and the state ownership indicator. Also, at the borrower-lender level, we control for (log of) beginning-of-period credit exposure, the share of unused credit line in the total credit, and the default indicator to capture bank-firm specific determinants of the credit outcomes.

To capture the compositional effects of foreign funds, we additionally condition the estimates on the bank-level share of external debt structured under loan agreements (Foreign debt structure variable). In our sample of commercial banks, few large domestic institutions heavily rely on dollar liquidity supplied via loans. A significant part of this funding is provided by the parties directly affiliated with the mentioned banks. Hence, it is reasonable to assume that these organizations may face lower USD liquidity constraints in comparison with the other banks that structure their liabilities in longer maturity bonds. We also explicitily account for maturity structure of the foreign bank debt by conditioning on the share of external liabilities with the remaining maturity of less than one year (Short foreign debt variable). Immediate refinancing needs may act as an important driver of bank credit supply, especially, in times of higher volatility or depreciation of the exchange rate. The inclusion of this variable in the control list helps to mitigate any concerns about the correlation of debt maturity with the level of foreign funding.

The summary statistics for the Tapering shock and the whole credit sample are reported, correspondingly, in Tables 2.A.1 and 2.A.2. The full panel spans 74 banks, with 53 banks having non-zero credit claims on firms right before the tapering shock. In both cases, an average corporate loan is provided by a bank with around 5% of its total liabilities funded from abroad, with the maximum exposure as of the end of April 2013 ranging up to 15%.

Table 2.A.2 contains summary statistics on firm-level credit characteristics, as well as on their employment state. The latter is derived from the registry of the

Brazilian Ministry of Labor and Employment. The raw data file collects information on each job spell defined by the work start and end dates and employer and employee tax numbers. We perform several adjustments to convert the data file into the format appropriate for the cross-section analysis. Thus, for the tapering part, we drop all the job spells where employees were recorded to start working before 1970. We further drop the records with zero wages, nonstandard employee ids, and any job types other than full-time contract employment. The remaining records are then aligned with the tapering shock timing, i.e. we calculate the stock of active labor force as of the end of April 2013 and the analogous statistics for April 2014. The data is then aggregated to the firm level by calculating, for each date, the counts of workers and the average of their log-tenure. By focusing on the labor stock we do not consider employment turnover explicitly: any job spell beginning right after April 2013 and ending in less than a year is dropped from the analysis.

The firm-level employment variables included in the regressions as controls are (the log of) the number of employees and their average log tenure as of the end of April 2013. To trace the labor market consequences of shrinking credit supply, we use firm employment growth rates and changes in the average tenure of their employees as the dependent variables. Both are calculated over one year following the Bernanke speech (April 2013–April 2014), with employment growth rate defined as the change of the number of employees over the average number of firm workers during this year.

Moving from the cross-section analysis to the panel data setup allows us to explicitly introduce dependence on macroeconomic shocks. We model bank foreign liabilities as the lender's exposure to general economic conditions and we focus our analysis on its relation to the hedging costs. Namely, we run a series of panel regressions with foreign funds interacted with the OITP USD index and implied volatility of the BRL/USD rate. The coefficient on the double interaction indicates whether banks with larger hedging needs act differently in comparison with the lenders that are not exposed to these risks in times following FX rate adjustments.

As the recent literature documented a noticeable dependence of the local credit supply on the global financial conditions, in particular, money rates in the US, we interact Wu-Xia Shadow Federal Funds rate with lender foreign liabilities to account for this effect (Wu and Xia (2016)). Furthermore, since local currency devaluation can have a significant effect on firm credit demand, we employ firm-time fixed effects in an attempt to isolate the credit supply movements. By analogy with the cross-section analysis, we include a list of time-varying bank and loan characteristics as the control variables to account for other drivers of credit supply. We do this in order to capture potential confounding factors, as well as to boost the efficiency of the fixed effect estimator.

Most of the time-series used in this section, including the FX rate implied volatility, inflation rate, money market rate, commodity price index, and economic activity index, are provided by the Bank of Brazil Statistics department. The US shadow rate is published by the Federal Reserve Bank of Atlanta. The OITP in-

dex of US dollar value is published by by the Board of Governors of the Federal Reserve System. To mitigate concerns about endogeneity of the FX interventions, we strip the OITP index of its Brazilian component and recalculate the index using the adjusted weights. As such, the index represents a weighted average of the currencies of Mexico, China, Taiwan, Korea, Singapore, Hong Kong, Malaysia, Thailand, Philippines, Indonesia, India, Israel, Saudi Arabia, Russia, Argentina, Venezuela, Chile and Colombia against the US dollar.

Finally, to measure the level of interventions of the Bank of Brazil in the hedging markets, we use the ratio of the gross swaps position of the regulator relative to its foreign reserves. Even though the intervention contracts are settled in the local currency, relevance the the BCB foreign reserves may be an important indicator of potential convertability risks. The summary statistics of the panel data is reported in Tables 2.A.3.

2.4 Results

2.4.1 The Tapering Shock

Table 2.1 reports the baseline estimates of the credit supply dependence on the lender's foreign funds around the Tapering shock. We first use the one quarter period to trace the impact of worsened global conditions: the dependent variable is the credit growth at the bank-firm level over the months April 2013–July 2013. To allow for rather conservative inference, we calculate the standard errors under the two-way lender and industry clustering with the latter defined by the first three digits of firm's CNAE attribute. Cross-section specification in first differences eliminates any time-invariant level component of firm credit demand as well as the macroeconomic effects common to all firms and lenders. If conditional on observables the *same* borrower wes indifferent between the *several* credit sources, the coefficient on bank foreign funding could be directly attributed to the lenders' supply decisions.

All the specifications of Table 2.1 indicate that the dependence on foreign funds had a negative effect on the bank credit supply in the aftermath of the tapering talk. Thus, the coefficient on the foreign funds variable is negative and statistically different from zero at the conventional levels. The estimated economic effect of one standard deviation differential in foreign funding is around 2pp of quarterly credit growth. The estimate is robust to the inclusion of borrower fixed effects (column 2) which eliminate approximately 40% of the variation of the dependent variable. Accounting for observable determinants of credit market outcomes (column 3) neither changes the main coefficient of interest.

As it could be expected for the adverse economic conditions, firms with larger unused credit lines demonstrated higher credit growth rates, while those borrowers that were in default *ex-ante* were further cut off from the credit market. Banks with external debt structured mostly under loan agreements exhibited higher credit supply growth. This result goes well in line with our hypothesis that having close off-

Table 2.1: QE tapering: credit markets

	Δ Credit		
	(1)	(2)	(3)
Foreign debt	−0.92***	−0.75***	−0.63***
	(0.30)	(0.20)	(0.15)
Foreign debt structure			0.07***
			(0.01)
Short foreign debt			−0.19***
			(0.03)
Bank capital			0.13
			(0.11)
Bank size			0.02***
			(0.00)
NPL			−0.14
			(0.23)
State owned			0.03***
			(0.01)
Credit line			0.13***
			(0.01)
Credit			−0.03***
			(0.01)
Default			−0.03***
			(0.01)
Firm FE	*n*	*y*	*y*
Controls	*n*	*n*	*y*
R^2	0.01	0.42	0.44
# observations	194090	186718	186718
# firms	84519	77147	77147
# banks	51	51	51
# industries	254	254	254

The table reports estimates of versions of the equation

$$\Delta\text{Credit}_{f,b} = \beta_1 \text{Foreign Debt}_b + \gamma X_{f,b} + \theta_f + e_{f,b},$$

where $\Delta\text{Credit}_{f,b}$ is log growth rate of credit provided to firm f by bank b, over one quarter after Tapering Speech (end of April'13–end of July'13), Foreign Debt_b is bank's *ex-ante* share of foreign debt in its total liabilities, θ_f is firm fixed effect, and $X_{f,b}$ is a matrix of controls; all explanatory variables are measured as of the end of April'13. Constant in column 1 is omitted. Standard errors (in parenthesis) are calculated under two-way clustering by bank and 3-digit CNAE industry.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

shore dollar providers may alleviate USD liquidity shortage and, thus, temporarily insure the lender against the capital outflows. Shorter maturities of external liabilities, on the contrary, affect bank credit supply negatively: immediate refinancing needs in the situation of decreasing supply of foreign capital may force the bank to shrink its loan portfolio.

While the baseline results suggest that the bank dependence on foreign funding had a negative effect on the credit supply, a borrower could offset a part of the shock by substituting the exposed creditor with another lender. To check whether indeed it was the case, we run a set of firm-level regressions with the growth rate of firm total credit as the dependent variable. The corresponding estimates are reported in Table 2.A.4, where the left panel presents estimates for the total credit growth of banks included in the sample, while the right one reports the analogous set of regressions with credit from all banks — local or foreign, commercial or investment — and non-depositary institutions as the dependent variable. All the firm-level explanatory variables are calculated as the weighted average of the loan-level data, with weights proportional to the share of each lender in the total credit liabilities of a firm. If that the supply shock was not correlated with the credit demand, the coefficient on the foreign funds variable can be used to characterize the degree of credit substitution.

The estimates indicate that the loan supply shift was offset only partially. Hence, the estimated coefficient is negative and statistically significant at 1% level (we calculate the standard errors under two-way clustering allowing for potentially non-zero error correlation if the firms belong to the same industry or, additionally, if they have identical main creditor. The latter is defined to be the lender with the largest credit exposure to the firm as of the end of April 2013). A one standard deviation change in bank dependence on foreign funding corresponds to 1–1.5%pp lower quarterly growth rates of credit. This result is robust to control for unobserved heterogeneity at the industry–state level, as well as for *ex-ante* firm and creditors characteristics. The estimates reported in the right panel are smaller only marginally. This observation suggests that neither foreign banks nor non-bank lenders were of a great help in offsetting the credit supply decrease of the local banks.

To estimate the effect of the BCB FX interventions, we first amend the regressions with the following quarter of credit growth dynamics. Namely, we expand the dataset in such a way that each bank-firm pair contains two observations corresponding to (1) the first three months after the Tapering shock (April 2013–July 2013) and (2) to the next quarter of the BCB interventions (July 2013–October 2013). To trace the policy effect, we augment the explanatory variables with a dummy variable indicating the period after policy announcement (the second quarter) and with an interaction of this indicator with bank foreign debt. The "post-policy" dummy, if identified, demonstrates the difference in the aggregate growth rates of credit between the two periods. The interaction shows whether the loan growth dynamics of the exposed banks changed significantly after the BCB policy was announced. To account for potential demand factors, we employ firm-period

fixed effect estimator. We fix all other explanatary variables at their *ex-ante* levels.

Table 2.2 reports the corresponding estimates (left panel). According to these results, the FX interventions had a positive effect on the credit supply: if before policy announcement banks with high levels of external debt demonstrated lower credit growth rates in comparison to the non-exposed lenders, in the first quarter of policy implementation this difference was partially mitigated. In particular, in the post-policy period, the credit supply sensitivity to foreign funds is estimated to be twice as small as one of the post-tapering months. Put differently, the BCB policy reduced the credit growth differential between the exposed and non-exposed banks, although, it was not able to completely offset the original shock.

The right panel of Table 2.2 reports the results of a similar exercise but with three-quarters of credit growth observations encoded in the "post-policy" period. Quantitatively and statistically, the estimates are akin to the ones discussed above. The results suggest that the BCB interventions were effective rather at the beginning of the policy implementation. These dynamics goes well in line with the conclusions of Chamon et al. (2017) who show that the second round of the BCB interventions had somewhat smaller effects.

Table 2.A.5 presents the total credit growth models in the context of policy evaluation. We concentrate on the two periods: the first quarter after the Tapering announcement and the subsequent three-months period of the BCB interventions. The estimates of the credit supply elasticity to foreign funding during the period immediately after the US monetary tightening shock are similar to the ones discussed above. Analogously, we find a positive effect of the BCB interventions. The latter results, however, are somewhat stronger in magnitude, especially when controlling for all the observable determinants of the *ex-ante* bank and firm characteristics. This observation can indicate that exploring variation within industry-state-period groups may not suffice for accounting for all the firm-level credit demand shifters. In particular, if during the policy period firms with foreign-funded banks experienced positive demand shock (relative to their industry-state average) due to, for instance, better trade perspectives, then the estimated credit supply coefficient would be biased.

To quantify the transmission of credit shock to the labor market, we run a set of firm-level cross-section regressions with employment characteristics as the dependent variables. If the credit market conditions were not favoring their growth or made financing of their working capital more costly, the firms could adjust the labor demand. We investigate the employment outcomes that realized during the first year after the Tapering shock (April 2013–April 2014). Since labor markets are sticky with most of the fixed contract dynamics concentrated at the end of the calendar year, it is hard to isolate the short-term implications of the BCB interventions. Therefore, our results summarize the overall effects of worsened credit conditions on the employment adjustment.

Table 2.2: QE tapering vs. FX interventions: credit markets

	Δ Credit; +1 policy quarter			Δ Credit; +3 policy quarters		
	(1)	(2)	(3)	(4)	(5)	(6)
Foreign debt	−0.92***	−0.75***	−0.67***	−0.92***	−0.75***	−0.76***
	(0.30)	(0.20)	(0.14)	(0.30)	(0.20)	(0.14)
FX intv × Foreign debt	0.44*	0.41***	0.45***	0.50**	0.46***	0.46***
	(0.26)	(0.15)	(0.16)	(0.19)	(0.11)	(0.12)
FX intv	−0.02***			−0.02***		
	(0.01)			(0.00)		
Firm-time FE	*n*	*y*	*y*	*n*	*y*	*y*
Controls	*n*	*n*	*y*	*n*	*n*	*y*
R^2	0.01	0.42	0.44	0.01	0.41	0.44
# observations	382507	362715	357660	745503	694156	668707
# firms	84544	77466	77147	84651	79413	78842
# banks	51	51	51	52	52	51
# industries	254	254	254	254	254	254

The table reports estimates of versions of the equation

$$\Delta\text{Credit}_{f,b,t} = \beta_1 \text{Foreign Debt}_b + \beta_2 \text{Foreign Debt}_b \times \text{FX intv}_t + \gamma X_{f,b} + \theta_{f,t} + e_{f,b,t},$$

where $\Delta\text{Credit}_{f,b,t}$ is quarterly log growth rate of credit provided to firm f by bank b, Foreign Debt_b is bank's *ex-ante* share of foreign debt in its total liabilities (demeaned), $\theta_{f,t}$ is firm-quarter fixed effect, and $X_{f,b}$ is a matrix of controls; all explanatory variables are measured as of the end of April'13. FX intv_t is equal to one for periods t of active BCB FX intervention program, and zero otherwise. Controls include Foreign debt structure, Short foreign debt, Bank capital, Bank size, NPL, State ownership, Credit line, Credit level, and Default indicator (not reported); all continuous explanatory variables are demeaned. The left panel spans the period of end of April'13–end of October'13 (2 quarters with 1 quarter of the post-policy period). The left panel spans the period of end of April'13–end of April'14 (4 quarters with 3 quarters of the post-policy period). Constant in column 1 is omitted. Standard errors (in parenthesis) are calculated under two-way clustering by main bank and 3-digit CNAE industry. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

In the left panel of Table 2.3, we report the estimated model parameters with the labor growth rate as the dependent variable, while those of the average tenure of firm employees are grouped in the right panel. We employ industry-state fixed effect estimator to account for potential confounding factors. If firm labor demand was positively correlated with bank foreign funding beyond the common industry-state component, our estimates are likely to be biased towards zero.

The results suggest that firms transmitted part of the credit supply shift to the labor markets: employers that were funded mostly by the lenders exposed to the shocks in the FX markets demonstrated lower labor growth rates. Firms that differed in the banks' FX exposure by 2pp (a standard deviation in the foreign debt) demonstrated a 1pp differential in the annual employment growth rates. At the same time, employers that relied on banks with larger foreign funding had the average tenure of their employees increased. Coupled with the previous result, this suggests that the adjustment of labor stock to the shrinking credit supply happened, among the other things, along with the tenure dimension with less experienced workers leaving the jobs more frequently than the ones with longer experience.

2.4.2 Panel data analysis

We extend the cross-section analysis of the previous section by introducing time-series variation in macroeconomic conditions. In the panel setup, we are primarily interested in the coefficients on the double interaction of bank foreign funding and the global financial conditions that may potentially amplify the main effect. Thus, we analyse whether changes in USD strength and volatility in the FX markets are of any importance for the exposed local banks; in addition to all the control variables used in the cross-section analysis, all the estimates are conditioned on the opportunity costs of investing in Brazilian markets proxied by the US shadow money rate — a well-documented driver of the international capital flows. As before, we employ two-way lender and industry clustering that makes inference robust to any non-zero correlation of the observations (contemporaneous or in time) that have a common lender or represent organizations of similar economic activity.

Table 2.4 reports the baseline results for the panel data specifications. Column 1 indicates that the US money rate is an important stand-alone factor of the credit supply of the Brazilian banks that depend on foreign funding. Tightening monetary policy in the US has a negative effect on the Brazilian banks that have a higher dependence on international capital markets. For a bank with the average level of foreign funding, a 25bp change in the US monetary conditions is equivalent to additional 1pp annual growth rate of credit. A 1pp increase in the US rate more than doubles the negative elasticity of the credit supply of the exposed local banks to their foreign liabilities.

Table 2.3: QE tapering: labor markets

	Δ Employment			Δ Av. tenure		
	(1)	(2)	(3)	(4)	(5)	(6)
Foreign debt	−0.73***	−0.81***	−0.66**	8.68**	7.91**	10.53***
	(0.13)	(0.16)	(0.26)	(3.75)	(3.36)	(3.23)
Industry-state FE	*n*	*y*	*y*	*n*	*y*	*y*
Controls	*n*	*n*	*y*	*n*	*n*	*y*
R^2	0.00	0.09	0.12	0.00	0.09	0.13
# observations	84732	81330	80891	82109	78714	78327
# firms	51	51	51	51	51	51
# (main) banks	254	226	226	254	225	225

The table reports estimates of versions of the equation

$$\Delta Y_f = \beta_1 \text{Foreign Debt}_f + \gamma X_f + \theta_i + e_f,$$

where ΔY_f is growth rate of firm level employment (left panel), or change in the average log tenure of firm employees (right panel); both rates are calculated over one year after Tapering speech (end of April'14–end of April'13). Foreign Debt_f is a weighted average of firm lenders' *ex-ante* share of foreign debt in their total liabilities, θ_i is industry-state fixed effect, and X_f is a matrix of controls; all explanatory variables are measured as of the end of April'13; bank-firm level variables are aggregated to the firm level by taking the weigted average of the corresponding values with weights proportional to the bank's share in firm total *ex-ante* credit liabilities. Controls include Foreign debt structure, Short foreign debt, Bank capital, Bank size, NPL, State ownership, Credit line, Credit level, Default indicator, log of Number of Employees, and log of Average tenure of employees (not reported). Constant in column 1 is omitted. Standard errors (in parenthesis) are calculated under two-way clustering by main bank and 3-digit CNAE industry. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 2.4: Credit regression estimates, firm-bank panel

	(1)	(2)	(3)	(4)	(5)
Foreign debt	−0.19**	−0.16**	−0.18**	−0.19**	−0.22**
	(0.08)	(0.08)	(0.08)	(0.09)	(0.08)
×Δ US money rate	−0.28***	−0.31***	−0.40***	−0.22***	−0.40***
	(0.06)	(0.05)	(0.07)	(0.06)	(0.07)
×Δ OITP USD index		−4.75***		−9.18**	
		(1.64)		(4.06)	
×Δ FX volatility			−0.40***		−0.81**
			(0.13)		(0.31)
Other macro	*n*	*n*	*n*	*y*	*y*
R^2	0.44	0.44	0.44	0.44	0.44
# observations	5574065	5574065	5574065	5574065	5574065

The table reports estimates of versions of the equation

$$\Delta\text{Credit}_{f,b,t} = \beta_1\text{Foreign Debt}_{b,t-1} + \beta_2\text{Foreign Debt}_{b,t-1} \times \Delta\text{FX}_{t-1} + \gamma X_{f,b,t-1} + \theta_{f,t} + e_{f,b,t},$$

where $\Delta\text{Credit}_{f,b,t}$ is quarterly log growth rate of credit provided to firm f by bank b, $\text{Foreign Debt}_{b,t}$ is bank's share of foreign debt in its total liabilities, $\theta_{f,t}$ is firm-quarter fixed effect, and $X_{f,b,t}$ is a matrix of controls. All columns report estimates of the firm-time fixed effect estimator. The sample period is 2008Q2–2015Q2. In all columns, the estimates are conditioned on lagged control variables including Bank capital, Bank size, NPL, Foreign debt structure, Short foreign debt, State ownership, Credit line, Credit level, and Default indicator; additional macroeconomic variables interacted with foreign funding in columns 4–5 include: (changes in) Brazilian money market rate, inflation, IBC Br index, and VIX (not reported); all continuous explanatory variables are demeaned. Standard errors (in parenthesis) are calculated under two-way clustering by bank (74 clusters) and 3-digit CNAE industry (258 clusters). * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Column 2 shows that the FX markets act as an additional determinant of the local credit supply. Strengthening of the US dollar against the currencies of the developing countries has economically and statistically important negative effect on the credit supply shocks in the domestic economy. For a domestic lender with the average level of foreign funds, a one standard deviation change in the US index growth rate (2pp) accounts for a shift in subsequent local credit growth rates of 1.5pp. The effect is almost twice as high when estimated conditionally on other macroeconomic variables interacted with bank external debt dependence. Relative to their standard deviations, the economic significance of the USD index is of similar magnitude as the one of the US shadow rate when estimated without taking into account other macroeconomic shocks, and exceeds the one of the money rate when conditioning on the local aggregate factors (column 4).

In column 3 we report similar specification with bank foreign funds interacted with the implied BRL/USD volatility measure. Rising uncertainty frequently accompanies local currency devaluations and may directly affect investors hedging costs. We find, that in times following positive shocks to the BRL volatility the growth rates of credit provided by the banks with higher foreign funds exposure are lower than those of the non-exposed lenders. Everything else being equal, after a one standard deviation shock to the FX volatility, a 5pp difference in the foreign funding of a hypothetical pair of banks results, on average, in an additional 2.5pp differential in their credit growth. The economic effect is twice as high in a specification controlling for other local and global macroeconomic conditions (column 5).

We implement a set of robustness checks and report the results in Table 2.A.6. Thus, we first rerun the baseline regression omitting the second and the third quarters of 2013 (columns 1 and 3) — this provides additional evidence that the results are not driven solely by the observations around the Tapering speech. In columns 2 and 4 we interact foreign funding with changes in the Brazilian economic policy uncertainty index (Baker et al. (2016)). While the additional interaction, as expected, has a negative effect, it does not alter our main conclusions in any significant manner. Next, we use changes in BRL/USD rate as a measure of FX rate fluctuations. Although potentially endogenous, the estimated economic and statistical significance is close the one discussed above. Finally, we rerun the baseline regression with the commodity price index used as an indicator of FX rate adjustments. Brazil is an important exporter of soybeans, iron ore, petroleum, meat and sugar, and as such, it is subject to world commodity price shocks. The changes in terms of trade trigger FX rate adjustments that are frequently accompanied by an increased level of uncertainty. We report the corresponding estimates in column 6. As commodity price changes and FX shocks are strongly negatively correlated, the estimated parameters have the opposite sign. The economic and statistical relevance of the effect is similar to the previous estimates.

In the last part of our analysis, we explore the effects of BCB interventions in the panel setup. To do this, we further interact the variables of interest with the measure of interventions of Bank of Brazil in derivative markets. The latter is

constructed as the ratio of the Bank swap notional amounts relative to its foreign reserves and ranges up to 0.3 by the end of our sample. At the beginning of the sample period, the BCB was involved in the "reverse swap" sales trying to mitigate the excess appreciation of BRL. Hence, the policy variable defined in this way may have negative values. A higher level of the Bank interventions indicates its increasing role as the hedger of last resort. As BCB provided this insurance against local currency devaluations at a relatively low price, we expect it to mitigate the effect of FX rate fluctuations on the credit supply dynamics.

Table 2.5: Interventions and credit markets, firm-bank panel

	(1)	(2)	(3)	(4)
Foreign debt	−0.23**	−0.20**	−0.24**	−0.25***
	(0.09)	(0.08)	(0.10)	(0.10)
×FX intv	0.48	0.65**	0.84**	0.56**
	(0.40)	(0.25)	(0.37)	(0.26)
×Δ OITP USD	−6.29**		−11.04**	
	(2.60)		(4.91)	
×Δ OITP USD× FX intv	46.62**		42.86***	
	(18.78)		(12.17)	
×Δ FX vol.		−0.52***		−0.90**
		(0.15)		(0.35)
×Δ FX vol. × FX intv		2.21		3.71*
		(1.33)		(2.16)
Other macro controls	*n*	*n*	*y*	*y*
R^2	0.44	0.44	0.44	0.44
# observations	5574065	5574065	5574065	5574065

The table reports estimates of versions of the equation

$$\begin{aligned}\Delta\text{Credit}_{f,b,t} = {} & \beta_1 \text{Foreign Debt}_{b,t-1} \\ & + \beta_2 \text{Foreign Debt}_{b,t-1} \times \Delta\text{FX}_{t-1} + \beta_3 \text{Foreign Debt}_{b,t-1} \times \text{FX intv}_{t-1} \\ & + \beta_4 \text{Foreign Debt}_{b,t-1} \times \Delta\text{FX}_{t-1} \times \text{FX intv}_{t-1} + \gamma X_{f,b,t-1} + \theta_{f,t} + e_{f,b,t}.\end{aligned}$$

where $\Delta\text{Credit}_{f,b,t}$ is quarterly log growth rate of credit provided to firm f by bank b, $\text{Foreign Debt}_{b,t}$ is bank's share of foreign debt in its total liabilities, $\theta_{f,t}$ is firm-quarter fixed effect, and $X_{f,b,t}$ is a matrix of controls. FX intv_t is the ratio of outstanding notional amounts of the BCB FX swaps to the Bank's foreign reserves. All columns report estimates of the firm-time fixed effect estimator. The sample period is 2008Q2–2015Q2. In all columns, the estimates are conditioned on lagged control variables including Bank capital, Bank size, NPL, Foreign debt structure, Short foreign debt, State ownership, Credit line, Credit level, and Default indicator; all columns include interaction of Foreign debt and ΔUS money rate; columns 3 and 4 additionally include interactions of Foreign debt and other macroeconomic variables: ΔBR money rate, ΔInflation, ΔIBC Br, ΔVIX; all continuous explanatory variables are demeaned. Standard errors (in parenthesis) are calculated under two-way clustering by bank (74 clusters) and 3-digit CNAE industry (258 clusters). * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The estimates reported in Table 2.5 support this hypothesis: the coefficient on the triple interaction of bank foreign dependence, FX fluctuations, and the interventions measure is positive and statistically significant. The result indicates that the Bank can partially offset the otherwise-negative effect of FX shocks on the exposed lenders by a sufficiently large level of interventions. According to the specification with the full set of macroeconomic controls, an increase in the policy intensity by its one standard deviation decreases the sensitivity of the exposed banks to the FX changes by half.

Relatedly, the intervention program seem to have a positive *average* effect on the exposed banks — even in the absence of substantial changes in macroeconomic conditions. While in normal times the banks with foreign funding exhibit slightly lower credit growth rates than their domestically-funded peers, the BCB interventions flip this relationship around and allows the exposed lenders to catch up in their credit provision. The triple interaction coefficients show that this effect is economically much stronger when the BCB steps in right after BRL depreciation or increased market uncertainty, but the underlying effect is present even in periods when the FX markets are relatively quiet. The latter indicates that the interventions may provide a subsidy to the exposed banks (or "tax" them in periods of the reverse swap sales) which is large enough to affect their lending policies.

2.5 Conclusions

The evidence presented in this chapter suggests that bank credit supply may strongly depend on the external financial conditions and foreign exchange markets that transmit to the domestic economy the shocks from abroad. To smooth this transmission, the central bank may attempt to intervene in the FX markets. We analyzed a particular form of intervention — in the markets of FX forwards in Brazil — that allowed the USD liquidity suppliers and hedging "consumers" to adjust to the new macroeconomic conditions less costly by transferring part of the FX risks on the supervisor balance sheet. We showed that the policy could achieve its aims, at least, partially and, thus, support the domestic loan provision.

In a way, this chapter continues the topic discussed in the first section of the thesis: a central bank can minimize the costs of adverse economic shocks by providing the necessary insurance against a situation that, in its core, constitutes a coordination failure. In the case of liquidity provision, the bank may not face constraints regarding the amount of liquidity to supply, but it still needs to weight the (credit) risks that it is willing to accept and the potential adverse consequences of the policy for the ultimate issuers of collateralizable liabilities.

In the case of interventions in the markets of FX derivatives, a central bank may similarly accept some risks on its balance sheet and face important economic constraints. Namely, as the policy studied in this chapter was designed to settle the intervention bets in the local currency, the foreign investors were exposed to additional convertibility risks. *Ex-post*, the general economic conditions in Brazil

were relatively favorable to keep the USD providers in the country after adjusting to the "post-Tapering" conditions. However, in a potential counterfactual outcome where a further adverse shock could hit the local markets, the convertibility risks could exacerbate the coordination failure among the foreign investors and provoke a "run" on the domestic economy. By putting the risks on the regulator balance sheet, interventions did not eliminate them from the markets but rather concentrated FX depreciation risk on the central element of the system. By doing so, the Bank did make the adverse outcome less probable but at the same time it might have increased the costs associated with the unlikely event of a sudden stop. The efficacy of the interventions, thus, implicitly relies on the adequacy of this risk redistribution and — ultimately — on the levels of the foreign reserves accessible to the central bank.

Appendix

2.A Summary statistics and robustness checks

Table 2.A.1: QE tapering: summary statistics, firm-bank level

	N	Mean	SD	10%	25%	50%	75%	90%
Δ Credit:								
April'13–July'13	194090	−0.01	0.36	−0.27	−0.13	−0.05	0.03	0.34
July'13–October'13	183869	−0.02	0.33	−0.27	−0.13	−0.05	0.02	0.27
October'14–January'13	174172	−0.03	0.32	−0.27	−0.13	−0.05	0.02	0.27
January'13–April'14	166402	−0.05	0.30	−0.28	−0.14	−0.06	0.01	0.20
Foreign debt	194090	0.05	0.03	0.00	0.04	0.04	0.08	0.08
Foreign debt structure	194090	0.51	0.47	0.00	0.01	0.29	1.00	1.00
Short foreign debt	194090	0.23	0.16	0.00	0.10	0.27	0.37	0.37
Bank capital	194090	0.09	0.03	0.04	0.08	0.08	0.11	0.11
Bank size	194090	26.87	1.25	25.27	27.15	27.31	27.50	27.50
NPL	194090	0.05	0.02	0.04	0.04	0.06	0.06	0.06
State owned	194090	0.48	0.50	0.00	0.00	0.00	1.00	1.00
Credit line	194090	0.19	0.28	0.00	0.00	0.05	0.29	0.63
Credit	194090	4.69	1.52	2.79	3.62	4.63	5.62	6.57
Default	194090	0.03	0.18	0.00	0.00	0.00	0.00	0.00

Table 2.A.2: QE tapering: summary statistics, firm level

	N	Mean	SD	10%	25%	50%	75%	90%
Δ Total credit:								
April'13–July'13	84550	−0.01	0.32	−0.26	−0.11	−0.03	0.09	0.33
July'13–October'13	84327	−0.02	0.31	−0.25	−0.11	−0.04	0.07	0.29
Δ Total credit (+ all other lenders):								
April'13–July'13	84635	−0.01	0.30	−0.25	−0.11	−0.03	0.09	0.31
July'13–October'13	84635	−0.02	0.30	−0.24	−0.11	−0.04	0.07	0.28
Δ Employment	84732	0.05	0.53	−0.40	0.00	0.08	0.29	0.55
Δ Av. tenure	82109	4.04	8.83	−6.00	0.00	4.68	10.12	12.00
Foreign debt	84732	0.05	0.02	0.02	0.03	0.05	0.06	0.07
Foreign debt structure	84732	0.56	0.31	0.09	0.30	0.60	0.85	0.98
Short foreign debt	84732	0.23	0.10	0.08	0.17	0.25	0.29	0.34
Bank capital	84732	0.09	0.02	0.05	0.07	0.09	0.10	0.11
Bank size	84732	27.05	0.74	26.26	27.16	27.31	27.40	27.46
NPL	84732	0.05	0.01	0.04	0.04	0.05	0.06	0.06
State owned	84732	0.54	0.37	0.00	0.19	0.60	0.89	1.00
Credit line	84732	0.20	0.21	0.00	0.03	0.13	0.30	0.50
Credit	84732	5.82	1.43	4.13	4.85	5.70	6.60	7.57
Default	84732	0.04	0.17	0.00	0.00	0.00	0.00	0.00
Av. tenure	84294	2.80	0.80	1.81	2.32	2.82	3.31	3.79
Employment	84732	2.18	1.43	0.69	1.10	2.08	2.94	3.99

Table 2.A.3: Summary statistics, firm-bank panel

	Mean	SD	10%	25%	50%	75%	90%
Δ Credit	−0.01	0.38	−0.31	−0.14	−0.05	0.04	0.36
Foreign debt	0.04	0.03	0.00	0.02	0.04	0.06	0.08
Foreign debt structure	0.54	0.45	0.00	0.02	0.75	1.00	1.00
Short foreign debt	0.46	0.36	0.00	0.14	0.37	0.78	1.00
Bank capital	0.09	0.03	0.04	0.07	0.09	0.11	0.12
Bank size	26.68	1.30	24.81	26.67	27.13	27.38	27.58
NPL	0.06	0.02	0.04	0.05	0.06	0.06	0.07
State owned	0.46	0.50	0.00	0.00	0.00	1.00	1.00
Credit line	0.17	0.28	0.00	0.00	0.00	0.24	0.63
Credit	11.39	1.53	9.45	10.29	11.31	12.33	13.31
Default	0.06	0.24	0.00	0.00	0.00	0.00	0.00
Δ OITP USD index	0.00	0.02	−0.02	−0.01	−0.00	0.01	0.04
Δ FX volatility	0.00	0.31	−0.31	−0.20	−0.02	0.07	0.33
Δ US money rate	−0.12	0.44	−0.61	−0.32	−0.11	0.16	0.47
Δ BR money rate	0.09	0.92	−1.08	−0.23	0.25	0.91	1.00
Δ Commodity price	−0.00	0.07	−0.08	−0.03	0.00	0.05	0.10
Δ Inflation	0.14	0.64	−0.77	−0.31	0.18	0.53	0.82
Δ IBC Br	0.00	0.02	−0.02	−0.01	0.01	0.02	0.03
Δ FX rate	0.02	0.08	−0.05	−0.04	−0.01	0.05	0.12
Δ VIX	−0.02	0.29	−0.38	−0.25	−0.09	0.18	0.31
Δ Political uncertainty	−0.01	0.61	−0.73	−0.45	−0.07	0.48	0.95
FX interventions	0.07	0.12	−0.03	−0.00	0.00	0.21	0.29

Table 2.A.4: QE tapering: total credit regression estimates

	Δ Total credit			Δ Total credit (+ other lenders)		
	(1)	(2)	(3)	(4)	(5)	(6)
Foreign debt	−1.15***	−1.16***	−0.60***	−1.00***	−1.00***	−0.45**
	(0.14)	(0.13)	(0.20)	(0.13)	(0.12)	(0.19)
Industry-state FE	*n*	*y*	*y*	*n*	*y*	*y*
Controls	*n*	*n*	*y*	*n*	*n*	*y*
R^2	0.01	0.09	0.15	0.00	0.09	0.15
# observations	84550	81147	80708	84635	81232	80793
# (main) banks	51	51	51	51	51	51
# industries	254	226	226	254	226	226

The table reports estimates of versions of the equation

$$\Delta\text{Credit}_f = \beta_1 \text{Foreign Debt}_f + \gamma X_f + \theta_i + e_f,$$

where ΔCredit_f is log growth rate of total credit liabilities of a firm f, over one quarter after Tapering Speech (end of April'13–end of July'13), Foreign Debt_f is a weighted average of firm lenders' *ex-ante* share of foreign debt in their total liabilities, θ_i is industry-state fixed effect, and X_f is a matrix of controls; all explanatory variables are measured as of the end of April'13; bank-firm level variables are aggregated to the firm level by taking the weigted average of the corresponding values with weights proportional to the bank's share in firm total *ex-ante* credit liabilities. Controls include Foreign debt structure, Short foreign debt, Bank capital, Bank size, NPL, State ownership, Credit line, Credit level, Default indicator, log of Number of Employees, and log of Average tenure of employees (not reported). The left panel uses growth of credit of all local commercial banks as the dependent variable; the right panel uses growth of credit of all domestic commercial, foreign and investment banks and non-bank institutioins. Constant in column 1 is omitted. Standard errors (in parenthesis) are calculated under two-way clustering by main bank and 3-digit CNAE industry.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 2.A.5: QE tapering vs. FX interventions: total credit regression estimates

	Δ Total credit			Δ Total credit (+ other lenders)		
	(1)	(2)	(3)	(4)	(5)	(6)
Foreign debt	−1.15***	−1.16***	−0.54***	−1.00***	−1.00***	−0.49***
	(0.14)	(0.13)	(0.16)	(0.13)	(0.12)	(0.12)
FX intv × Foreign debt	0.66***	0.71***	0.71***	0.55***	0.60***	0.59***
	(0.15)	(0.13)	(0.13)	(0.15)	(0.13)	(0.13)
FX intv	−0.01***			−0.01***		
	(0.00)			(0.00)		
Industry-state-time FE	*n*	*y*	*y*	*n*	*y*	*y*
Controls	*n*	*n*	*y*	*n*	*n*	*y*
R^2	0.00	0.09	0.15	0.00	0.09	0.15
# observations	168877	162069	161191	169270	162464	161586
# firms	51	51	51	51	51	51
# (main) banks	254	226	226	254	226	226

The table reports estimates of versions of the equation

$$\Delta\text{Credit}_{f,t} = \beta_1 \text{Foreign Debt}_f + \beta_1 \text{Foreign Debt}_f \times \text{FX intv}_t + \gamma X_f + \theta_{i,t} + e_{f,t},$$

where $\Delta\text{Credit}_{f,t}$ is quarterly log growth rate of total credit liabilities of a firm f, Foreign Debt_f is a weighted average of firm lenders' *ex-ante* share of foreign debt in their total liabilities (demeaned), $\theta_{i,t}$ is industry-state-time fixed effect, and X_f is a matrix of controls; all explanatory variables are measured as of the end of April'13; bank-firm level variables are aggregated to the firm level by taking the weigted average of the corresponding values with weights proportional to the bank's share in firm total *ex-ante* credit liabilities. Controls include Foreign debt structure, Short foreign debt, Bank capital, Bank size, NPL, State ownership, Credit line, Credit level, Default indicator, log of Number of Employees, and log of Average tenure of employees (not reported); all continuous explanatory variables are demeaned. The left panel uses growth of credit of all local commercial banks as the dependent variable; the right panel uses growth of credit of all domestic commercial, foreign and investment banks and non-bank institutioins. The panels span the period of end of April'13–end of October'13 (2 quarters with 1 quarter of the post-policy period). Constant in column 1 is omitted. Standard errors (in parenthesis) are calculated under two-way clustering by main bank and 3-digit CNAE industry.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 2.A.6: Credit regression estimates, firm-bank panel, robustness checks

	(1)	(2)	(3)	(4)	(5)	(6)
Foreign debt	−0.14*	−0.19**	−0.18**	−0.22**	−0.17**	−0.16*
	(0.08)	(0.09)	(0.07)	(0.08)	(0.08)	(0.08)
×Δ OITP USD	−5.18***	−8.58**				
	(1.85)	(3.82)				
×Δ FX vol			−0.40***	−0.79**		
			(0.14)	(0.30)		
×Δ Policy uncertainty		−0.21***		−0.23***		
		(0.07)		(0.08)		
×Δ BRL					−0.94***	
					(0.32)	
×Δ Commodity price						1.91***
						(0.61)
Other macro	*n*	*y*	*n*	*y*	*n*	*n*
Except 2013 Q2-3	*y*	*n*	*y*	*n*	*n*	*n*
R^2	0.44	0.44	0.44	0.44	0.44	0.44
# observations	5158763	5574065	5158763	5574065	5574065	5574065

The table reports estimates of versions of the equation

$$\Delta\text{Credit}_{f,b,t} = \beta_1 \text{Foreign Debt}_{b,t-1} + \beta_2 \text{Foreign Debt}_{b,t-1} \times \Delta\text{FX}_{t-1} + \gamma X_{f,b,t-1} + \theta_{f,t} + e_{f,b,t}.$$

where $\Delta\text{Credit}_{f,b,t}$ is quarterly log growth rate of credit provided to firm f by bank b, $\text{Foreign Debt}_{b,t}$ is bank's share of foreign debt in its total liabilities, $\theta_{f,t}$ is firm-quarter fixed effect, and $X_{f,b,t}$ is a matrix of controls. All columns report estimates of the firm-time fixed effect estimator. The sample period is 2008Q2–2015Q2. In all columns, the estimates are conditioned on lagged control variables including Bank capital, Bank size, NPL, Foreign debt structure, Short foreign debt, State ownership, Credit line, Credit level, Default indicator, and non-interacted foreign funding, as well as Foregin debt interacted with Δ US money rate; additional macroeconomic variables interacted with foreign funding in columns 4–5 include: (changes in) Brazilian money market rate, inflation, IBC Br index, and VIX (not reported); all continuous explanatory variables are demeaned. Standard errors (in parenthesis) are calculated under two-way clustering by bank (74 clusters) and 3-digit CNAE industry (258 clusters). * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Chapter 3

ASSET ENCUMBRANCE AND BANK RISK: FIRST EVIDENCE FROM PUBLIC DISCLOSURES IN EUROPE

Joint with Albert Banal-Estañol and Enrique Benito.
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3.1 Introduction

As of June 2011, Dexia, a Franco-Belgian bank, reported a strong Tier 1 Capital Ratio of 11.4%[1]. Out of the 91 institutions analysed in the European Banking Authority (EBA) stress tests, Dexia came joint 12th, with a forecast Core Tier 1 capital ratio of 10.4% under the adverse stress scenario[2]. From a liquidity standpoint, the bank had built up a buffer of €88bn in liquid securities, had decreased short-term funding needs by €47bn and its short-term ratings had been reaffirmed as investment grade by the main credit rating agencies. But just three months later, in October 2011, Dexia was partly nationalised by the Belgian and French governments. Several commentators highlighted the high levels of "encumbered" assets as the key factor precipitating its move into government arms.[3][4].

[1] See Dexia 2Q & 1H 2011 Results and Business Highlights Presentation, 4 August 2011

[2] The Core Tier 1 ratio represents the ratio of very high quality capital (shareholders' capital and reserves) to risk-weighted assets (RWA). The Tier 1 capital ratio includes, in addition to Core Tier 1 capital, other perpetual capital resources such as subordinated debt instruments with conversion features and is also expressed as a fraction of RWA.

[3] See e.g. Financial Times, "Bank collateral drying up in rush for security", October 2011.

[4] More recently, in June 2017, Banco Popular was put into resolution by the European Single Supervisory Mechanism (SSM) and was acquired by Banco Santander for a symbolic amount of €1.

Asset encumbrance refers to the existence of financial bank balance sheet assets being subject to arrangements that restrict the bank's ability to freely transfer or realise them. Bank assets become encumbered when these are used as collateral to raise funding, for example in repurchase agreements (repos) or in other collateralised transactions such as asset-backed securitisations, covered bonds, or derivatives[5]. In the particular case of Dexia, more than €66bn of its €88bn buffer securities were encumbered through different secured funding arrangements, particularly with the European Central Bank (ECB), and were therefore unavailable for obtaining emergency funding.

Policymakers are acting decisively in order to address what some consider to be excessive levels of asset encumbrance. Some jurisdictions have introduced limits on the level of encumbrance (Australia, New Zealand) or ceilings on the amount of secured funding or covered bonds (Canada, US), while others have incorporated encumbrance levels in deposit insurance premiums (Canada). Several authors have proposed linking capital requirements to the banks' asset encumbrance levels or establishing further limits to asset encumbrance as a back-stop (Helberg and Lindset (2014); IMF (2013); Juks (2012)). As part of the Basel III regulatory package, the Net Stable Funding Ratio (NSFR), an additional minimum liquidity requirement of the LCR will be introduced in 2018. The NSFR heavily penalises asset encumbrance by requiring substantial amounts of stable funding to finance encumbered assets. In Europe, regulatory reporting and disclosure requirements have been introduced and all institutions are required to incorporate asset encumbrance within their risk management frameworks. The Dutch National Bank has even committed to "keeping encumbrance to a minimum" (De Nederlandsche Bank (2016)).

Despite the importance of asset encumbrance, the phenomenon remains poorly understood. There is not even a consensus as to how asset encumbrance should be measured, and there is limited knowledge of how asset encumbrance varies across countries or bank business models. Surprisingly, the relationship between bank risk and asset encumbrance remains unexplored empirically. As highlighted by an incipient theoretical literature and policy papers, higher asset encumbrance could result in a reduction of the assets that become available to unsecured creditors under insolvency, an effect coined as "structural subordination" (Bank of England (2012); CGFS (2011); Houben et al. (2013); IMF (2013); Juks (2012); Le Leslé (2012)). This may be priced in by unsecured creditors, potentially increasing overall funding costs. On the other hand, increasing the proportion of secured funding, which carries lower rollover risks and is generally cheaper than equivalent unsecured funding, could translate into an increased capacity of debt repayment and a lower probability of default.

This chapter tries to shed some light on these issues in three steps. First, we

Yet, as of year-end 2016, the Spanish bank Banco Popular reported a Tier 1 capital ratio of 12.3% and had passed the EBA stress tests undertaken in 2016 with a solid margin. However, nearly 40% of its total balance sheet assets were encumbered as of December 2016.

[5]Collateralisation is a common method of mitigating counterparty credit risk in derivative markets through the provisioning of margin.

define asset encumbrance, describe how assets become encumbered and review the sources of encumbrance. Second, we provide descriptive evidence of asset encumbrance levels by country, bank credit quality, size and business model using different encumbrance metrics. To do so, we build a novel dataset using information provided in the asset encumbrance disclosures published for the first time throughout 2015 by European banks, following a set of harmonised definitions provided by the EBA (EBA (2014)). Finally, we investigate the association between bank risk and the levels of asset encumbrance empirically. In line with recent studies, we estimate the relationship between bank balance sheet ratios, based on capital adequacy, liquidity, asset quality and earnings potential (CAMEL) indicators, typically used in supervisory rating systems to classify a bank's overall condition, and implied five-year CDS spreads. We then consider the extent to which asset encumbrance contributes to the explanatory power of such models. Our analysis provides, to the best of our knowledge, the first empirical investigation of the relationship between encumbrance and bank risk.

Our findings show that banks with higher encumbrance levels present lower CDS spreads across all three metrics of asset encumbrance considered — i.e. bank risk seems to be negatively associated with asset encumbrance. In addition, and consistently with the demise of Dexia, we find that ratios measuring asset encumbrance or asset quality provide more valuable information on bank risk than capital and liquidity ratios. This result is consistent with recent literature pointing to limited reliance by markets on capital and liquidity ratios to account for overall bank risk (Podpiera and Ötker (2010); Chiaramonte and Casu (2013); Kanagaretnam et al. (2016)).

We find that CAMEL and other bank-level variables play a mediating role in the relationship between asset encumbrance and bank risk. For banks with a high reliance on central bank funding and high levels of liquid assets, such as Dexia, or with a high leverage ratio and high levels of impaired loans, such as Banco Popular, or for banks located in Southern Europe (GIIPS), asset encumbrance is less beneficial and could even be detrimental in absolute terms[6]. Banks with high levels of loan loss provisions and Nordic banks, on the contrary, could further benefit from increasing their levels of asset encumbrance. Banks in Nordic countries rely to a large extent on covered bonds, which are perceived as a very safe investment and source of funding. These findings imply that regulators need to be cautious when assessing asset encumbrance levels and leaping to across-the-board conclusions about its effects.

The remainder of the chapter is structured as follows. Section 3.2 defines asset encumbrance and explains its sources. Section 3.3 explores the benefits and risks of asset encumbrance from the perspective of both secured and unsecured creditors. Section 3.4 presents the methodology used and the data. Section 3.5 presents the

[6]In the demise of Banco Popular (see footnote 4), the bank had high levels of asset encumbrance and of impaired loans. As of December 2016, almost 15% of Popular's loan portfolio was non-performing compared to a European average of 5.1%. Its Basel III Leverage Ratio was also high (5.31% compared to a weighted average for European banks of 5.2% as per EBA (2017)).

results. The final section concludes.

3.2 Asset Encumbrance: Definition and Sources

In this section we define asset encumbrance and describe how assets become encumbered. We also review the most common sources of asset encumbrance (i.e. the liabilities or obligations that give rise to encumbered assets).

3.2.1 Defining asset encumbrance

European regulations define encumbered assets as "*assets pledged or subject to any form of arrangement to secure, collateralize or credit enhance any transaction from which it cannot be freely withdrawn*"[7]. The Basel Committee on Banking Supervision (BCBS) defines unencumbered assets as those assets which are "*free of legal, regulatory, contractual or other restrictions on the ability of the bank to liquidate, sell, transfer, or assign the asset*"[8].

To clarify the definition of encumbrance, let us consider a bank (Bank A) whose assets include loans and a portfolio of securities (government or corporate bonds, equities, etc.), financed via equity capital, retail deposits and unsecured wholesale funding, as shown in the left hand side of figure 3.A.1. Bank A could obtain additional funding from a counterparty, let us say Bank B, by entering into a secured financing transaction, as shown in the right hand side of figure 3.A.1. Under such arrangement Bank A provides collateral to Bank B in order to mitigate the risk of failing to keep interest repayments or repaying the borrowings. In exchange, Bank A benefits from cheaper funding when compared to an equivalent unsecured transaction[9]. The arrangement imposes restrictions to Bank A on its ability to sell, transfer or dispose of the collateral provided during the term of the transaction. Bank A would consider such assets encumbered.

Figure 3.A.1 represents the securities provided as collateral as recorded or recognised in Bank A's balance sheet rather than being transferred to Bank B's balance sheet. Collateral obtained by Bank B is therefore represented in an off-balance sheet (OBS) rather than an on-balance sheet, and is known as "OBS collateral" or simply "collateral received". The assumption that the collateral remains recognised from Bank A's balance sheet is a necessary condition for being considered an encumbered asset of Bank A. If the assets used as collateral were derecognised by Bank A then they would be recognised by Bank B and they would not be encumbered for Bank A.

In practice, the recognition or derecognition of collateral provided depends on the contractual terms of the transaction as well as its accounting treatment. Derecognition cannot occur unless the securities are transferred to the counterparty.

[7] See European Commission (2015).

[8] See BCBS (2013)

[9] In addition, the arrangement may provide for savings in regulatory capital requirements to Bank B as well as lower regulatory liquidity requirements to Bank A and Bank B.

This can be achieved by using "title transfer" arrangements, whereby full ownership of the collateral is passed on to the counterparty during the term of the transaction[10]. Collateral can also be provided under "security interest" arrangements, which do not transfer ownership but concede rights to the counterparty to obtain full ownership of the collateral under some pre-determined event, such as failure to repay[11]. The use of one technique over the other depends on market practice. Collateral provided in secured financing transactions such as repurchase agreements (i.e. repo) is typically provided by way of title transfer whereas collateral used as a margin for OTC derivatives can be provided using both methods[12].

The transfer of title over collateral, however, is not a sufficient condition for derecognition to occur, with the actual outcome depending on the applicable accounting treatment. Under International Financial Reporting Standards (IFRS), IAS 39 applies a set of tests to assess whether (i) the risks and rewards and (ii) control over the asset have been transferred[13]. If the risks and rewards have not been transferred, or in other words, if the collateral provider continues to be exposed to the risks of ownership of the assets such as loss in market value and/or the benefits that they generate such as dividends, then the collateral would remain recognised on its balance even if a transfer of assets has occurred. But even if the risks and rewards had been transferred, further control tests are undertaken to understand which entity controls the asset. If the collateral provider could direct how the benefits of that asset are realised, then the collateral would not be derecognised either.

As illustrated in figure 3.A.1, the value of securities that Bank A posted as collateral is higher than the value of the borrowings. This practice is known as overcollateralisation and is intended to mitigate the risk of the collateral falling in value during the term of the transaction. It is usually undertaken by means of a "haircut" or "margin ratio"[14]. Collateral agreements often require a frequent (sometimes daily) marked-to-market valuation of the collateral and requests to top up the value of collateral, known as collateral calls, may be triggered if its market value falls below certain pre-determined threshold amounts.

Even in the case in which the collateral received is not reflected in its balance sheet, Bank B could reuse some or all of the collateral received from Bank A to obtain financing from a third party (let us say, Bank C). As illustrated in figure 3.A.2, this re-use of collateral by Bank B would result in the encumbrance of OBS collateral. As such, encumbrance can affect both on-balance sheet assets as well as OBS collateral. The practice of providing collateral that has been previously

[10]Under title transfer, Bank B would have to return the collateral (or equivalent securities) to Bank A when the original transaction matures.

[11]Security interest arrangements are also known as collateral pledges.

[12]Under English Law the collateral for OTC derivatives is typically provided by way of title transfer, whereas under New York Law collateral is typically provided under security interest.

[13]The treatment under US GAAP (ASC 860) differs from IFRS since the focus is on whether the transferor has surrendered control over a financial asset.

[14]The agreed haircut or margin ratio determines the percentage by which the market value of a security is reduced for the purpose of calculating the amount of collateral being provided.

received is known as collateral re-use or re-hypothecation. It is common practice and may result in long "collateral chains"[15].

3.2.2 Sources of asset encumbrance

The liabilities or obligations that give rise to encumbered assets are known as "sources of asset encumbrance" or "matching liabilities". The typical bank will have encumbered assets from several sources but the simplest institutions may rely only on a single source or may present no encumbered assets at all. We now discuss some of the most common sources of asset encumbrance[16].

Secured financing transactions

Secured financing transactions encompass myriad transactions involving the temporary provision of securities to borrow cash or other securities. Common types include repurchase agreements (repos), buy/sell backs or securities borrowing and lending. Collateral in repo is provided under a title transfer but it remains recognised in the balance sheet of the collateral provider's (i.e. the repo seller) since the risks and rewards of the collateral are retained[17]. Thus, repo collateral is encumbered for the collateral provider. Encumbered assets in repo are predominantly government bonds, followed by corporate bonds and covered bonds. Asset-backed securities and equities are also used as collateral. Most of the funding provided by central banks is transacted through repo. Like Dexia, many European banks were, and some still are, heavily reliant on repo financing from the ECB.

Asset-backed securities (ABS) and mortgage-backed securities (MBS)

Another potential source of asset encumbrance is securitisations. These entail ABS and MBS bonds or notes being issued and receivables, which may include retail or

[15]The terms re-hypothecation and re-use are often used interchangeably and we will do so here. In practice there are legal distinctions between them that may be relevant in a different context. Recent studies have analysed the concept of re-hypothecation and "collateral velocity". Analytical work includes Adrian and Shin (2010) and Singh (2010). More recent work has focussed on liquidity mismatches and the role of collateral in intermediation chains. Brunnermeier and Krishnamurthy (2014) introduced the Liquidity Mismatch Index (LMI) which compares the market liquidity of assets and the funding liquidity of liabilities, thus capturing the length of collateral intermediation chains.

[16]In addition to the sources covered in this section, transactions that may result in encumbered assets include collateral swaps, also known as collateral upgrade transactions, where collateral of a different quality is exchanged. Collateralised guarantees rely on securities to secure an existing or future liability. Other arrangements, such as factoring—which include the transfer of trade receivables to an institution—may result in similar encumbrance to securitisations.

[17]If this was not the case, banks could artificially reduce its overall leverage by derecognising collateral in repurchase agreements. This treatment was exploited by Lehman Brothers under the well-known "Repo 105" scheme, characterised by the New York Attorney General Andrew Cuomo as a "massive accounting fraud" and leading to a review by the accounting standard settlers of the accounting treatment of repo transactions.

commercial mortgages in MBS, or credit card debt or other loans in ABS, being used as collateral.

A traditional two-step securitisation involves the initial transfer of the receivables of the originating bank to a Special Purpose Vehicle (SPV) and the sale of the ABS or MBS to investors. The overall securitisation structure is intended to make sure that there is a true sale of receivables to the SPV and that the SPS is "bankruptcy remote". Accounting standards however, may require that the SPV is consolidated into the "sponsoring" bank balance sheet, including all of its assets and liabilities, even the receivables[18]. If the underlying receivables were consolidated, this would result in the recognition of such receivables on the sponsor's balance sheet. However, tests to assess whether the assets meet the criteria for accounting derecognition, as discussed earlier, shall still be undertaken. If derecognition criteria are not met the receivables would be encumbered. This is often the case since it is common for the sponsoring bank to keep an active role in the securitisation, for example, by servicing the assets or providing support by retaining certain tranches to absorb first losses and potential risks in relation to timings in the collection of the receivables.

ABS or MBS can be used as collateral to raise funding with counterparties and central banks. Thus, a common practice across some banks, especially during the Eurozone crisis, is the retention of their self-issued ABS or MBS rather than its sale to investors[19]. If notes are retained, they would not be encumbered. But if the notes are used to raise fresh funding, for example, from the central bank via repo, the receivables would become encumbered as it occurs in securities' financing transactions.

Figure 3.A.3 (left-hand side) illustrates how securitised receivables can be encumbered (highlighted in green) by collateralising ABSs that are either (i) sold to investors or (ii) used as repo collateral to obtain funding from another counterparty.

Covered bonds

Covered bonds are similar to MBS but the mortgages used as collateral always remain recognised on the consolidated balance sheet of the issuing entity and thus always generate encumbrance. The issuer and the investors have dual recourse to the collateral. This feature, together with the existence of overcollateralisation requirements and the dynamic replenishment of non-performing loans in the collateral pool imply that these instruments are perceived as being very safe. There is indeed no known default on covered bonds since their inception.

The use of covered bonds as collateral has significantly increased in recent times. For many banks in peripheral European countries (GIIPS) funding collat-

[18]The consolidation models under IFRS and GAAP are relatively similar and are based on the criteria of entity control over the SPV.

[19]The acceptance of securitised notes as collateral in the ECB facilities led to an important increase in retention levels during the Eurozone crisis, with overall retention as a proportion of total gross issuance increasing from 26% in the first half of 2007 to 42% in the first half of 2012 (IMF (2013)).

eralised by retained covered bonds became the main source of long-term funding during the Eurozone sovereign crisis, as their access to unsecured markets was partially or fully closed (Van Rixtel and Gasperini (2013)).

Derivatives

Derivatives also generate encumbrance, as collateralisation has become a key method of mitigating counterparty credit risk in derivative markets, both on over-the-counter (OTC) and exchange-traded (ETD) derivatives. Collateralisation occurs because of the provisioning of the margin, in two different forms. A variation margin is posted during the course of the transaction to cover adverse changes in value (i.e. a negative mark-to-market value). Initial margin (also known as an independent amount) is posted at the beginning of a transaction to cover potential future adverse changes in the value of the contract, and is recalculated on a regular basis.

The margin provided is subject to restrictions and therefore constitutes encumbered assets. This is illustrated in figure 3.A.3 (right-hand side)[20]. The margin can be provided in the form of cash or securities and it is common to provide re-hypothecation rights to the counterparty. According to the latest ISDA Margin Survey, for non-cleared OTC derivatives cash represents 76.6% of the collateral provided, followed by government bonds (13.4%) and other securities (10.1%), including US municipal bonds, government agency/government-sponsored enterprises (GSEs), and equities (ISDA (2015)).

3.3 Asset Encumbrance: Risks and Benefits

The potential negative impact of asset encumbrance on unsecured creditors has been the focus of much discussion recently. As highlighted by an incipient theoretical literature, higher asset encumbrance would result in a reduction of the assets that become available to unsecured creditors under insolvency, an effect coined as "structural subordination" (Bank of England (2012); CGFS (2011); Houben et al. (2013); IMF (2013); Juks (2012); Le Leslé (2012)). The same seniority that secured creditors enjoy means that as more secured debt is issued, balance sheet shocks are asymmetrically concentrated on unsecured creditors, exacerbating the possibility of a run of unsecured creditors (Ahnert et al. (2016); Matta and Perotti (2015)). The resulting shifting of risks depends on the magnitude of the haircuts being applied since the required overcollateralisation reduces the amount of collateral available for unsecured funding (Eisenbach et al. (2014)).

If unsecured creditors reflect the risk of structural subordination into required returns, this could result in higher overall funding costs to institutions. As stated

[20]The figure assumes that the variation margin is not offset against the derivative liability (i.e. the negative fair value from the derivative) therefore becoming encumbered. Some contracts allow for such an offsetting of the variation margin. The outstanding exposure between the counterparties is settled and the terms of the derivative contracts are reset so that the fair value is zero, leading to no encumbered assets due to an exchange of the variation margin.

by Dr Joachim Nigel, a former member of the executive board of the Deutsche Bundesbank in a speech at the 2013 European Supervisor Education Conference on the future of European financial supervision: "Higher asset encumbrance has an impact on unsecured bank creditors. The more bank assets are used for secured funding, the less remain to secure investors in unsecured instruments in the case of insolvency. They will price in a risk premium for this form of bank funding".

In addition, a higher amount of encumbered assets may reduce a bank's headroom to obtain funding under a stressed market environment. This could in turn trigger investor concerns about the bank's viability, as shown in Dexia's demise. During economic downturns, falling collateral values and higher haircuts result in higher overcollateralisation levels, requiring more assets to be pledged to raise a given level of funding and increasing asset encumbrance (Bank of England (2012)). This latter effect would in turn magnify the impact of asset encumbrance on unsecured creditors via structural subordination. There is evidence that during the Eurozone crisis, not only the funding costs of banks increased significantly alongside the increases in asset encumbrance, but larger overcollateralisation levels also shrank the pools of unencumbered assets, further reducing banks' ability to raise secured and unsecured funding (CGFS (2011); CGFS (2013); ECB (2012))[21].

As it is shown in the data, higher asset encumbrance may also bring in benefits for unsecured creditors. Clearly, secured creditors benefit from the safety that collateral provides. This is reflected in lower funding costs than equivalent unsecured funding. Secured funding also carries a lower rollover risk. There is indeed evidence that repo funding was rolled-over during the financial crisis, up to the eve of default (Gorton and Metrick (2012); Gai et al. (2013)). As a result, higher collateralisation could lead to a lower probability of default and increased capacity of debt repayment, which would also benefit unsecured creditors.

In addition, higher collateralisation could provide a reduction in the cost of settling creditors' conflicts in case of resolution or bankruptcy (Hardy (2014)). Claimants holding collateral do not have to enter the contest for residual assets and, despite increasing levels of structural subordination, the remaining claimants have less to fight over, thus reducing bankruptcy costs. This would also benefit unsecured creditors. In sum, asset encumbrance carries risks of subordinating unsecured creditors, increasing funding costs and reducing a bank's headroom to obtain funding under stressed conditions. However, it may also bring benefits to both secured and unsecured creditors, which could lead to a decreased probability of default and decreased overall funding costs.

[21] Recent literature has also analysed the system-wide implications of increased asset encumbrance levels and the potential for increased susceptibility to procyclical swings in the underlying value of the collateral assets (Gai et al. (2013); Haldane et al. (2011); Krishnamurthy et al. (2014); Perotti (2011)). More generally, the amplification role of haircut shocks in generating procyclicality has been broadly considered in the literature (see e.g. Adrian and Shin (2010); Brunnermeier and Pedersen (2009); Geanakoplos (2010); Gorton and Metrick (2012)).

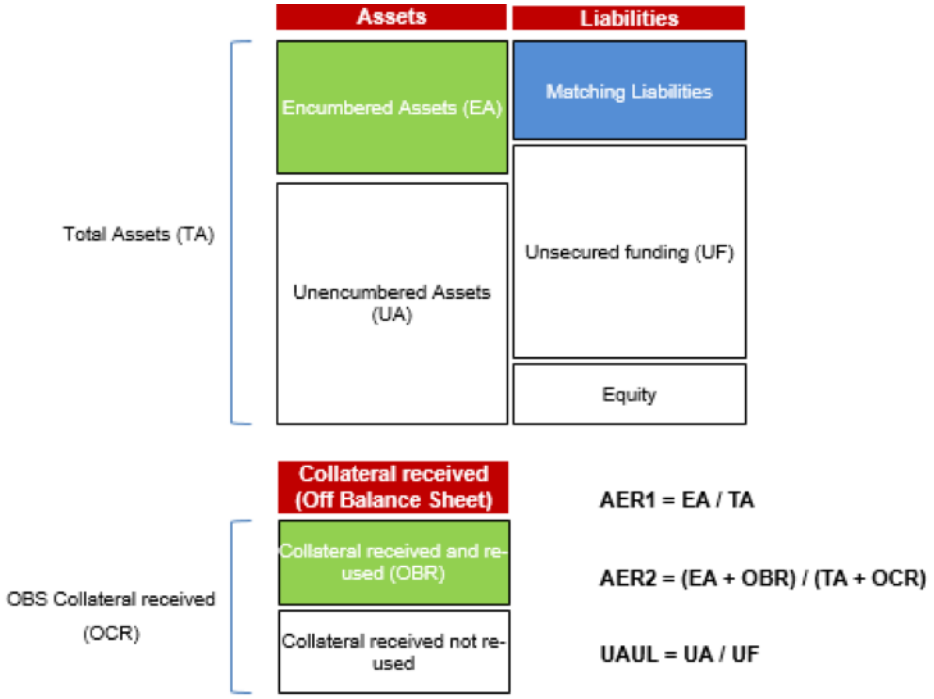
3.4 Data and Methodology

Our analysis has two parts. First, we provide a descriptive analysis of asset encumbrance levels by country, bank credit quality, size and business model. We then assess the extent to which bank CDS premia are associated with asset encumbrance through a series of multivariate regressions.

3.4.1 Measuring asset encumbrance

There is currently no consensus as to how asset encumbrance shall be measured and different measures have been proposed. We focus on the three key ratios being used by policymakers. The computation of each ratio is illustrated in figure 3.1.

Figure 3.1: Asset encumbrance metrics



The asset encumbrance ratios (AERs) capture the amount of encumbered assets as a proportion of total assets. There are two variations:

- The ratio of *encumbered assets to total assets*, which captures the overall proportion of balance sheet assets that have been encumbered. This ratio has been used by the Bank of England and the European Systemic Risk Board (ESRB) to undertake analysis of the UK and European banking sectors respectively (Beau et al. (2014 Q4); ESRB (2013)). We denote it as AER1.
- The ratio of *encumbered assets and other collateral received and re-used to total assets and total collateral received*, which captures the overall pro-

portion of encumbered balance sheet assets as well as off-balance sheet collateral. This ratio is used by the EBA to undertake their risk assessment of the European banking system and to apply more comprehensive regulatory reporting requirements (EBA (2016)). We denote this ratio as AER2.

The third ratio focusses instead on unencumbered assets:

- The ratio of *unencumbered assets to unsecured liabilities* (UAUL), which captures the proportion of assets which are not subject to collateral agreements as a proportion of unsecured creditor's claims and provides an indication of the amount of structural subordination of unsecured creditors. According to a report from the Bank of International Settlements' Committee on the Global Financial System (CGFS (2013)), the UAUL ratio is the most appropriate measure of asset encumbrance.

As opposed to AER1 and AER2, UAUL is a measure of how many assets are available to unsecured creditors under insolvency, and should therefore capture the structural subordination of unsecured creditors more directly than AER1 and AER2. Since UAUL is measured relative to unsecured funding, this ratio would be unable to capture low levels of unencumbered assets relative to the total assets of banks that rely heavily on capital or secured funding. As opposed to AER2, AER1 and UAUL do not capture encumbrance arising from off-balance sheet activities.

Computing asset encumbrance measures at the bank level is not straightforward since accounting data provides limited information to infer the amount of banks' encumbered assets, unencumbered assets and matching liabilities. Accounting statements are accompanied by disclosures which try to shed light on the amount of assets that are collateralising transactions but, as noted by the EBA: "existing disclosures in International Financial Reporting Standards (IFRS) may convey certain situations of encumbrance but fail to provide a comprehensive view on the phenomenon" (EBA (2014)). For this reason, the EBA introduced new guidelines in 2014 proposing the requirement to disclose asset encumbrance reporting templates. EBA guidelines do not constitute a regulatory requirement and, although most did, not all of the European institutions disclosed such information.

We extract data from the risk disclosures of banks, including information on encumbered assets, unencumbered assets, off-balance sheet collateral received and available for encumbrance, OBS collateral received and re-used and matching liabilities as of year-end 2014. We complement the disclosure data with data on total assets and equity extracted from Bankscope to compute the asset encumbrance ratios, AER1 and AER2 considered for each institution. For UAUL, we use a slightly modified version which we denote as AUAUL (Adjusted UAUL), calculated as

$$\text{AUAUL}_i = \frac{\max(\text{UAUL}) - \text{UAUL}_i}{\max(\text{UAUL}) - \min(\text{UAUL})},$$

where UAUL_i is bank's i ratio of unencumbered assets to unsecured liabilities and $\max(\cdot)$ and $\min(\cdot)$ return, correspondingly, the sample maximum and minimum of

their arguments. This adjustment facilitates comparisons with AER1 and AER2 by ensuring that higher encumbrance is associated with a higher AUAUL and that its values fall between 0 and 1.

3.4.2 Other variables

Our main dependent variable in the multivariate regressions is a measure of bank risk represented by banks' CDS spreads as of year-end 2015. CDS spreads are widely considered to be a good indicator of bank risk and can be a proxy for bank unsecured funding costs (see Babihuga and Spaltro (2014); Beau et al. (2014 Q4)).

We use implied rather than market-based spreads because only the largest global institutions are involved in CDS issuance. For most banks, Fitch Solutions determines the implied spreads on a daily basis using a proprietary model that includes, as inputs, banks' financial fundamental information, distance-to-default information derived from the equity market, and other market variables. In line with the existing literature, we focus on five-year senior spreads since these contracts account for 85% of the market and are highly liquid. Data is provided by Fitch Solutions and extracted from Bankscope.

Explanatory variables include, in addition to the asset encumbrance measures, CAMEL and control variables. We follow Chiaramonte and Casu (2013) to select the following CAMEL variables:

- Capital Adequacy:
  - The Tier 1 capital ratio, which represents the ratio of high-quality capital (shareholders' capital, reserves and other perpetual capital resources such as subordinated debt), divided by risk-weighted assets (RWA).
  - The leverage ratio, which is calculated as the fraction of common equity to total assets and reflects the level of indebtedness of a firm.
- Liquidity:
  - The net loans to deposits and short-term funding ratio, which is a measure of structural liquidity. A lower value of the ratio means the bank relies to a greater extent on more stable deposit funding, as opposed to wholesale funding, to finance its loan book.
  - The liquid assets to total assets ratio, which measures the amount of liquid assets that the bank holds and that could be converted into cash to withstand a liquidity stress event.
- Quality of assets:
  - The ratio of loan-loss reserve to gross loans, which measures the quality of the loan portfolio by indicating the proportion of reserves for losses relative to the banks' loan portfolio.

  - The ratio of unreserved impaired loans to equity, which is another indicator of the quality of the loan portfolio but expressed relative to common equity. It is also known as the "capital impairment ratio".

- Earnings potential:

  - The return on equity ratio (ROE), which measures the bank's income-producing ability as reflected by its net income relative to the bank's common equity.
  - The return on assets ratio (ROA), which is an indicator of the return on a firm's investments and is calculated by dividing the bank's net income over its total assets.

Control variables include bank size (measured by the natural logarithm of total assets), central bank exposure to total assets and off-balance sheet exposure to total assets. We include dummy variables to differentiate the business model of the institution using three categories: "Commercial banks and Bank holding companies (BHC)", "cooperative and savings banks" and "other banks". We also include a dummy variable to identify which banks are investment grade. We use implied ratings in order to avoid compromising the sample size, in a similar fashion to CDS spreads. Implied ratings are provided by Fitch Solutions and derived from proprietary fundamental data. These provide a forward-looking assessment of the stand-alone financial strength of a bank and are categorised according to a 10-point rating scale from A to F where A denotes the maximum creditworthiness, with four interim scores (A/B, B/C, C/D and D/E).

Our final data sample includes institutions with total assets above €1bn for which CDS spreads, asset encumbrance, CAMEL and control variables are available, resulting in 367 banks.

3.4.3 Model specification

To construct our model specifications, we follow recent studies which estimate the relationship between CAMEL indicators and CDS spreads (see e.g. Chiaramonte and Casu (2013)). Our baseline model specification is as follows:

$$CDS_i = \beta_1 AE_i + \beta_2 CAMEL_i + \beta_3 X_i + \theta_c + \epsilon_i,$$

where CDS is the natural log of the CDS spread for bank i at year-end 2015; AE is the asset encumbrance measure for bank i at year-end 2014 (disclosed during the year 2015); CAMEL represents the set of eight CAMEL variables for bank i at year-end 2014; X represents the control variables for bank i at yearend 2014; and θ_c is country fixed effects.

We also look at the relationship between encumbrance and CDS spreads for different types of banks, by interacting the asset encumbrance ratios with the CAMEL

indicators and some of the control variables, using the following model:

$$CDS_i = \beta_1 AE_i + \beta_2 CAMEL_i + \beta_3 X_i + \beta_4 AE_i \times CAMEL_i + \beta_5 AE_i \times X_i + \theta_c + \epsilon_i .$$

Country fixed effects are included in all models to help to control for factors affecting CDS premia at the country level, including regulatory particularities common to all banks of a country. To account for the potential correlation of the errors among the banks belonging to the same business category in a given country, we apply country-business model clustering in all our regression models. The latter restricts the inference to rather conservative conclusions in which German saving banks, for example, are effectively treated as one observation when assessing the statistical importance of the effects.

Even though we intend to control for potentially confounding factors by accounting for observable and unobservable determinants of bank risks, the data limitations do not allow us to push identification further. One can raise reasonable concerns that the statistical relationship between encumbrance and risks arises due to omitting an important factor jointly affecting CDS premiums and the equilibrium choice of the collateral structure. Upon data availability, the analysis can be extended in the first-differences or panel setup.

3.5 Results

In this section we present the results of our analysis. We first provide a descriptive analysis of asset encumbrance followed by the regression results.

3.5.1 Descriptive analysis and summary statistics

Table 3.1 presents the summary statistics of the variables of study. The mean values of AER1, AER2 and AUAUL are 0.13, 0.14 and 0.60 respectively. Note that there is a wide disparity across banks in our sample. AER1 and AER2 present standard deviations of 0.11 and 0.12 respectively. Although the standard deviation of AUAUL is lower (0.08), the mean and the original standard deviation of UAUL are 1.06 and 0.15.

Table 3.1: Summary statistics of asset encumbrance metrics

	Mean	Median	SD	Min	Max
AER1	0.13	0.09	0.11	0.00	0.68
AER2	0.14	0.10	0.12	0.00	0.70
AER3	0.60	0.59	0.08	0.00	1.00

Table 3.2: Correlation matrix of asset encumbrance metrics

	AER1	AER2	AER3
AER1	1		
AER2	0.974***	1	
AER3	0.388***	0.363***	1

Table 3.2 presents the correlation matrix of encumbrance ratios. AER1 and AER2 present a high correlation of 0.97 which is expected given their similar construction with the only difference being the inclusion of off-balance sheet collateral in AER2. The correlation coefficients of AUAUL with AER1 and AER2 are 0.39 and 0.36 respectively.

Figure 3.1 shows the mean ratio levels of AER1 (blue, left scale) and AUAUL (green, right scale) for those countries with more than one observation. The countries are shown in four groups corresponding to GIIPS, Nordic countries, core countries including Austria, Belgium, Germany, France, UK, Luxembourg and the Netherlands, and other European countries such as the Eastern European countries and Malta. Results show a wide disparity in mean encumbrance levels across countries. All the GIIPS countries presenthigher mean encumbrance ratios than the sample average, as do Nordic countries such as Denmark and Sweden. Denmark, in particular, presents the highest mean ratio of all countries in the sample. Nordic countries have a long tradition of covered bond issuance, which may help explain these results. Of the remaining countries, Belgium, France and the UK present higher mean encumbrance levels than the overall sample average. Belgium, Malta, Netherlands and the UK present higher mean values of AUAUL than the sample mean. Luxembourg and some of the countries classified as "other" such as Bulgaria, Poland and Malta present the lowest values of AER1 but also the largest differences between AUAUL and AER1. Table 3.A.1 in Appendix reports the average encumbrance levels by each country.

Table 3.3 shows the mean levels of the two asset encumbrance ratios across rating categories. Banks within the most extreme categories, A/B and E/F, present the lowest mean AER1 and AER2 ratios of all categories. For AUAUL, it is banks in categories D/E and E/F that present the lowest mean values.

As shown in the same table, mean encumbrance levels tend to increase with bank size, measured in terms of total assets, across all ratios. Since securitisations involve substantial costs, mostly of a fixed nature, these should be particularly costly to issue for smaller banks (Adrian and Shin (2010); Carbó-Valverde et al. (2012); Panetta and Pozzolo (2010)).

Table 3.3 also reports the mean ratio levels by type of institution. We distinguish between "commercial banks and bank holding companies (BHC)", "cooperative banks", "savings banks" and "other banks", including mortgage banks and pure investment banks. Savings banks show the lowest levels for both AER1 and AUAUL. Institutions classified as "other" show relatively high values of AER1 but

Figure 3.1: Average asset encumbrance by country

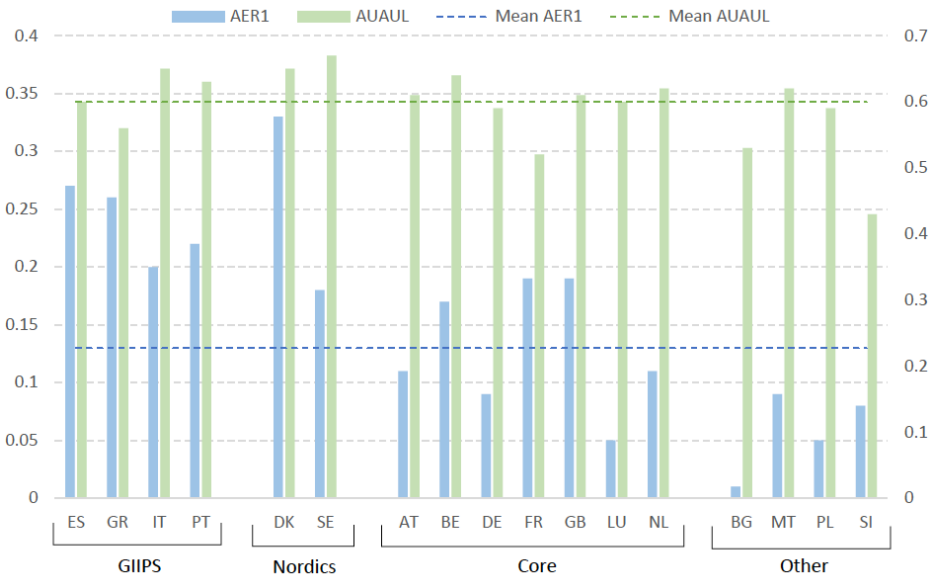


Table 3.3: Average levels of asset encumbrance, by bank groups

	AER1	AER2	AER3
By credit rating			
A/B	0.08	0.08	0.61
B	0.15	0.16	0.61
B/C	0.12	0.13	0.60
C	0.13	0.14	0.60
C/D	0.13	0.14	0.62
D	0.12	0.13	0.63
D/E	0.14	0.14	0.50
E/F	0.03	0.03	0.57
By bank size			
< €3.5bn	0.10	0.11	0.60
€3.5–15bn	0.12	0.13	0.60
€15–50bn	0.19	0.19	0.63
€50–170bn	0.25	0.25	0.56
€170–600bn	0.27	0.28	0.65
> €600bn	0.15	0.20	0.58
By bank type			
BHC & Commercial	0.18	0.19	0.61
Cooperative	0.14	0.14	0.62
Saving	0.09	0.10	0.56
Other	0.22	0.22	0.61

not AUAUL. Cooperative banks show the highest average level of asset encumbrance when measured by AUAUL.

3.5.2 Regression analysis

Table 3.A.2 presents the summary statistics of the variables of study. The average value of the CDS spread variable is 5.14, corresponding to 171 basis points. The median value is 5.17, corresponding to 176 basis points. In terms of bank CAMELS indicators, we find that, on average, a sample bank has a tier 1 ratio of 0.15, a leverage ratio of 0.08, net loans to deposits and a short-term funding ratio of 0.77, a liquid assets to total assets ratio of 0.18. The average ratio of the loan-loss reserve to gross loans is 0.04, and the ratio of unreserved impaired loans to equity is 0.33. The average ROA and ROE are nearly 0. From all the control variables, central bank exposure presents the lowest standard deviation of 0.01.

Baseline regression results

Table 3.4 reports the results of the baseline regressions. In all regressions, we control for country fixed effects and cluster errors by bank country-business-type.

Models 1–3 include the three asset encumbrance measures as explanatory variables. A negative and significant association between banks' implied CDS spreads and asset encumbrance emerges across all models. Thus, our initial evidence suggests a net positive perception of creditors towards asset encumbrance. As suggested in the theoretical discussion, higher collateralisation could lead to a lower probability of default and an increased capacity of debt repayment. Higher collateralisation could also reduce bankruptcy costs and increase value (Hardy (2014)).

While the coefficients for AER1 and AUAUL are highly significant, AER2 is significant only at the 10% level. An increase in AER2 is also associated with a lower decrease in CDS spreads when compared to AER1 and AUAUL. In contrast to AER1, AER2 reflects the encumbrance of OBS collateral. This finding could point to a more negative perception of on encumbrance of off-balance sheet collateral compared to on-balance assets. High levels of encumbered OBS collateral are characteristic of investment banks which engage in matched book trading, the activity of carrying large volumes of repos and reverse repos, effectively re-using collateral received to finance repo liabilities.

Table 3.4: Baseline results

	(1)	(2)	(3)
AER1	−0.177***		
	(0.06)		
AER2		−0.131*	
		(0.07)	
AER3			−0.267***
			(0.10)
Tier 1 Capital Ratio	1.058	1.046	1.103
	(0.93)	(0.92)	(0.92)
Leverage Ratio	−1.164	−1.102	−1.195
	(1.42)	(1.40)	(1.52)
Net loans to deposits & ST funding	−0.049	−0.053	−0.055
	(0.04)	(0.04)	(0.04)
Liquid assets	−0.105	−0.103	−0.108*
	(0.07)	(0.07)	(0.06)
Loan loss reserves	1.927***	1.959***	2.085***
	(0.61)	(0.64)	(0.62)
Unreserved impaired loans	−0.060*	−0.062*	−0.063*
	(0.03)	(0.03)	(0.03)
ROA	−16.398***	−16.369***	−17.019***
	(4.92)	(4.91)	(4.78)
ROE	0.538***	0.528***	0.555***
	(0.18)	(0.18)	(0.17)

Table 3.4: Baseline results (continued)

	(1)	(2)	(3)
Investment grade	−0.466***	−0.466***	−0.464***
	(0.02)	(0.02)	(0.02)
BHC and commercial	0.035	0.039	0.050
	(0.05)	(0.05)	(0.05)
Saving and cooperative	−0.007	−0.002	0.002
	(0.05)	(0.05)	(0.05)
Central bank exposure	1.150**	1.171**	1.190**
	(0.56)	(0.55)	(0.53)
OBS / TA	0.077	0.073	0.072
	(0.09)	(0.09)	(0.08)
Size	−0.149***	−0.149***	−0.157***
	(0.02)	(0.02)	(0.02)
Country FE	*y*	*y*	*y*
R^2	0.79	0.79	0.79
N observations	367	367	367
N clusters	50	50	50

The dependent variable in all models is *ln*CDS. Standard errors (in parenthesis) are clustered by country-business type of bank. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

In contrast to asset encumbrance ratios, the coefficients for capital and liquidity ratios turn out to be insignificant in all models. Variables such as asset encumbrance or asset quality seem to provide more valuable information on bank risk than capital and liquidity ratios. These results are consistent with recent literature pointing to a limited market reliance on capital and liquidity ratios to account for overall bank risk. Ötker-Robe and Podpiera (2010) find no significance in capital and liquidity ratios over the period 2004–2008 using a sample of 29 European Large Complex Financial Institutions (LCFI). Chiaramonte and Casu (2013), using a sample of 57 mostly European banks, find no statistical significance for Tier 1 and leverage and a limited statistical significance of liquidity ratios. Hasan et al. (2016) also find no statistically significant relation with the Tier 1 capital or liquidity ratios using a sample of 161 global banks in 23 countries. Kanagaretnam et al. (2016) find in a sample of 27 U.S. Bank Holding Companies (BHC) that the capital ratio is not significantly related to CDS spreads.

The coefficients for the ratio of loan-loss reserve to gross loans ratio are all positive and highly significant. The higher this ratio, the lower the quality of the loan portfolio; and therefore an increase in loan loss reserves should lead to an increase in CDS spreads. This result is consistent with Hasan et al. (2016) who also find a positive relationship between CDS spreads and the loan loss provision ratio.

The coefficients for the ratio of unreserved impaired loans to equity are all negative and significant on a 10% level. Banks with a higher value of this ratio exhibit higher impairments that have not been provisioned. Thus, this result implies that investors are not excessively concerned with such impairments. Chiaramonte and Casu (2013) also obtain this inverse relationship.

We observe opposing signs on the effects of ROA and ROE. The coefficients on ROA are all negative and highly significant. A negative sign for ROA could point to investors perceiving banks with a lower level of operating income relative to a level of investment as riskier. The coefficients for ROE are positive and highly significant, pointing to increased perceived default risk in institutions with higher profitability relative to their capital base. This result is somewhat surprising. Given the subdued profitability in traditional lending businesses in Europe, this finding could point to concerns by markets with banks that engage in highly profitable activities such as trade finance, invoice discounting or securities lending, with a comparatively low capital base. Relatedly, conditional on assets profitability, ROE may signal about bank's leverage: if traditional measures of leverage are not very infromative, one can observe positive CDS dependence on ROE when simultaneously controlling for asset profitability.

The coefficient on the ratio of central bank exposure to total assets turns out to be positive and significant, implying that reliance on central bank funding is positively associated with bank risk. Not surprisingly, credit quality is also strongly associated with lower CDS spreads. Negative and highly significant coefficients are obtained across all models. The coefficient for size turns out to be negative, pointing out to a size advantage. The ratio of off-balance sheet items to total assets

and business model variables are not statistically significant.

Mediation effects

Our second set of regressions explores the relationship between CDS spreads and key variables, including the interactions of asset encumbrance metrics with CAMEL, control variables, GIIPs and Nordic countries dummies. The results are presented in table 3.5. All models include the individual (non-interacted) CAMEL and control variables but for clarity these are not shown since the coefficients are very much in line with those presented in table 3.5.

We first discuss models 1 and 2 together as they yield very similar results. The stand-alone coefficients of asset encumbrance ratios (AER1 an AER2) are negative and significant. Several coefficients of the interacted CAMEL and control variables are statistically significant at the conventional levels, pointing to the existence of mediating effects in the relationship between asset encumbrance and CDS spreads. We first discuss the results for the interactions with control variables followed by CAMEL variables.

The coefficients for the interaction of asset encumbrance with the GIIPS and Nordic country dummies are significant and have opposite signs. GIIPS and Nordic countries present, on average, the highest levels of asset encumbrance in our sample. For GIIPS, the coefficient is positive, however, it is not large enough to offset the negative relationship between asset encumbrance and the bank risk arising from the main effect. This may indicate that, conditional on other variables, encumbrance ratios are not informative about bank credit risks in the GIIPS countries. For Nordic countries, the interaction coefficient is negative, i.e. it amplifies the average effect. This may reflect a positive perception towards asset encumbrance arising from the issuance of covered bonds that are typically considered very safe investments.

A positive and significant coefficient is obtained for the interaction with the ratio of central bank exposure to total assets. High asset encumbrance levels in banks with high amounts of central bank funding, as in Dexia's case, are negatively perceived by investors. For banks with high levels of central bank exposure (the maximum of which is 0.12 in our sample), the positive effect of the interaction term offsets the negative effect of the stand-alone asset encumbrance coefficient, thus making higher levels of encumbered assets detrimental in absolute terms.

The interaction with the investment grade is positive, suggesting that encumbrance levels are less informative for banks with good credit quality. When estimated at the sample averages, the elasticity of the CDS premium with respect to the asset encumbrance is twice as small for the banks with high credit ratings in comparison with the more risky institutions. This result suggests that disclosure of encumbrance levels can provide additional valuable information for the investors interested in banks with low credit ratings.

Table 3.5: Heterogeneous effects of asset encumbrance

	(1)	(2)	(3)
AER	−0.712***	−0.605***	−0.552
	(0.19)	(0.21)	(0.48)
AER ×			
Tier 1 Capital Ratio	−5.500	−5.182	3.596
	(4.97)	(4.83)	(2.95)
Leverage Ratio	15.409**	15.180**	2.751
	(6.03)	(6.42)	(4.81)
Net loans to deposits & ST funding	0.522***	0.554***	0.172
	(0.16)	(0.17)	(0.34)
Liquid assets	0.845**	0.978**	−0.358
	(0.38)	(0.41)	(0.51)
Loan loss reserves	−12.749***	−11.524***	−8.465***
	(3.66)	(3.49)	(3.15)
Unreserved impaired loans	0.650**	0.595**	0.553
	(0.29)	(0.30)	(0.57)
ROA	15.780	28.157	−52.962
	(29.44)	(36.22)	(67.71)
ROE	−0.430	−1.059	2.658
	(1.41)	(1.83)	(4.32)
Central bank exposure	10.914**	8.900*	9.887
	(4.16)	(4.65)	(10.08)
OBS	−0.012	−0.119	3.054

Table 3.5: Heterogeneous effects of asset encumbrance (continued)

	(1)	(2)	(3)
	(0.82)	(0.81)	(2.15)
Size	0.125	0.073	−0.061
	(0.16)	(0.16)	(0.29)
Investment grade	0.348*	0.351*	0.317
	(0.20)	(0.20)	(0.19)
GIIPS	0.671***	0.466**	0.068
	(0.17)	(0.22)	(0.41)
Nordics	−0.466**	−0.712**	−1.236***
	(0.21)	(0.27)	(0.41)
BHC and commercial	0.048	0.146	0.404
	(0.19)	(0.23)	(0.46)
Saving and cooperative	0.234	0.262	0.539
	(0.18)	(0.19)	(0.32)
Country FE	*y*	*y*	*y*
R^2	0.81	0.81	0.80
N observations	367	367	367
N clusters	50	50	50

The dependent variable in all models is *ln*CDS. Standard errors (in parenthesis) are clustered by country-business type of bank. All continuous explanatory variables are demeaned. All estimates are conditioned on a set of non-interacted control variables similar to Table 3.4 (not reported). * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

A negative and significant coefficient is found for the interaction with the ratio of loan loss reserves to gross loans. Although higher loan loss reserves may point to a lower quality of the loan portfolio, excess reserves may signal a lower probability of incurring unexpected losses in the future and may therefore be perceived positively by markets. A positive and significant coefficient, however, is found for the interaction with the unreserved impaired loans to equity ratio. This could point to concerns by investors in banks with large amounts of encumbered assets that lack the reserves to deal with future loan defaults. This finding is in line with the demise of Banco Popular, which presented high levels of asset encumbrance and simultaneously impaired loans.

The coefficients for the interactions of asset encumbrance with the Tier 1 capital and leverage ratios have conflictive signs, negative and positive, although the former turns out to be not significant. The leverage ratio is a non-risk-based measure of capital adequacy. A high value of the leverage ratio accompanied by larger amounts of encumbered assets could point to increasing risk in the loan portfolio which in turn would point to higher overall bank risk[22]. Similarly to central bank exposure, the positive effect of the interaction term may offset the negative effect of the stand-alone asset encumbrance coefficient, thus making higher levels of encumbered assets detrimental in absolute terms.

Model 3 presents the results for AUAUL. While the stand-alone coefficient of AUAUL ratio turns out to be not significant, the coefficients corresponding to the interaction with the loan loss reserves to gross loans ratio and the Nordics dummy are both significant and of a negative sign. Consistent with the results of models 1 and 2, banks with high levels of asset encumbrance and with high levels of loan loss provisions, or based in Nordic countries, could benefit from increasing their levels of asset encumbrance. The effects of the remaining interacted variables are less significant but almost all, including central bank exposure and GIIPS, conserve the same sign found for models 1 and 2.

3.6 Conclusion

Asset encumbrance has been a much discussed subject in recent literature and policymakers have been actively addressing what some regulators consider to be excessive levels of asset encumbrance. Still, the question of whether asset encumbrance is as perverse as it is portrayed arises. The risks of asset encumbrance because of the structural subordination of unsecured creditors, or because of the reduction of a bank's capacity to obtain funding, may end up being a concern for a subset of banks only. Other banks, on the other hand, could be signalling their overall "health" by, and thus benefit from, increasing asset encumbrance levels (issuing covered bonds to private investors, for instance). Our descriptive analysis shows a wide disparity in mean encumbrance levels across countries with southern Eu-

[22] As noted in footnote 6, Banco Popular had a relative high value of the Basel III leverage ratio (5.31%) compared to a weighted average for European banks of 5.2% as of year-end 2016.

ropean (GIIPS) and Nordic countries presenting higher mean encumbrance ratios than the sample average. Banks within the most and least creditworthy-rating categories present the lowest mean AER1 and AER2 ratios. For AUAUL, however, it is only banks in the least creditworthy categories that present the lowest mean values. Mean encumbrance levels tend to increase with bank size, measured in terms of total assets, across all ratios which could be explained by the substantial costs of securitisation issuance for smaller banks. By type of institution, saving banks show the lowest levels for both AER1 and AUAUL whereas cooperative banks show the highest average level of asset encumbrance when measured by AUAUL.

Our empirical analysis provides, to the best of our knowledge, the first investigation of the relationship between asset encumbrance and bank risk. We show that asset encumbrance is, on average, negatively associated with bank risk across different asset encumbrance measures. We also find that ratios measuring asset encumbrance or asset quality provide more valuable information on bank risk than capital and liquidity ratios, which is consistent with the recent literature pointing to a limited reliance by markets on capital and liquidity ratios to account for overall bank risk.

We also show that certain bank-level variables play a mediating role in the relationship between asset encumbrance and bank risk: for banks that have a high exposure to the central bank, high levels of unreserved impaired loans, high leverage ratio and/or located in southern Europe, larger amounts of encumbered assets and encumbered OBS collateral are less beneficial and could even be detrimental in absolute terms. Banks with high levels of loan loss provisions and/or based in Nordic countries, in contrast, benefit from increased levels of asset encumbrance. Banks in Nordic countries rely to a large extent on covered bonds, which are perceived as a very safe investment and source of funding. These results suggest that regulators need to be cautious before leaping to allencompassing conclusions when assessing the effects of asset encumbrance levels.

Appendix

3.A Asset encumbrance measures by country

Table 3.A.1: Average levels of asset encumbrance, by country

	AER1	AER2	AUAUL
AT	0.11	0.10	0.61
BE	0.17	0.18	0.64
BG	0.01	0.07	0.53
CY	0.00	0.00	0.59
DE	0.09	0.09	0.59
DK	0.33	0.34	0.65
ES	0.27	0.28	0.60
FI	0.02	0.02	0.62
FR	0.19	0.23	0.52
GB	0.19	0.21	0.61
GR	0.26	0.26	0.56
IE	0.21	0.22	0.65
IT	0.20	0.20	0.65
LU	0.05	0.04	0.60
MT	0.09	0.09	0.62
NL	0.11	0.11	0.62
PL	0.05	0.05	0.59
PT	0.22	0.22	0.63
SE	0.18	0.18	0.67
SI	0.08	0.08	0.43
Total	0.13	0.14	0.60

Table 3.A.2: Summary statistics, variables of study

	Mean	Med	SD	Min	Max
*ln*CDS	5.14	5.17	0.33	4.56	6.56
CAMEL variables					
Tier 1 Ratio	0.15	0.14	0.04	0.05	0.35
Leverage ratio (Equity / TA)	0.08	0.08	0.02	0.01	0.18
Net loans to deposits and ST funding	0.77	0.75	0.24	0.05	2.05
Liquid assets / TA	0.18	0.11	0.23	0.01	2.98
Loan loss reserves / gross loans	0.04	0.02	0.04	0.00	0.27
Unreserved impaired loans / equity	0.33	0.14	0.49	0.00	4.63
ROA	0.00	0.00	0.01	−0.04	0.03
ROE	0.01	0.02	0.10	−1.08	0.32
Control variables					
Central bank exposure / TA	0.01	0.01	0.01	0.00	0.12
OBS / TA	0.08	0.06	0.10	0.00	1.66
Investment grade	0.66	1.00	0.47	0.00	1.00
BHC and commercial banks	0.19	0.00	0.39	0.00	1.00
Saving and cooperative banks	0.75	1.00	0.43	0.00	1.00
Size	6.75	6.41	0.84	6.00	9.32
GIIPS	0.28	0.00	0.45	0.00	1.00
Nordics	0.02	0.00	0.15	0.00	1.00

Figure 3.A.1: Encumbrance of assets when obtaining secured funding

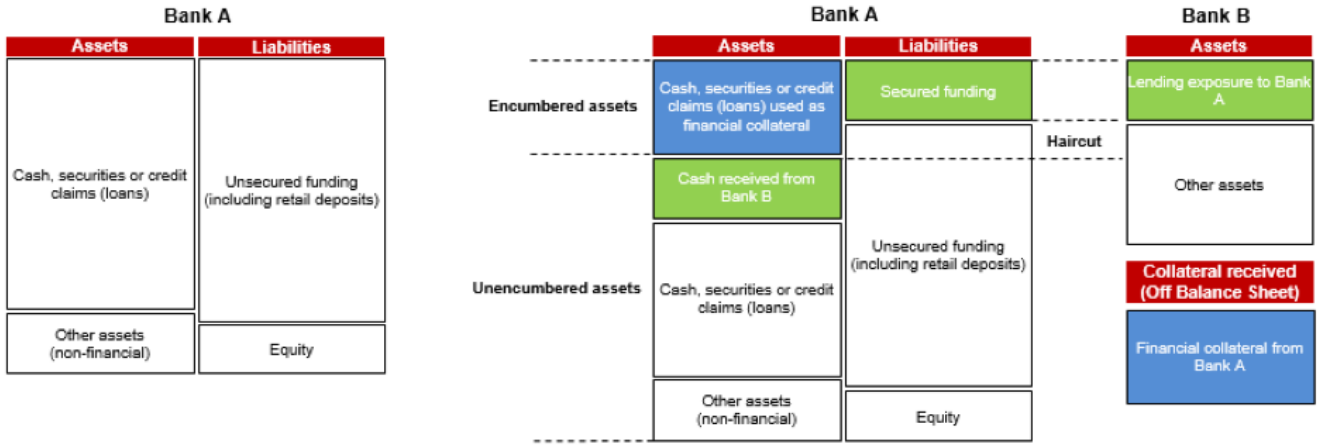


Figure 3.A.2: Collateral received and re-used

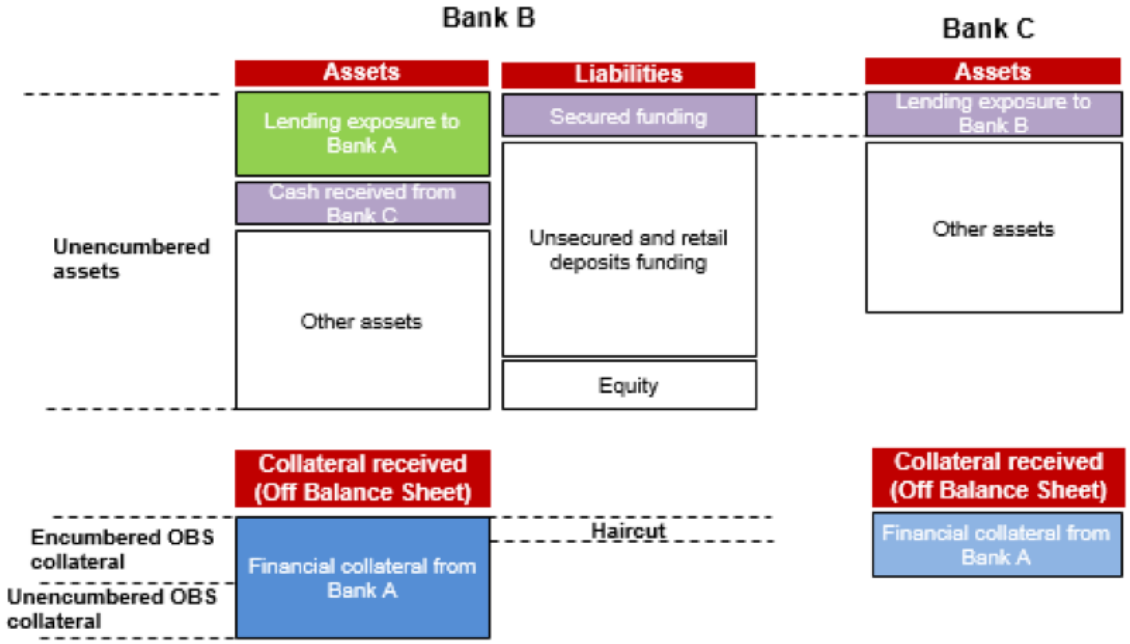
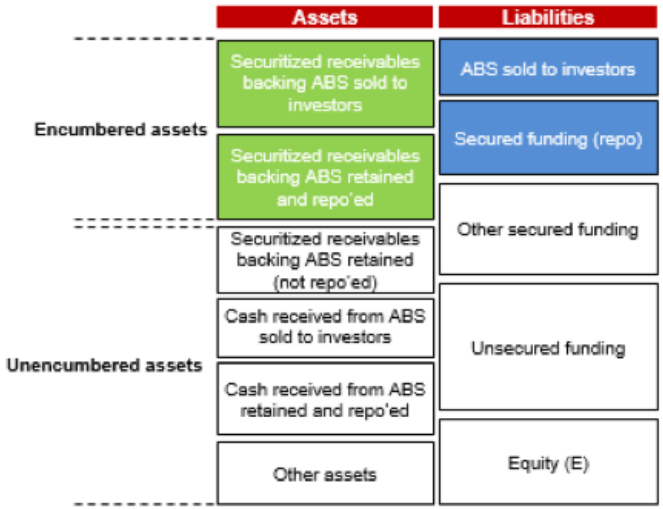
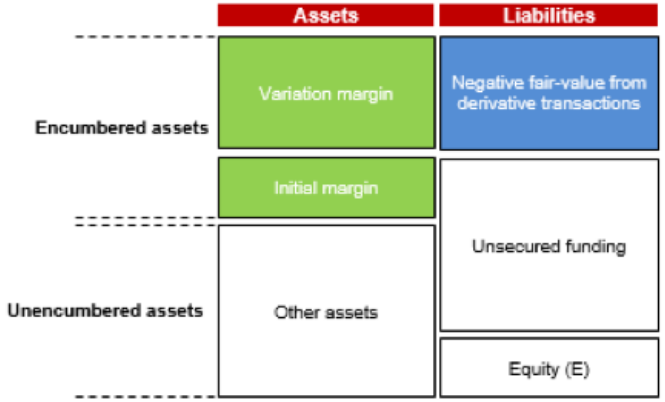


Figure 3.A.3: Encumbered and unencumbered assets from securitization and derivative transactions





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