Essays on the consequences of banking shocks

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Per tu, vida.

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Abstract

This thesis revolves around banking behavior and its implications for financial stability. The first chapter examines how banks buy and sell securities during the crisis, and we find that some banks -the ones specialized in trading and better capitalized- increase their exposure to securities during the crisis, in particular for securities that fell in price, but reduce lending. The second chapter identifies the lending channel of reserve requirements by studying a change in the policy in Uruguay. We find that reserve requirements decrease credit supply after the policy shock, although this reduction is less important for riskier borrowers, and it is binding for firms. The last chapter reviews the methods to estimate competition in the banking system and proposes a completely different approach by using new tools developed in the empirical industrial organization literature.

Resum

Aquesta tesi està dedicada al comportament del sistema bancari i les seves implicacions per la estabilitat financera. El primer capítol examina com els bancs compren i venen actius financers durant la crisi, i trobem que alguns bancs -els que estan especialitzats en compra-venta d'actius i els més capitalitzats- augmenten les seves compres d'actius financers, en particular els que baixen de preu, però disminueixen el crèdit. El segon capítol identifica el canal de transmissió de les exigències de reserva mitjançant l'estudi d'un canvi d'aquesta regulació a Uruguay. Trobem que les exigències de reserve disminueixen l'oferta de crèdit bancari després del 'shock' regulatori, tot i que aquesta reducció és menys important per les empreses amb més risc, i és vinculant per a les empresas. El tercer capítol revisa els mètodes per estimar el grau de competència al sector bancari i proposa un procediment totalment diferent utilitzant les eines desenvolupades a la literatura empírica d'organització industrial.

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Chapter 1

SECURITIES TRADING BY BANKS AND CREDIT SUPPLY: MICRO-EVIDENCE (JOINT WITH P. ABBASSI, R. IYER, AND J.-L. PEYDRÓ)

"*Adverse spillovers from a fire sale may take the form of a credit crunch that affects borrowers more generally. Such a credit crunch may arise as other financial intermediaries (e.g., banks) withdraw capital from lending, so as to exploit the now-more-attractive returns to buying up fire-sold assets. Ultimately, it is the risk of this credit contraction, and its implications for economic activity more broadly, that may be the most compelling basis for regulatory intervention.*"

Jeremy Stein, Governor of the Federal Reserve Board (2013).

1.1 Introduction

The role of security trading by banks has assumed significant importance in the modern financial system (Langfield and Pagano, 2014). Commercial banks today hold a significant amount of securities in their asset portfolio (e.g., 20% in the US and 19% in Germany). In the aftermath of the financial crisis, there is considerable debate both in academic and policy circles about the implications of securities trading by banks for credit supply and securities markets. An important argument is that during the crisis, banks' securities trading activities led to a reduction in credit supply (Stein, 2013). Moreover, there have been several policy initiatives to impose restrictions on banks' trading activities arguing excessive bank risk-taking (Volcker rule in the US, the Liikanen Report in the EU, and the Vickers Report in the UK). However, empirical analysis is scant due to the lack of comprehensive micro datasets on securities holdings by banks. In this paper, we empirically analyze securities trading by banks and the associated spillovers to the supply of credit to the real sector using both security and credit register for banks.

On the theoretical front, there is a growing literature that analyzes the role of securities trading by banks and its implications for credit supply and securities markets. Diamond and Rajan (2011) show that during a crisis, fire sales in securities markets can lead banks that have a higher expertise in securities trading to increase their investment in securities and reduce the supply of credit to the real sector. Uhlig (2010) argues that finite resources with investors with trading expertise and uncertainty aversion are important factors in explaining the fire sale prices observed in the 2008 crisis. In effect, these papers argue that in the presence of funding constraints, banks with trading expertise may reduce credit supply as they withdraw funds from lending to profit from trading opportunities. Shleifer and Vishny (2010) show that during a crisis, as a result of fire sales in securities markets, the returns from investing in distressed securities are higher than the returns from lending. In sum, these theories highlight an externality, from security investments of banks during a crisis to a reduction in the supply of credit to the real sector.

Despite the importance for theory and policy of understanding banks' securities investments during a crisis and its implications for credit supply, the empirical analysis has been elusive. The main constraint that has hampered empirical research is lack of comprehensive micro data at the security level on banks' trading activities. Comparing aggregate data on banks' securities holdings does not present a precise, clear picture of investment behavior as it does not take into account the time-varying, unobservable heterogeneity in security characteristics (e.g., risk, liquidity, outstanding volumes, etc.). Aggregate data may show that two banks have very similar overall level of security investments, however, risk, maturity, coupons, and other characteristics of these securities could be very different. Moreover, in crisis times, as some securities are more affected than others in their risk or even issuance (even within a same rating category), comparison using aggregate bank holdings becomes very difficult.

In this paper, we overcome use a unique, proprietary dataset from the Bundesbank (the German central bank) that provides information on *security-level* holdings for all banks in Germany, a bank-dominated system, at a quarterly frequency for the period between 2005 and 2012. Each security is also matched with security-level information, notably price, rating, coupons, and maturity. Importantly, not only do we have the security-level holdings of each bank, but also the credit register containing information on the individual loans made by banks. The security and credit registers are matched with comprehensive bank balance sheet information.

The main testable hypothesis, which we motivate in the paper with a stylized theoretical model, is that, during a crisis, banks with higher trading expertise will increase their investments in securities, especially in securities that had a (larger) price drop, to profit from the trading opportunities, thereby withdrawing funds from lending. To examine this channel, we first examine the investment behavior of banks that are most active in securities markets. The idea being that banks that are generally active in securities markets are better at identifying trading opportunities during a crisis, as compared to other banks that do not routinely engage in high levels of securities trading.

To proxy for active presence and expertise in securities markets, we use membership of banks to the largest fixed-income trading platform in Germany (Eurex Exchange), as banks that trade actively would have direct membership rather than use an intermediary. The notion being that banks which generally engage in trading activities and have expertise will have a trading desk in place and the necessary infrastructure, like direct membership, etc., to facilitate trading activities. Supporting this classification, we find that the amount of securities bought and sold (as a fraction of total assets) are consistently larger for banks with trading expertise across all the periods. We also find this measure to be highly correlated with the fraction of trading income to net income (in the pre-crisis period) with a correlation coefficient of 0.6. Thus, the trading expertise dummy is highly correlated with banks that have a higher fraction of income generated from trading activities.[1]

For identification, we analyze the data at the *security-quarter-bank* level and include security*time fixed effects to account for unobserved time-variant heterogeneity across securities, e.g. risk, liquidity, outstanding volumes and level of issuance (supplyof securities), etc. Thus, we examine the changes in level of holdings for the same security at the same time by different banks. We also analyze specifications without these fixed effects, with similar results, though aggregate data in securities may mask unobservable differences in risk, liquidity, and changes in overall supply of securities. Furthermore, to isolate compositional effects (based on security price changes), we can include bank*time (or

[1]As discussed later, even if we use the fraction of trading gains to net income in the pre-crisis period as proxy for trading expertise, we find similar results in the paper.

bank) fixed effects to control exhaustively for time-varying heterogeneity across banks. Finally, we identify the associated lending behavior of banks by analyzing borrower-quarter-bank level data and controlling for time-varying, unobserved firm fundamentals that proxies for credit demand using borrower*time fixed effects (see, e.g., Khwaja and Mian, 2008). Thus, we compare lending by different banks to the same firm during the same time period.

In crisis times, we find that banks with higher trading expertise ("trading banks") increase their level of security investments as compared to other banks ("non-trading banks").[2] For trading banks, securities as a fraction of total assets increase from 19% in the pre-crisis period to 23% during the crisis, whereas there is no significant change for non-trading banks.[3] In the aggregate, the increase in security holdings by trading banks corresponds to around 144 billion Euros, which is equivalent to 6% of the GDP of Germany (as on 2007). Moreover, trading banks especially buy more of the securities that had a larger drop in price. Importantly, the investment in securities that had a larger drop in price is primarily concentrated in low-rated and long-term securities.

The investment behavior of banks can be illustrated by the following example. One can see from Figure 1.1 (left panel) that after the failure of Lehman Brothers in September 2008, there is a sharp drop in the price of JP Morgan medium-term note (falls from 100 to 85 Euro cents).[4] Around this period, German banks with higher trading expertise increase their holdings of this JP Morgan note (right panel). After the price rebounds back to 100 over the subsequent quarters, they reduce their holdings. In contrast, other banks do not increase their holdings around the Lehman crisis (dashed line).

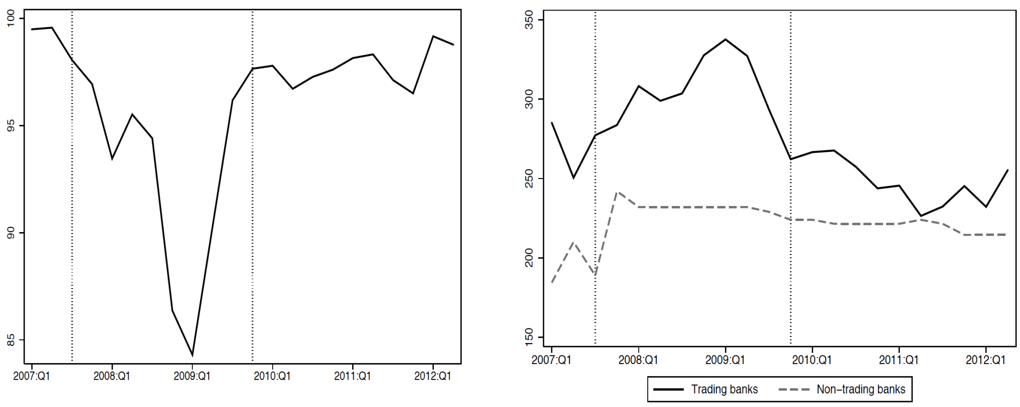
[2]Note that securities as a fraction of total assets for non-trading banks are not trivial (18% on average), though these banks buy and sell -i.e., trade- a substantially lower fraction of their securities in each period as compared to trading banks. We define the crisis period starting in the third quarter of 2007, when banking problems surfaced, to the last quarter of 2009, when Germany came out of the economic recession. The results are not sensitive to the way we define crisis period.

[3]Note that the increase in securities holdings is without any bank or security controls, thought for identification, we will use fixed effects to control for unobservables

[4]Subfigure (a) shows the monthly price development of the seven-year JP Morgan medium-term floating rate note. Subfigure (b) depicts the euro-denominated holdings (in millions) of this security by trading banks and non-trading banks. The first vertical line refers to the start of the financial crisis in 2007:Q3, and the second vertical line denotes 2009:Q4, the end of the crisis in Germany. See also Figure 1.6 for investments in Greek government bonds by trading and non-trading banks. We find increasing investments by trading banks in these securities at the point when CDS spreads of Greece were widening.

Figure 1.1: Investment behavior

(a) Market price of a seven-year JP Morgan note (b) Securities holdings of the seven-year JP Morgan note



While trading banks in general buy more of securities that had a larger fall in price, we also find that the capital level of banks plays an important role. The level of investments in securities is increasing in the level of capital for trading banks. Furthermore, trading banks with a higher level of equity capital buy a greater volume of securities that had a larger price drop in the previous quarter. We then examine how these effects vary based on credit ratings and maturity. We find the strongest quantitative impact of capital on investments for securities with credit ratings below triple-A and with residual maturity higher than one year. In fact, we do not find differential effects for triple-A rated securities. These effects are robust to inclusion of bank*time fixed effects that control for overall time-varying heterogeneity in bank characteristics.

Moreover, we also find that the prices of securities revert over the subsequent quarters. Thus, trading banks invest more in securities with higher ex-ante yield (proxied by previous fall in price, especially in securities with low ratings and long-term maturity) and obtain higher ex-post returns. Finally, during the crisis we do not find any significant differences in selling behavior across securities that had a larger drop in price, either based on trading expertise or on the level of bank capital. We also find that banks sell more of securities where they have higher accumulated losses. This effect is more pronounced for non-trading banks with a higher level of capital.

While we find that trading banks invest more in securities that had a larger price drop, a crucial question that arises is whether this has any spillovers on the supply of credit to the real economy. One could be concerned that trading banks lend to corporate borrowers who have different fundamentals such as risk, size, and growth opportunities. We use borrower*time fixed effects to control for time-varying, unobserved borrower fundamentals that proxies for credit demand. Thus, we examine - at the same time for the same borrower - whether there is differential lending behavior by banks based on their trading expertise. In addition, given that for trading banks, capital significantly affects the level of securities investment, we also examine whether the level of bank capital matters for the supply of credit to firms.

We find that trading banks decrease their supply of credit to non-financial firms during the crisis as compared to other banks - i.e., for the same borrower at the same time, trading banks reduce lending relative to other banks. Furthermore, there is a larger drop in credit supply by trading banks with a higher level of capital. That is, for trading banks, a higher level of capital is associated with a larger reduction in lending as compared to other banks. These results are the mirror opposite of results for security investments by banks with trading expertise. As discussed later, the existence of funding constraints, risk aversion and competing returns between securities trading and lending can lead to banks with higher capital ratio increasing investment in risky securities and reducing credit supply.

The results are robust to the inclusion of bank*firm fixed effects (in addition to firm*time fixed effects) to account for time-invariant bank characteristics and bank-firm relationships.[5] In addition, controlling for accumulated gains/losses on banks' existing securities portfolio (which controls for potential hangover of losses on existing investments or profits from trading in the crisis) does not alter the results. In fact, we find that banks with higher unrealized gains on existing investments lend less than other banks. The previous finding and the finding that trading banks with a higher level of capital decrease their lending by more while investing more in securities that had a larger drop in price are more consistent with the securities channel crowding out credit rather than the accumulated losses channel.[6]

We also do not find any differences in the subsequent default rates for borrowers between trading and non-trading banks. Thus, there is no differential risk-taking

[5]We also find that the main bank coefficient is almost identical in value (and statistically not different) if we do not control for borrower*time fixed effects, despite that the R-squared decreases by almost 40 points. This suggests that the covariance between bank characteristics (trading and capital) and unobserved firm fundamentals is zero.

[6]If hangover of losses on existing investments was the main reason for lower credit supply, one would expect the overall effect of trading banks on credit reduction to be smaller (not higher) for banks with a higher level of capital, and that banks with unrealized losses on investment to lend less (not more).

in terms of lending associated with banks based on trading expertise. Moreover, the results on credit availability are binding at the firm level, which suggests that firms cannot compensate for the reduction in credit by trading banks with credit from other banks.[7] Note also that credit from trading banks constitutes an important fraction of the total lending in the economy and, therefore, our results suggest important macro effects. Finally, in contrast to the crisis, in the pre-crisis and post-crisis periods, all the main effects of trading versus non-trading banks are not present for credit and investments.[8]

We examine several potential alternative channels (see robustness section) and find that the above results are most consistent with trading banks increasing their investments in securities during the crisis to profit from the trading opportunities, which results in crowding out of credit supply by five percentage points.[9] We find that the average realized returns (annualized) on investments made, especially after the failure of Lehman Brothers, are approximately 12.5% over the next year.[10] The finding that banks with higher capital buy more of securities that had a larger price drop is consistent with these banks having higher risk-bearing capacity to absorb negative shocks in case the price of securities drops below their purchase price.

Our results contribute to the literature that shows that securities trading by banks during a crisis can affect credit supply (Shleifer and Vishny, 2010; Uhlig, 2010; Diamond and Rajan, 2011). Given that we find that banks with higher trading expertise withdraw funds from lending, our results also contribute to the literature that analyses liquidity provision by private intermediaries to firms and the role of government intervention (Holmstrom and Tirole, 1998). In addition, our results also contribute to theories that highlight strong synergies between the assets

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[7] Some of the largest firms could substitute credit with debt securities, though evidence using our dataset on fixed-income securities does not support this. Note that Germany is a bank-dominated system with bank credit being the main source of finance

[8] This is consistent with the idea that, in general, when security prices are not very depressed (and also when funding constraints are not binding), there is no significant crowding out of lending due to securities investment. Note, however, that in some quarters in the euro sovereign crisis, there are significant results.

[9] In the periodic survey conducted by ECB, most banks reported funding constraints as an important factor affecting banking operations mainly in the middle of the crisis.

[10] See Figure 1.5. As discussed later, we compute realized returns in several different ways and find magnitudes between 12% and 15%. We also find that trading banks report higher net profits and income from trading, which suggests that these trading activities are not a part of a hedge. Moreover, though we do not have the loan rate at the loan level, the average loan rate in our credit data was approximately 5% during the crisis, thus significantly lower than the return on securities by banks.

and liabilities of banks (Diamond and Dybvig, 1983; Diamond and Rajan, 2001; Kashyap, Stein, and Rajan, 2002; Gennaioli, Shleifer, and Vishny, 2013; Hanson, Shleifer, Stein, and Vishny, 2014).[11] Our results highlight these synergies as banks with a higher level of capital (stronger liabilities) buy riskier securities in the crisis (securities that had a larger drop in price, especially those with long-term maturity and lower rating).

Given our findings on bank capital and securities trading, our results are consistent with models of financial intermediation where the capital level of banks affects asset demand (Xiong, 2001; Gromb and Vayanos, 2002; Brunnermeier and Pedersen, 2009; Adrian and Shin, 2010; He and Krishnamurthy, 2013; Brunnermeier and Sannikov, 2014). Our results suggest that in a crisis, the capital level of banks plays an important role in their investments in securities markets. Our results suggest that trading banks with higher capital can buy more of the securities that had a larger drop in price, especially lower-rated and long-term securities, as higher equity capital provides buffers to absorb potential negative shocks in these riskier securities. Moreover, the results are also consistent with models of fire sales and lack of arbitrage capital (Shleifer and Vishny, 1992, 1997; Allen and Gale, 1994, 1998, 2005; Duffie, 2010; Uhlig, 2010; Acharya, Shin, and Yorulmazer, 2013).

Our results also add to the literature that examines investment behavior of banks in sovereign debt during the European sovereign crisis (Acharya and Steffen, 2014; Battistini, Pagano, and Simonelli, 2014; Drechsler et al., 2014).[12] The main focus of these papers is to examine risk-shifting incentives and financial repression by euro area governments.[13] One limitation of these papers is that they only have data on investments in sovereign securities in some particular periods or only collateral posted by the banks with the European Central Bank. In addition, these papers do not focus on credit supply during the crisis.

Finally, our results also contribute to the literature that examines the effects on

[11] Hanson et al. (2014) analyze synergies between bank assets and liabilities and argue that safer financial institutions with stronger liabilities (e.g., banks with higher capital) have a comparative advantage in crisis times at holding relatively illiquid, fixed-income assets with substantial transitory price volatility.

[12] See also Becker and Ivashina, 2015 for evidence on search for yield by insurance companies.

[13] These papers examine sovereign debt investments of banks during the sovereign debt crisis (corresponding to the post-crisis period in our data). Acharya and Steffen (2014) find that weakly capitalized banks increase their investments in risky sovereign debt consistent with risk shifting and moral suasion (using a sample of euro area banks). Drechsler et al. (2014) examine the collateral posted by banks in the euro area to avail liquidity from ECB and find evidence consistent with risk-shifting incentives of weakly capitalized banks. Note, however, that these papers do not find risk-shifting behavior in the period after the failure of Lehman Brothers.

credit supply during a crisis (see e.g. Ivashina and Scharfstein, 2010; Iyer et al., 2014; Jiménez et al., 2012, 2014). These papers document a decrease in lending by banks during the crisis, especially those banks more exposed to the shock. To the best of our knowledge, we are the first paper that uses detailed data on both security investments and credit -i.e., a security register and a credit register- which are crucial for comprehensive empirical analysis of the trading behavior of banks in the crisis and the associated effects on the supply of credit to the real sector.

The remainder of the paper is structured as follows. Section 2 presents the data and the testable hypotheses using a stylized theoretical model. Section 3 presents the estimation approach and discusses the results. Section 4 concludes.

1.2 Data and hypotheses

In this section we present the data and a simple model to guide the empirical analysis.

1.2.1 Data

We use the proprietary security and credit registers from the Deutsche Bundesbank, which is the micro and macro-prudential supervisor of the German banking system.[14] We have access to the micro data on securities investments of banks (negotiable bonds and debt securities, equities, and mutual fund shares) at the security level for each bank in Germany, on a quarterly frequency from the last quarter of 2005 to the last quarter of 2012.[15] For each security, banks report the notional amount they hold at the end of each quarter (stock of individual securities at the end of each quarter). We use the unique International Security Identification Number (ISIN) associated with every security to merge the data on security investments with (i) the Eurosystem's Centralized Securities Database (CSDB) to obtain further information regarding the issuer of the security (domicile country and sector); (ii) Bloomberg to obtain price data (nominal currency, market price);[16] (iii) FactSet to obtain security-level information on rating, coupons, and maturity. Moreover, we supplement this database on security investments with

[14]For micro-prudential regulation the responsibilities are coordinated with 'BaFin'

[15]The reporting requirement specifies that securities holdings, which are passed on or acquired as part of a repo contract, are not double-counted in the securities database. Thus, the transactions captured in analysis are not a mechanical artifact of repo transactions. Also, securities holdings of banks in special purpose vehicles are not reported, as these are off-balance sheet items.

[16]We verified the accuracy of the price data from Bloomberg for a subset of securities using the price data that is reported by CSDB.

confidential supervisory monthly balance sheet statistics at the bank level. In particular, we collect monthly balance sheet items such as each bank's equity capital, total assets, Tier 1 capital ratio, interbank borrowings, and savings deposits.

Finally, we obtain data on individual loans made by banks from the German credit register maintained by the Deutsche Bundesbank. Banks must report on a quarterly frequency all borrowers whose overall credit exposure exceeds EUR 1.5 million. Note that lending to small and medium-sized firms is not fully covered by this dataset. However, the credit register covers nearly 70% of the total credit volume in Germany. The credit register provides information on the amount of loans outstanding at the borrower level for each bank. In addition, it also provides information on the date of default (where applicable). The credit register, however, does not record the maturity and interest rate associated with the loans.

The complete securities holdings data consists of all securities held by 2,057 banks in the German banking system. We prune this data as follows. We consider only debt securities and exclude equities and shares of mutual funds. As a fraction of total holdings of securities, fixed income securities comprise 99% of the investments. Then, we delete the securities for which the total holdings for the entire banking sector were below EUR 10 million.[17] The resulting set of securities comprise 95% of the total holdings. We also exclude from the analysis banks with total assets below EUR 1 billion. In addition, we exclude Landesbanks and mortgage banks from the analysis.[18] The final sample consists of 504 banks holding 89% of the securities holdings of the total banking system.

1.2.2 Hypotheses

Before we present the results, and as a complement to the theoretical papers we highlighted in the Introduction, we present a simple model to guide the empirical analysis. The main intuition behind the model is the following. In a crisis, when the expected returns from investing in securities are high, banks with higher trading expertise invest more in securities and cut back on credit in the presence of funding constraints (see Diamond and Rajan, 2011; Shleifer and Vishny, 2010).[19]

[17] We do this for computational reasons. These securities also account for a very small fraction of the overall asset holdings. We also drop banks below EUR 1 billion in total assets. These banks are generally not active in securities markets and account for a small fraction of the aggregate securities holdings and credit.

[18] Landesbanks are (at least partly) owned by the respective federal state and thus considered to enjoy an implicit fiscal guarantee. Law prohibits mortgage banks to engage in (risky securities) investments. The results are robust to including these banks in the sample.

[19] The assumption is that expertise is required to identify profitable trading opportunities in securities market during the crisis. See also Gorton and Metrick (2012) and Dang, Gorton and

In addition, trading banks with higher risk-bearing capacity (higher capital ratio) will invest even more in securities and further decrease the supply of credit (much in line with He and Krishnamurthy, 2013). We now proceed to a more detailed exposition.

Assume a two-period world with one security that has random returns. We denote the security's price at $t = 0$ as P_0. At $t = 1$, P_1 can be either S_H or S_L, with probability $1/2$ (without loss of generality, we assume $S_H > S_L$). Banks receive a private signal at $t = 0$ regarding the price of the security at $t = 1$. The signal can have two values: σ_H and σ_L. We assume that the signal is informative: $Pr(\sigma = \sigma_H|S_H) = \theta \geq 1/2 = Pr(\sigma = \sigma_L|S_L)$. We interpret the precision of the signal, θ, as the "trading expertise" of banks. That is, banks that have trading expertise receive signals with lower noise.

After receiving the private signal, banks decide on how much to invest in securities at the given price P_0. If a bank receives a good signal, σ_H, then it buys n units of this security (otherwise the bank does not buy any unit of the security). If the price of the security at $t = 1$ is S_H, the bank obtains the amount $n(S_H - P_0)$. The probability of this event happening is $Pr(S = S_H|\sigma = \sigma_H) = \theta$. The bank also obtains $n(S_L - P_0)$ with probability $(1 - \theta)$. The bank's optimization problem can be summarized as follows:
$\max_n n \times (\theta S_H + (1 - \theta)S_L - P_0) - \frac{1}{\tau}Var(n(\hat{S} - P_0)) + g(L)$ subject to the following funding constraint: $P_0 n + L \leq W$.
where n is the amount invested in securities, L is the credit supplied to the real economy, and W is the available funding. The first part of the objective function is the expected return of the risky security, the second part is the variance of this return, and the last part, $g(L)$, is the payoff from the lending investment. τ can be interpreted as the risk-bearing capacity of the bank, which can come from capital constraints stemming from the market or regulation or from risk aversion (see He and Krishnamurthy, 2012, 2013). We assume that the budget constraint W in the model is binding during a crisis -i.e., banks cannot easily raise more funds to invest.[20] Therefore, banks need to choose how much of their funds (W) to allocate to investments in securities ($P_0 n$) and how much to allocate to lending (L).

The first order condition, assuming that the funding constraint is binding, is:
$\theta S_H + (1 - \theta)S_L - P_0 - \frac{2n}{\tau}(1 - \theta)\theta(S_H - S_L)^2 - P_0 g'(W - P_0 n) = 0$. Solving

Holmstrom (2013) for papers that argue about breakdown in trading of debt securities during a crisis due to lack of expertise to evaluate the quality of the debt securities

[20]In the periodic survey conducted by ECB, most banks reported funding constraints as an important factor affecting banking operations in the middle of the crisis.

for the optimal n[21]: $n^* = \frac{\tau}{2}\frac{\theta S_H + (1-\theta)S_L - P_0(1+c)}{(1-\theta)\theta(S_H - S_L)^2} = n$ and $L^* = W - P_0 n^*$.

Given these optimality conditions, we obtain the following testable predictions:

Proposition 1: $\frac{\partial n^*}{\partial \theta} > 0$, $\frac{\partial L^*}{\partial \theta} < 0$. *Banks with higher trading expertise have higher investment in securities and reduce the supply of credit as compared to banks with lower trading expertise.*

Proposition 2: $\frac{\partial n^{*2}}{\partial \theta \partial \tau} > 0$, $\frac{\partial L^{*2}}{\partial \theta \partial \tau} < 0$. *The trading ability and risk-bearing capacity reinforce each other with regard to investment in securities and consequently, this implies further reduction in credit supplied. Thus, the effects are reinforced with higher bank capital.*

Proposition 3: $\frac{\partial n^*}{\partial P_0} < 0$, $\frac{\partial L^*}{\partial P_0} > 0$. *A decrease in the initial security price (an increase in the expected return) increases the overall investment in securities and decreases lending.*[22]

Proposition 4: $\frac{\partial n^{*2}}{\partial P_0 \partial \tau} < 0$, $\frac{\partial n^{*2}}{\partial P_0 \partial \theta} < 0$, $\frac{\partial L^{*2}}{\partial P_0 \partial \tau} > 0$, $\frac{\partial L^{*2}}{\partial P_0 \partial \theta} > 0$. *The effects described in Proposition 3, both in terms of securities investments and lending, are stronger for banks with higher trading expertise and higher risk-bearing capacity.*

It is important to highlight that the negative externality from securities investment by banks to lending relies on three features: (1) an increase in expected returns from investing in securities; (2) funding constraints; and (3) securities markets and lending markets have some degree of segmentation (i.e., that loan rates do not adjust immediately to be equal to security returns). See Stein (2013) and Diamond and Rajan (2011) for a discussion of the externalities. [23]

[21] To derive this equation, we have assumed linear loan returns: $g(L) = cL$. We have assumed that loans are riskless with constant returns to scale (marginal profit equals c). Note that as long as the volatility of a loan portfolio is sufficiently low with respect to the volatility of securities? returns, the main propositions would hold. Note also that we take prices and returns as given in the model and ignore other equilibrium considerations. We also assume that capital and level of funding constraints are independent (see, e.g., He and Krishnamurthy, 2013, and Brunnermeier et al., 2012, for models that relate both).

[22] To get this relation, one needs to further assume that gross returns from investing in securities are below twice of those from investing in loans $((\theta S_H + (1-\theta)S_L/P_0 < 2(1+c))$. To obtain an interior solution, we also need $0 \leq n^* \leq W/P_0$. The first condition, $0 \leq n^*$, is satisfied as long as the expected return in securities is higher than the expected return in lending: $\theta S_H + (1-\theta)S_L - P_0 \geq P_0 c$. The second condition only states that the bank needs to have enough funds to finance its investment in securities. In other words, the returns from securities investments need to be higher than those from lending so that there is positive investment in securities, but not too high so that there is still some lending.

[23] Note that it is also difficult for banks to increase interest rates substantially to compensate for

To examine whether the testable predictions of the model are borne out in the data, we analyze the crisis, when there was a sudden shock to the securities markets and there were constraints to bank funding. We first analyze security investments by banks with higher trading expertise and examine how it varies based on their level of capital. In particular, we examine investments in securities that were most affected by the crisis, i.e. those that had a large drop in price. Moreover, we identify the associated lending behavior of trading banks and the effects based on their level of capital. Finally, we analyze these results outside the crisis period when securities markets were less volatile and funding constraints were lower.

1.3 Results

In this section, we first discuss the summary statistics. We then present the equations that we use for the estimation along with the results for both the securities and credit analyses. Finally, we discuss other potential alternative channels and further robustness.

1.3.1 Summary statistics and initial results

Table 1.1, Panel A, presents the summary statistics of the portfolio holdings of banks with (higher) trading expertise decomposed into three subsamples covering the key time periods. We denote the period from 2005:Q4 until 2007:Q2 as the pre-crisis period, while we define the subsample 2007:Q3 - 2009:Q4 as the crisis period.[24] Since 2009:Q4 is the last quarter with year-to-year negative GDP growth in Germany, we refer to the period thereafter as the post-crisis sample. To empirically proxy for trading expertise of banks, we create a dummy that takes the value of one when a bank has membership to the largest fixed-income trading platform in Germany (Eurex Exchange).[25] The idea is that banks that are generally more active and with higher expertise in securities trading will have membership to the trading platform rather than using an intermediary. The notion being that banks which generally engage in trading activities and have expertise will have a trading desk in place and the necessary infrastructure like direct membership, etc., to facilitate trading activities.

the returns from security investments due to the risk of adverse selection and moral hazard that arise in lending (Stiglitz and Weiss, 1981).

[24]For references that the financial crisis starts in Europe in 2007:Q3, see Iyer et al. (2014) and the references therein.

[25]Eurex Exchange is a German trading platform for bonds, repo, and other alternative asset classes.

Supporting this classification, we find that banks with trading expertise buy and sell a significantly larger fraction of securities (relative to other banks reported in Panel B of Table 1.1). Both the amount of securities bought and sold (as a fraction of total assets) are consistently larger for banks with trading expertise across all the periods. The correlation coefficient of trading expertise dummy with trading gains as a fraction of net income is close to 0.6. Thus, the trading expertise dummy is highly correlated with banks that have a higher fraction of income generated from trading activities. Furthermore, banks that are generally expected to have large trading desks, like Deutsche Bank, Commerzbank, Unicredit, etc., show up in the classification as banks with trading expertise. We also estimated the main results using trading revenues as a fraction of total revenues and find similar results to those reported below. We prefer not using the pre-crisis trading revenues as one could argue that they are endogenous to banks performance entering the crisis and could therefore bias the results. Note that while these banks trade more (buy and sell more) securities relative to other banks, in the pre-crisis period, we do not find that they increase their overall fraction of security holdings (in fact, they are similar in the level of holdings of securities in the pre-crisis).

Interestingly, looking at the securities to total assets, we find that trading banks increase their securities holdings in the crisis period. The fraction of securities to total assets goes up from 19% in the pre-crisis period to 23% during the crisis and then comes down to 22% in the post-crisis period. We do not find any significant difference for nontrading banks (from 18% to 19%).[26] Thus -unconditionally- trading banks on average increase their securities holdings in the crisis period.

While the securities holdings of trading banks increase during the crisis, loans as a fraction of total assets decrease. From the pre-crisis level of 67%, it decreases to 64% in the crisis. In contrast, for the non-trading banks, loans as a fraction of total assets increases from 69% to 70%. Note that, in general, the quality of loans in Germany was not bad and also Germany had a faster recovery from the crisis as compared to other European countries.[27]

[26]Note that our classification does not exhaust the entire set of banks that have trading expertise. Thus, it is possible that there are other banks in the group classified as non-experts that also have trading ability. This classification bias should reduce the likelihood of us finding any significant differences across the two groups.

[27]The average default rate on loans at the peak of the crisis was 1.1%. Some of the German banks (mainly Landesbanks) experienced problems due to investments in securities originated by banks from other countries and not from defaults arising from loans to German borrowers. As discussed earlier, we exclude Landesbanks from the main analysis.

All in all, the summary statistics reported above suggest that trading banks increase their overall level of security investments in the crisis and decrease credit. These patterns appear clearly in the data -i.e., comparing only trading banks across the pre-crisis and crisis period, or comparing trading versus non-trading banks in the crisis period with respect to the pre-crisis period.

A very similar picture also emerges from a graphical representation of the main variables of interest. Figure 1.3 presents the investments in securities by trading banks as compared to non-trading banks. Trading banks invest more in securities, especially during the crisis period. Furthermore, in line with Figure 1.1 (discussed earlier in the introduction) there is a sharp spike in their security investments in the period after the failure of Lehman Brothers. In contrast, an opposite picture emerges when we look at credit growth (Figure 1.4). We see that during the crisis, trading banks decrease their credit growth relative to nontrading banks.

Examining the composition of securities holdings of banks, we see that for trading banks, the fraction of triple-A securities to total securities holdings decreases from 49% in the pre-crisis period to 37% in the crisis and then increases to 55% in the post-crisis period; instead, for non-trading banks, the fraction of triple-A securities remains stable at around 44% across the three different periods. Therefore, there are substantial differences in composition of securities across different ratings for trading and non-trading banks. In particular, trading banks not only substantially increase their overall securities holding during the crisis, but they add more of non-triple-A securities.

For trading banks, the ratio of long-term securities goes up from 71% in the pre-crisis period to 78% in the crisis (and further to 86% in the post-crisis period); instead, for the non-trading banks, the fraction of long-term securities remains stable in the pre-crisis and crisis periods at 78%. Thus, trading banks also buy relatively more of long-term securities. Thus, trading banks increase overall investments in the crisis, and especially in lower-rated and long-term securities (looking only at trading banks across periods or comparing trading versus non-trading banks across periods).

Moreover, for trading banks, the fraction of domestic securities to total securities decreases from 64% to 49% and increases to 57% in the post-crisis period, and the fraction of sovereign securities held decreases from 37% in the pre-crisis period to 31% during the crisis, increasing to 42% in the post-crisis period. Instead, for the non-trading banks, the fraction of sovereign securities is at around 23% in the pre-crisis, 22% in the crisis period, and at 23% in the post-crisis period, and the fraction of domestic securities is 79% in the pre-crisis, 72% in the crisis, and further decreases to 67% in the post-crisis period. In terms of size, trading banks vis-à-vis other banks are on average larger. Note that in the main regressions we include controls for size and other bank characteristics. We also find that during the crisis, both trading and non-trading banks increase in size.[28] The average capital ratio (equity to total assets) is 4.8% for trading banks in the pre-crisis period and remains at the same level in the crisis (4.81%), increasing to 5.44% in the post-crisis period; for nontrading banks, the capital ratio is 5.07% in the pre-crisis and crisis periods and 5.22% in the post-crisis period.

In terms of the prices of securities, Figure 1.2 presents the evolution of prices over the sample period. There is a wide variation in the prices of securities. We find large price drops in the crisis period (2007:Q3 to 2009:Q4), though there is also a recovery of prices. On average, in some quarters, the average prices of securities drop by around 20% (annualized price change). However, there is also wide heterogeneity in the price changes across different securities. One can see that there are hardly any significant price drops for securities that are rated triple-A and securities with maturity lower than one year (non triple-A and long maturity securities have the largest price drops). This again highlights the importance of examining investment behavior at the security level, since using aggregate data would mask these differences and could be misleading.

1.3.2 Securities analysis

We now examine the investment behavior in securities using the micro data. The summary statistics and graphs presented above suggest that in the crisis period, trading banks increase investments in securities and decrease credit as compared to non-trading banks. However, to understand the underlying mechanism, and for empirical identification, one needs to analyze data at the micro level (both for securities and credit). We formally examine the differential behavior of trading banks relative to non-trading banks using a regression framework. Table 1.2 reports the results for banks' investment behavior in the crisis period based on trading expertise.[29]

Before we move to the security-level data, we start by examining whether trading banks increase their overall fraction of investments in securities relative to non-trading banks. In column 1, we examine at the bank level the change in the level of securities holdings as a fraction of total assets in the crisis period. We find

[28] A similar pattern is also reported (He, Khang and Krishnamurthy, 2010) for U.S banks. In all the specifications, we control for bank characteristics.

[29] In some of the estimations the number of observations varies due to missing data. However, this does not affect the robustness of the results.

that trading banks increase their level of securities holdings relative to non-trading banks over the crisis period. This result lines up with the summary statistics and Figure 1.3, where we find that trading banks increase their securities holdings in the crisis. Therefore, both conditionally (controlling for other bank characteristics in Table 1.2) and unconditionally (without any control in Table 1.1 and Figure 1.3), we find that trading banks increase their level of investments during the crisis.

We then move on to separately examining buying and selling behavior across securities. Our model for buying and selling behavior is at the security-quarter-bank level (to be able to control for time-varying, unobserved heterogeneity in securities) and takes the following form:

$$Log(Amount^{buy/sell})_{ibt} = \beta TradingExpertise_b + \alpha_{it} + Controls_{t-1} + \epsilon_{ibt} \quad (1.1)$$

where $Amount$ refers to the nominal amount bought ('buy') or sold ('sell') of security i by bank b at quarter t, 0 otherwise -i.e., when there is a buy, we calculate the nominal amount by calculating the absolute difference in the holdings between quarter t and quarter $t-1$ and then taking the logarithm of this amount. For example, when examining buying behavior, the dependent variable takes a positive value if the bank has a net positive investment in the particular security and zero if there is no change in the level of holdings or if there is a net sell of the security. We also include security*time fixed effects (α_{it}) to control for time-varying, unobserved characteristics of individual securities.[30] Note that inclusion of security*time fixed effects controls for all unobserved and observed time-varying heterogeneity, including all the price variation in securities, thus the estimated coefficients are similar whether we use nominal holdings or holdings at market value as a dependent variable.

We use equation (1.1) as a baseline and modify it based on the hypothesis we are testing. In some estimations, we exploit interactions of bank variables (trading and capital) and security variables (e.g., price variation in the previous quarter) and thus modify the equation accordingly. Furthermore, we can also include bank (or bank*time) fixed effects to account for time-invariant (time-varying) heterogeneity in bank characteristics.

In columns 2 and 3, we examine, respectively, the overall buying and selling behavior of banks at the security-quarter-bank level. We find that trading banks in

[30]The inclusion of security*time fixed effects also helps us to control -in each time period- for how much of *each security* is issued and outstanding and, therefore, isolate the supply of securities. Also, when we use security*time fixed effects, we do not control for security-level variables as these are absorbed by the fixed effects.

general buy and sell more of securities as compared to non-trading banks (nearly twice as much, with a higher coefficient for buying than selling).[31] These results from columns 2 and 3 further help validate our classification of banks with higher trading expertise.[32] In columns 4 and 5, we add security*time fixed effects and find similar coefficients as in columns 2 and 3. We also find a similar pattern when we examine buying behavior across securities with different ratings and maturity (not reported).

We further examine whether there are differences in the composition of investments, conditional on buying, in Table 1.3. Based on the theoretical model described earlier, one would expect that, conditional on buying, banks with higher trading expertise would selectively increase investments in securities that had a larger price drop (in the previous period) as compared to other banks. To examine this, we estimate equation (1.1), restricting the sample to securities and banks where there are only buys.

In column 1, we find that trading banks buy more of the securities that had a larger percentage drop in price in the previous quarter (interaction of trading expertise dummy and lagged percentage change in price). Note that we introduce bank fixed effects, in addition to security-time fixed effects, to take into account time-invariant heterogeneity in bank characteristics and to isolate the compositional effects of buys. In columns 2 to 5, we analyze compositional effects depending on rating and maturity. We find that the effects are not significant for triple-A and short-term securities, but are significant only for non-triple- A rated securities and securities with a maturity longer than one year.

In Table 1.4, we examine whether trading banks differ in the composition of securities they sell. Table 1.4 is identical to Table 1.3, the only difference being that we examine sells. As one can see, we do not find any significant differences in selling behavior for securities that had a larger drop in price across banks based on trading expertise. We also do not find any compositional effects depending on rating or maturity.

While the results above show that trading banks buy more of securities that had a larger percentage drop in price, an important question that arises is whether there are differences in the level of investments based on bank capital. As discussed earlier, the capital level of banks could proxy for risk-bearing capacity. In Table

[31] We also ran the estimations where the dependent variable takes the value of one if the bank has a net positive investment in a security and zero otherwise, and we find similar results.

[32] We also find similar results for the pre-crisis and post-crisis periods, though in these periods there is no higher overall investment in securities for trading banks, as Table 1.9, Panel B, shows.

1.5, columns 1 to 4, we limit the analysis to banks with trading expertise. Thus, we examine whether trading banks differ in their investment behavior based on the level of capital. In column 1, we find that for trading banks, higher bank capital (lagged) not only implies a higher level of investments (buys), but also the coefficient on the interaction term with previous price change is negative and significant. Thus, trading banks with higher capital levels buy more of securities in general, especially those securities that had a larger drop in price. We find similar results when we estimate the model without any bank fixed effects or if we use the equity level measured as on 2007 (not reported).

In terms of economic magnitudes, a one percentage point increase in capital, on average, increases the amount of security bought by 11.1%. Furthermore, there is an additional 6.1% increase if the security fell in the previous quarter by one standard deviation. In column 2, we include both bank*time and security*time fixed effects to account for all time-varying heterogeneity in bank and security characteristics.[33] The results obtained are similar to those reported in column 1. These results (as well as the other results in the paper) are robust to inclusion of other interactions of bank characteristics with lagged percentage change in price, bank*security fixed effects and double clustering at the bank and security level.

In column 3, we include as controls the lagged cumulative gains/losses for individual securities that are present in the banks' investment portfolios. We do not find that banks buy more of securities where they have higher accumulated losses. In fact, we do not find any significant effect. Moreover, the interaction term of cumulative gains with capital is also not significant. These findings do not support the view that banks buy securities that had a larger drop in price in an effort to increase the price of these securities to make their existing portfolio look better. Thus, this finding is not consistent with window dressing activities being the driver of banks' investment in securities that had a larger price drop. Also, as discussed later, we find that banks with a higher level of capital sell more of securities where they have larger accumulated losses in their existing investment portfolio. In column 4, we estimate the regressions conditional on the bank buying a security. We again find similar results to those reported earlier. In columns 5 to 8, we report the estimations for non-trading banks. For these banks, we find that the overall level of investment in securities is not increasing in the level of capital (column 5). The coefficient on capital is not statistically significant. Moreover, unlike for trading banks, we do not find that higher capital is consistently associated with a

[33]The results are robust to inclusion of other interactions of bank characteristics with lagged percentage change in price. The results are also robust to inclusion of bank*security fixed effects and double clustering at the bank and security level.

higher level of investments in securities that had a larger drop in price (column 8 is not significant). In addition, whenever it is significant, the estimated magnitude is very small -the coefficient is less than one quarter of the estimated coefficient for trading banks. We also do not find any effect of cumulative gains/losses on existing investments on buying behavior (column 7). In column 8, when we condition on securities where there is a buy by a bank, we do not find any relation between the amount bought of a security that had a larger price drop and the capital level.[34]

In Table 1.6, we further examine whether the buying behavior of banks differs across securities with different ratings and maturity. In Panel A, we report the results for trading banks. In columns 1, 2, and 3, we find that the coefficient on the interaction term is only significant for non-triple-A rated securities. These results show that across all categories (except for triple-A), trading banks with a higher level of capital invest more in securities that had a larger drop in price.

Examining the buying behavior across securities with different maturities presents a very similar pattern (columns 4, 5, and 6). The coefficients are larger for securities with maturities longer than one year and not significant for securities with maturity less than one year. These results suggest that banks with a higher level of capital buy more of securities whose prices have previously fallen, especially in investments with lower ratings and long-term maturity. In fact, there are not significant effects for triple-A rated securities or for securities with residual maturity less than one year.

In Panel B, we report the results for non-trading banks. Again, in line with the results reported in Table 1.5, we find that the coefficient on the interaction term for capital and percentage change in price is substantially smaller in magnitude relative to those reported for trading banks, not statistically significant from columns 2 to 6. It is only significant for triple-A category (column 1), just the opposite of trading banks.[35]

The results above capture the differential investment behavior of banks with different levels of capital for securities. Note that most banks in Germany follow the German local GAAP (HGB) for regulatory reporting and for reporting financial statements. Under HGB, historical cost accounting prevails in contrast to fair value accounting (IFRS), which suggests that the association of capital and buy-

[34]This could be because of the small sample size in this estimation coupled with the large number of fixed effects. In fact, the cumulative gains cannot be estimated (we report the coefficients as 0.000).

[35]In general, we find that relative to non-trading banks, trading-banks buy more of securities across all different credit categories and maturities.

ing behavior is unlikely due to mark-to- market accounting concerns (Laux and Leuz, 2010).[36]

While in Tables 1.5 and 1.6 we examine the buying behavior of banks, it is also important to examine the selling behavior to understand whether banks are reluctant to book losses in their investment portfolios. Table 1.7 reports the regression results for the selling behavior of banks in the crisis period. In columns 1 through 4, we find that there is no significant effect of bank capital on selling behavior for trading banks. In column 3, we examine whether trading banks sell a higher volume of securities where they have larger accumulated gains or losses in their existing investment portfolio. We find that trading banks do not sell a higher volume of securities where they have larger accumulated losses. However, banks with higher levels of capital sell a higher volume of securities where they have larger accumulated losses. However, when we estimate the results conditional on only sells (column 4), we do not find significant effects.

Examining the selling behavior for non-trading banks (columns 5 to 8) across all different specifications, we find that they sell more of securities where they have higher accumulated losses. This effect is more pronounced for banks with a higher level of capital (column 8).

The overall results show that during a crisis, banks with higher trading expertise buy more of securities, especially those that had a larger fall in price. We also find that these effects are stronger for banks with higher capital levels. Furthermore, the strongest quantitative impact of capital on investments is for lower credit ratings (below triple-A) and for securities with residual maturity higher than one year. A crucial question that arises is whether these effects on securities trading by banks have spillovers on credit supply. That is, whether banks with higher trading expertise while increasing their investments in securities reduce their supply of credit to non-financial firms.

1.3.3 Credit analysis

To examine whether banks with higher trading expertise reduce their supply of credit relative to other banks, we exploit the data at the borrower-bank-time level.

[36]Under HGB, securities must be written down to the market value only when the market value falls below the reported amortized cost (unlike mark-to-market accounting). This decrease of the market value below historical cost has a direct impact on net income (unlike under IFRS) except when securities are placed in the held-to-maturity category. We do not have the data on categorization for banks; however, based on some studies (see Georgescu and Laux, 2013), for German banks, the average in held-to-maturity category is quite low (lower than 2.17%).

We use the following estimation equation:

$$\Delta Log(loancredit)_{jbt} = \beta TradingExpertise_b + \gamma_{jt} + Controls_{t-1} + \epsilon_{ibt} \quad (1.2)$$

where the dependent variable is the change in the log of credit granted by bank b to firm j during quarter t. We use borrower*time fixed effects (γ_{jt}) to control for time-varying, unobserved heterogeneity in borrower fundamentals (e.g., risk and growth opportunities) that proxy for credit demand (see e.g., Khwaja and Mian, 2008). Thus, we compare the change in the level of credit for the same borrower in the same time period across banks with different levels of trading expertise. Moreover, we also analyze the effect of bank capital on credit supply for trading and non-trading banks. In these regressions, we can use bank fixed effects to control for time-invariant heterogeneity in bank characteristics or include borrower*bank fixed effects to additionally control for different banking relationships for a firm. Finally, we also analyze whether there are implications for credit availability at the firm level (using aggregate changes in firm credit).

In Table 1.8, column 1, we start with examining the lending behavior of banks based on trading expertise and capital relative to other banks. We find that, in the crisis period, banks with (higher) trading expertise lend less to the same borrower (firm) at the same time as compared to other banks. The lending by trading banks is five percentage points lower than that of non-trading banks. In column 2, we examine whether trading banks with higher capital reduce lending by more. For banks with higher trading expertise, we find that higher capital is associated with a larger decline in credit. Thus, consistent with the model discussed earlier, trading banks with higher capital invest more in securities and also reduce the supply of credit by more. Note that the coefficient of non-trading banks and capital has the opposite sign than that for trading banks (higher capital implies more lending), although it is not statistically significant.

In column 3, we introduce controls for other bank characteristics and find that the coefficients reported in column 2 are almost identical and still remain statistically significant. In column 4, we control for the accumulated losses or potential gains on the existing security investments of banks. For instance, one could be concerned that trading banks reduce credit supply primarily due to losses on existing investments. While this argument does not explain why banks with higher trading expertise and a higher level of capital cut back more on credit, it is still important to examine the effects after controlling for unrealized losses or gains on a bank's investment portfolio. Again, we find that controlling for unrealized losses or gains does not change the magnitude or significance of the estimated coefficients.[37] Interestingly, we find that banks with higher unrealized gains on existing securities investments lend less relative to other banks (columns 5 to 7), although the result is not robust.

While the results above compare the lending behavior of two banks to the same firm at the same time period, one could still be concerned about borrowers matching with banks differentially. To analyze this differential matching channel, in columns 5 and 6, we run the estimation including bank(lender)*firm(borrower) fixed effects. The inclusion of bank fixed effects also helps to account for all time-invariant characteristics of banks. In column 5, even after controlling for bank*borrower fixed effects, we find that trading banks with a higher level of capital decrease supply of credit relative to other banks. Also, we find that the main bank coefficient remains very similar in magnitude to the earlier estimations. Moreover, in column 6, we also find that non-inclusion of borrower*time fixed effects does not alter at all the magnitude of the coefficients on the bank capital for trading banks, despite substantially reducing the R-squared from 64% to 27%. These results suggest that the covariance between bank capital for trading banks (supply) and firm fundamentals (demand) is negligible, thus suggesting that differential borrower demand arising due unobserved matching between banks and borrowers is unlikely to be the driver of the results. It also suggests that our main bank variable coefficients are exogenous to a large set of unobserved borrower fundamentals (see Altonji, Elder and Taber, 2005). We also estimated the regressions controlling for the loan exposures of banks to different business sectors, and the results remain unchanged (not reported). The results are also robust to double clustering at the bank and borrower level.

To examine whether banks differentially take incremental risk in loans, we also examine the interaction of trading banks with future loan defaults (two years down). Column 7 reports the results from this estimation. We find that the coefficient on the interaction term of trading banks with future default is not significantly different from zero.[38] These results suggest that trading banks did not differentially take on more risk in loans.

Finally, in column 8, we examine whether firms can substitute the decrease in credit supply from trading banks by borrowing more from other banks. For instance, imagine a firm that had two banking relationships before the crisis, one with a trading bank, and the other with a non-trading bank. Can the firm in-

[37]The results are also robust to controlling for realized gains and losses, though given that sells are low, the majority of gains and losses are unrealized.

[38]Loan defaults without the interaction is absorbed by the firm*time fixed effects, as we have loan defaults at the firm-time level.

crease the credit from the non-trading bank and not suffer any overall restriction of credit? To examine this issue, we first create the fraction of borrowing of a firm from banks with trading expertise before the crisis (2007:Q2). This variable does not vary at the firm level and therefore we cannot introduce firm fixed effects (credit change is at the firm level). In column 8, we find that for firms with a higher fraction of borrowing from trading banks, the total change in credit is negative and significant. Moreover, we also construct other measures of a firms' exposure to trading banks (such as higher than 50% of the firms total borrowing, or weighted averages based on the capital level of trading banks) and find similar results (not reported). Note that this specification (column 8), unlike the ones reported earlier (columns 1 to 7), does not account for firm fundamentals, but the results in previous columns suggest that the main bank variables are not correlated with firm heterogeneity.

These results suggest that firms that were borrowing more from banks with higher trading expertise faced a higher reduction in total credit (from banks). While we do not find firms issuing debt securities to compensate for the reduction in bank credit or banks buying bonds of the firms where they have outstanding credit, we cannot observe whether they substitute from other sources such as trade credit. To the extent that this is not the case, which seems plausible given that Germany is a bank-dominated system, our results suggest real effects.

1.3.4 Further robustness

While the results above show that in the crisis period, banks with higher trading expertise (especially the ones with higher capital) increase their investments in securities and reduce the supply of credit to non-financial firms, analysis of the pre-crisis and the post-crisis periods can help further shed light on the main mechanism. The main channel highlighted in the theoretical models described earlier relies on a large shock to securities markets (returns) during the crisis and the presence of bank funding constraints. This also suggests that in periods when there are no large shocks to securities markets or bank funding constraints are not binding, one would not expect to find similar results as in the crisis period. Note that even if returns from investing in securities markets are high, if the bank funding constraints are less binding, the spillover effects of higher investment in securities on credit supply should be lower or non-existent.

In Table 1.9, Panel A, we examine the lending behavior of banks in the pre-crisis and post-crisis periods. For both these periods, we do not find any significant difference in supply of credit by trading banks as compared to non-trading banks. In addition, the coefficient on capital for trading banks is not significant. In fact, in columns 2 and 3, for the pre-crisis period, the coefficient is positive, although not significant at conventional levels. Finally, there are also no significant differences in future default rates in these periods between banks with trading expertise relative to other banks (columns 3 and 6).

In Panel B, we examine the investment in securities in the pre-crisis and post crisis periods. While banks with higher trading expertise buy and sell more securities in general across all the periods (see summary statistics in Table 1.1), we do not find them substantially changing the proportion of investments in securities in the pre-crisis and post-crisis periods (columns 1 and 2 of Table 1.9, Panel B). In the post crisis period, we see that there is some volatility in securities markets, especially around the initial Greek crisis and also in 2011:Q2. It is interesting to note that trading banks buy into Greek bonds at the time when their spreads are widening but before the worst moments of the Greek crisis (see Figure 1.6).[39] However, we do not find a significant reduction in credit supply relative to other banks (also not significantly different from the coefficient in the pre-crisis period). Note that as compared to the crisis period, when most banks report capital and wholesale funding constraints as important factors affecting business operations, this is substantially less the case during the post-crisis period, especially in Germany (see Bundesbank and the ECB survey of Euro area banks).[40] Also, banks equity capital base is higher, at 5.4%, in the post-crisis period as compared to 4.8% in the crisis (see summary statistics in Table 1.1), thus also suggesting that capital constraints are less binding.

A crucial quantitative question is, what are the ex-post returns that banks with higher trading expertise obtain in the crisis? To do this, we examine the average return on a portfolio of securities formed by mimicking the investments of banks with higher trading expertise. We create a portfolio by selecting the same securities (that had fallen in price) and the same timing of investments. Using this method, we find that the realized returns (annualized) on investments made after the failure of Lehman Brothers are approximately 12.5% over the subsequent quarters (see Figure 1.5). The realized return on investments in securities with maturity of more than five years is higher at approximately 21% and non triple-A

[39]When we examine these particular quarters, we again see that there is a significant increase in securities as a fraction of total assets for trading banks as compared to other banks. See the spike in change in total securities for trading banks in Figure 1.3 for mid-2010.

[40]Though the bank liquidity problems can be solved with the ECB liquidity assistance, bank capital problems are not eliminated by ECB liquidity assistance. See Bernanke (1983) and Freixas and Rochet (2008) for discussion on why bank capital is costly, especially in crisis times. Admati and Hellwig (2013) question part of these costs.

is at 15%.[41]

While the results above are consistent with banks with higher trading expertise increasing their investment in securities during the crisis to profit from trading opportunities, thereby reducing the supply of credit, we examine several other alternative explanations. The first channel is through liquidity preference. That is, trading banks have a preference for liquid assets like securities as compared to loans. Based on this explanation, one should expect trading banks to buy more of securities that are liquid. However, this explanation is difficult to reconcile with the finding that trading banks with higher capital buy more of securities that are long-term rather than short-term and securities with lower ratings as compared to triple-A securities. For example, trading banks invest more in Greek sovereign debt exactly at the point when the spreads widen, which is difficult to reconcile with a purely liquidity preference based explanation. Note that liquidity preference by itself is not inconsistent with the banks trying to exploit trading opportunities in securities markets. For instance, several theoretical papers (Allen and Gale, 1998; Diamond and Rajan, 2011; Acharya, Shin, and Yorulmazer, 2013) argue that banks will hoard on liquidity rather than lock funds into loans, in anticipation of making high returns from acquiring securities in fire sales.[42]

We also investigate whether gains from trading act as a hedge against lending income. The idea being that trading banks expect future interest rates to be low, which in turn reduces their income from lending. Therefore, trading banks may invest in securities whose prices rise with lower interest rates, thus acting as a hedge against drop in lending income. To examine this channel, we use the data on lending income and trading income at the bank level from 1998 and find that they are positively correlated. This suggests that trading income from securities does not provide a hedge against lending income declines. In addition, while during a crisis there is generally a flight to highly rated securities, (e.g., holding high quality, German sovereign bonds provides a hedge), this is not generally the case for securities with long-term maturity and lower ratings. Thus it is difficult to explain the increase in investments in securities that had a larger price drop (especially in lower-rated and long-term maturity) and a reduction in credit supply purely by a hedging based explanation. The example that we discussed in the Introduction on the JP Morgan bond is illustrative of the trading opportunities for banks with higher trading expertise to obtain high returns on investments.

[41]We assume that the securities are sold in 2009:Q4. We also estimated the realized returns using the actual buying and selling behavior of banks. For the 2009:Q2, we find that returns are approximately 11.9%.

[42]See Allen and Carletti (2008) for a recent overview of the issues.

Another possible channel is that banks that have higher trading expertise buy more of securities that had a larger drop in price due to their market making activities and hence cut back on credit. While this explanation again suggests that banks reduce their credit supply to profit from income from market making, the channel is different from directly investing for trading purposes. Firstly, if market making was the main driver, one should also find trading banks selling more of the securities that had a larger price drop (or differential selling depending on the maturity and rating), whereas we only find results related to buys and not to sells. Also, we do not find these effects in the other periods. Furthermore, we find that the estimated gains from investments in securities that had a larger drop in price are positively correlated with trading income and net profits that banks report. This suggests that banks directly benefit from their trading activities.[43]

Finally, we also find similar results for investments in securities and reduction in credit for trading banks when we use Tier 1 capital ratios (not reported). Similar to the results reported earlier (Table 1.5, column 1), we find that banks with a higher level of Tier 1 capital buy more of securities. Furthermore, investment in securities that had a larger price drop is increasing in the level of Tier 1 capital. We also find that trading banks with higher Tier 1 capital decrease their credit supply by more. The economic magnitudes are also similar to the ones reported earlier. Moreover, another concern could be that some loans in the sample are under a model-based approach implemented under Basel II, which came into force in Germany before the crisis period. Thus, to make sure that the results are not driven by pro-cyclicality of lending that could arise due to Basel II, we estimate the results excluding these loans.[44] We find similar results to those reported earlier. The estimated coefficient (not reported) on trading banks is -0.079, and the interaction of trading expertise and capital is -0.03, both statistically significant and slightly higher in absolute value than the ones for the whole sample in Table 6.

In sum, the results are most consistent with banks that have higher trading expertise increasing their investments in securities to profit from the trading opportunities and withdrawing funds from lending.[45] Furthermore, banks with higher capital increase their investments by more and also reduce their credit supply by more. We also find that the capital level of banks plays an important role in their

[43]The finding that estimated gains from security investments are positively correlated with net profits that banks report also suggests that these security investments are not simply hedges.

[44]Under model-based regulation, banks report probability of default for loans using internal models, which affects risk weights. For loans under standard approach, the risk weights are static.

[45]See also Chakraborty, Goldstein and MacKinlay (2014) for evidence on banks reducing commercial lending when the increase their mortgage lending portfolio.

securities investment behavior. We find that banks with a higher level of capital buy more of the securities that had a larger drop in price. These results are consistent with equity capital providing buffers to absorb risk in case the price of securities further drops below their purchase price (and affects profits and capital).

1.4 Conclusion

We analyze security-trading activities of banks during a crisis and the associated spillovers to the supply of credit. Empirical analysis has been elusive due to the lack of comprehensive securities register for banks. We overcome this problem by using a proprietary dataset of the investments of banks at the security-level for each bank in each quarter for the period between 2005-2012, in conjunction with the credit register from Germany.

We find that banks with higher trading expertise increase their overall investments in securities during a crisis, especially in securities that had a larger drop in price. Furthermore, this effect is more pronounced for banks with a higher level of capital and in risky securities (low-rated and long-term securities). In fact, we do not find significant differential effects for triple-A rated securities. Interestingly, the overall ex-post returns are about 12.5% for trading-expertise banks in the crisis. In contrast to the behavior in securities markets, banks with higher trading expertise reduce their overall supply of credit in crisis times. The estimated magnitude of decrease in lending is approximately five percentage points. The reduction in credit supply is more pronounced for trading banks with higher capital, and moreover, we also find that the credit reduction is binding at the firm level. Given that credit from banks with trading expertise constitutes a large fraction of overall credit in Germany, and that Germany is a bank-dominated economy, the results suggest a significant impact on the availability of credit to firms during the crisis at the macro level.

The question that this naturally raises is whether banks should engage in securities trading. While there has been a move by some regulators to limit proprietary trading activities of banks, the welfare consequences are not clear. Our results suggest that during a crisis, securities trading by banks can crowd out lending. However, at the same time, we also find that banks buy securities that had a larger drop in price (especially long-term and lower-rated securities), in turn acting as risk-absorbers. Thus, to the extent that banks are large players in these markets, the results suggest that restrictions on securities trading by banks could affect the liquidity of these markets. The lingering questions that remain are, absent banks, would other intermediaries/governments be able to absorb the risk and provide liquidity to the securities markets? To what extent do the benefits associated with securities trading by banks outweigh the costs arising due to reduction in credit supply and the potential increase in systemic risk?[46] While these questions are beyond the scope of this paper, addressing them is an important avenue for future research.

[46]See Brunnermeier et al. (2012), Saunders et al. (2014), and Freixas et al. (2015) for analyses of systemic risk implications of bank trading activities.

1.5 Tables and Figures

Table 1.1: Summary statistics

PANEL A: TRADING BANKS

	Pre-crisis			Crisis			Post-crisis		
	Mean	Std.	Obs.	Mean	Std.	Obs.	Mean	Std.	Obs.
Securities holdings/TA	0.19	0.12	150	0.23	0.14	296	0.22	0.13	353
% Aaa securities	48.61	96.93	150	36.73	217.41	295	55.63	25.84	353
% domestic securities	64.09	27.72	150	57.60	30.24	296	49.45	53.37	348
% long-term securities	71.73	33.73	150	78.30	21.54	292	86.41	41.37	353
% sovereign securities	36.99	44.01	134	31.58	32.43	284	41.87	43.88	353
Buys/TA	0.035	0.035	150	0.039	0.046	296	0.029	0.030	353
Sells/TA	0.017	0.022	150	0.011	0.015	296	0.013	0.016	353
Loans/TA	0.67	0.13	150	0.64	0.15	296	0.61	0.15	353
Capital/TA	4.80	3.88	150	4.81	3.98	296	5.44	5.48	353
Size	16.65	1.91	150	16.80	1.88	296	16.85	1.94	353

PANEL B: NON-TRADING BANKS

	Pre-crisis			Crisis			Post-crisis		
	Mean	Std.	Obs.	Mean	Std.	Obs.	Mean	Std.	Obs.
Securities holdings/TA	0.18	0.11	2513	0.19	0.10	4983	0.20	0.11	5979
% Aaa securities	45.49	23.04	2281	44.13	25.02	4451	43.12	21.98	5491
% domestic securities	79.27	21.06	2503	72.39	24.99	4974	67.29	26.77	5941
% long-term securities	78.06	17.90	2502	78.12	20.13	4923	83.83	22.87	5950
% sovereign securities	23.66	19.03	1981	21.98	19.04	3634	23.14	18.67	4977
Buys/TA	0.019	0.042	2513	0.022	0.026	4983	0.015	0.018	5979
Sells/TA	0.007	0.037	2513	0.004	0.008	4983	0.003	0.007	5979
Loans/TA	0.69	0.12	2513	0.70	0.11	4983	0.68	0.12	5979
Capital/TA	5.07	1.31	2513	5.07	1.32	4983	5.22	1.34	5979
Size	14.46	0.84	2513	14.55	0.81	4983	14.65	0.78	5979

This table reports the summary statistics of the variables used in the paper, across three periods. We define pre-crisis (2006:Q1 - 2007:Q2), crisis (2007:Q3 - 2009:Q4), and post-crisis (2010:Q1 - 2012:Q4). Panel A reports the summary statistics for 'Trading banks'. Panel B reports the summary statistics for 'Non-trading banks'. We classify a bank as a 'Trading bank' (higher trading expertise) when it has membership to the largest fixed income platform in Germany (Eurex Exchange). 'Aaa' refers to the rating of securities. Domestic securities are securities where the issuer is German. Long-term securities are securities that have a remaining residual maturity higher than one year. Sovereign securities are securities issued by countries. 'Capital/TA' measures the book value of equity as a fraction of total assets (in %) for bank b. 'Size' refers to the logarithm of total assets (in EUR thousands) for bank b. The definition of the other variables can be found in the Table 1.10.

Table 1.2: Trading behavior during the crisis

	Dependent variable:				
	ΔSec/TA	Buys	Sells	Buys	Sells
	(1)	(2)	(3)	(4)	(5)
Trading bank$_b$	5.215**	2.419***	2.255***	2.043***	1.837***
	(2.563)	(0.571)	(0.54)	(0.475)	(0.411)
Bank controls	Y	Y	Y	Y	Y
Security*Time fixed effects	N	N	N	Y	Y
Bank fixed effects	N	N	N	N	N
Observations	504	248,399	258,731	248,399	258,731
R-squared	0.073	0.114	0.088	0.323	0.476

The dependent variable in column 1 is the change in Securities holdings/TA for each bank from 2007:Q2 to 2009:Q4. The dependent variable for the 'Buys' is $Log(Amount)_{i,b,t}$, which is the logarithm of the amount bought (in nominal value) by bank b of security i during quarter t, and zero otherwise. For the 'Sells', the dependent variable is the logarithm of the amount sold (in nominal value) by bank b of security i during quarter t, and zero otherwise. 'Trading bank' is a binary variable that equals the value of one when bank b has membership to the largest fixed income platform in Germany (Eurex Exchange), and zero otherwise, which proxies for banks with higher trading expertise. All regressions are estimated using ordinary least squares. Lagged, time-varying bank controls (Size, Capital/TA, Interbank borrowing/TA, Deposits/TA) are either included ('Y') or not included ('N'). Fixed effects are either included ('Y'), not included ('N'), or spanned by another set of fixed effects ('-'). Robust standard errors clustered at bank level following Arellano (1987) are reported in parentheses. ***: Significant at 1 percent level; **: Significant at 5 percent level; *: Significant at 10 percent level.

Table 1.3: Buying behavior during the crisis across securities

	Dependent variable: Buys				
	All	Aaa-rated	Below Aaa-rated	Up to 1 Year	Above 1 Year
	(1)	(2)	(3)	(4)	(5)
Trading bank_b* $\Delta\text{price}_{i,t-1}$	-0.231**	-0.160	-0.241*	0.164	-0.248***
	(0.113)	(0.159)	(0.138)	(0.748)	(0.113)
Bank controls	Y	Y	Y	Y	Y
Security*Time FE	Y	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y	Y
Observations	36,885	11,918	24,967	6,336	30,549
R-squared	0.703	0.682	0.721	0.714	0.708

The estimations report the buying behavior of banks across different securities *conditional on buying*. The dependent variable is $Log(Amount)_{i,b,t}$, which is the logarithm of the amount bought (in nominal value) by bank b of security i during quarter t. The splits are based on ratings and remaining residual maturity of the securities. 'Trading bank' is a binary variable that equals the value of one when bank b has membership to the largest fixed income platform in Germany (Eurex Exchange), and zero otherwise, which proxies for banks with higher trading expertise. The percentage price change of security i, '$\Delta\text{price}_{i,t-1}$', is demeaned by the sample mean and standardized using the standard deviation of the respective subset of securities in the crisis sample. All regressions are estimated using ordinary least squares. Lagged, time-varying bank controls (Size, Capital/TA, Interbank borrowing/TA, Deposits/TA) are either included ('Y') or not included ('N'). Fixed effects are either included ('Y'), not included ('N'), or spanned by another set of effects ('-'). Robust standard errors clustered at bank level following Arellano (1987) are reported in parentheses. ***: Significant at 1 percent level; **: Significant at 5 percent level; *: Significant at 10 percent level.

Table 1.4: Selling behavior during the crisis across securities

	Dependent variable: Sells				
	All	Aaa-rated	Below Aaa-rated	Up to 1 Year	Above 1 Year
	(1)	(2)	(3)	(4)	(5)
Trading bank$_b$*Δprice$_{i,t-1}$	0.073	0.159	0.057	0.162	0.058
	(0.075)	(0.258)	(0.085)	(0.188)	(0.086)
Bank controls	Y	Y	Y	Y	Y
Security*Time fixed effects	Y	Y	Y	Y	Y
Bank fixed effects	Y	Y	Y	Y	Y
Observations	48,546	14,682	33,864	16,055	32,491
R-squared	0.658	0.663	0.665	0.620	0.688

The estimations report the selling behavior of banks across different securities *conditional on selling*. The dependent variable is $Log(Amount)_{i,b,t}$, which is the logarithm of the amount sold (in nominal value) by bank b of security i during quarter t. The splits are based on ratings and remaining residual maturity of the securities. 'Trading bank' is a binary variable that equals the value of one when bank b has membership to the largest fixed income platform in Germany (Eurex Exchange), and zero otherwise, which proxies for banks with higher trading expertise. The percentage price change of security i, 'Δprice$_{i,t-1}$', is demeaned by the sample mean and standardized using the standard deviation of the respective subset of securities in the crisis sample. All regressions are estimated using ordinary least squares. Lagged, time-varying bank controls (Size, Capital/TA, Interbank borrowing/TA, Deposits/TA) are either included ('Y') or not included ('N'). Fixed effects are either included ('Y'), not included ('N'), or spanned by another set of effects ('-'). Robust standard errors clustered at bank level following Arellano (1987) are reported in parentheses. ***: Significant at 1 percent level; **: Significant at 5 percent level; *: Significant at 10 percent level.

Table 1.5: Buying behavior during the crisis based on capital

	Trading banks				Non-trading banks			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Capital/TA$_{b,t-1}$	0.111*				0.027			
	(0.061)				(0.068)			
Capital/TA$_{b,t-1}$*Δprice$_{i,t-1}$	-0.061***	-0.049*	-0.049*	-0.061**	-0.013***	-0.010***	-0.010***	-0.035
	(0.018)	(0.027)	(0.027)	(0.025)	(0.005)	(0.003)	(0.003)	(0.101)
Cumulative gains/TA$_{b,i,t-1}$	6.184	6.380	6.227	6.663	0.0125	0.369	0.307	0.000
	(5.444)	(5.817)	(5.824)	(13.98)	(0.356)	(0.356)	(0.364)	0.000
Capital/TA$_{b,t-1}$*Cumulative			-0.166	5.776			-0.176	0.000
gains/TA$_{b,i,t-1}$			(0.585)	(8.482)			(0.139)	(0.000)
Bank controls	Y	-	-	-	Y	-	-	-
Security*Time fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
Bank fixed effects	Y	-	-	-	Y	-	-	-
Bank*Time fixed effects	N	Y	Y	Y	N	Y	Y	Y
Observations	90,167	90,167	90,167	20,088	141,430	141,430	141,430	8,051
R-squared	0.502	0.507	0.507	0.793	0.340	0.375	0.375	0.958

The dependent variable is the $Log(Amount)_{i,b,t}$, which is the logarithm of the amount bought (in nominal value) by bank b of security i during quarter t, and zero otherwise, and column 4 and 8 report the results of the estimations conditional on buying a security. Columns 1 to 4 report the results for trading banks, and columns 5 to 8 for the other banks. 'Capital/TA$_{b,t-1}$' measures the book value of equity as a fraction of total assets (in %) for bank b in quarter $t-1$. The percentage price change of security i, 'Δprice$_{i,t-1}$', is demeaned by the sample mean and standardized using its standard deviation in the crisis sample. All regressions are estimated using ordinary least squares. Lagged, time-varying bank controls (Size, Capital/TA, Interbank borrowing/TA, Deposits/TA) are either included ('Y') or not included ('N'). Fixed effects are either included ('Y'), not included ('N'), or spanned by another set of effects ('-'). Robust standard errors clustered at bank level following Arellano (1987) are reported in parentheses. ***: Significant at 1 percent level; **: Significant at 5 percent level; *: Significant at 10 percent level.

Table 1.6: Buying behavior during the crisis across different types of securities

PANEL A: TRADING BANKS

	Trading banks					
	Aaa-rated	Aa to A rated	Bbb-rated and below	Up to 1 Year	1 to 5 Year	5 to 10 Year
	(1)	(2)	(3)	(4)	(5)	(6)
Capital/TA$_{b,t-1}$* Δprice$_{i,t-1}$	0.023	-0.085***	-0.062**	-0.037	-0.102***	-0.111***
	(0.038)	(0.032)	(0.030)	(0.045)	(0.028)	(0.032)
Security*Time FE	Y	Y	Y	Y	Y	Y
Bank*Time FE	Y	Y	Y	Y	Y	Y
Observations	29,037	25,791	23,860	17,615	52,182	21,603
R-squared	0.417	0.486	0.533	0.497	0.468	0.452

PANEL B: NON-TRADING BANKS

	Non-trading banks					
	Aaa-rated	Aa to A rated	Bbb-rated and below	Up to 1 Year	1 to 5 Year	5 to 10 Year
	(1)	(2)	(3)	(4)	(5)	(6)
Capital/TA$_{b,t-1}$* Δprice$_{i,t-1}$	-0.086*	-0.011	-0.001	-0.007	-0.010	-0.021
	(0.045)	(0.025)	(0.005)	(0.006)	(0.008)	(0.014)
Security*Time FE	Y	Y	Y	Y	Y	Y
Bank*Time FE	Y	Y	Y	Y	Y	Y
Observations	35,679	41,539	40,181	27,094	87,135	29,164
R-squared	0.516	0.456	0.490	0.530	0.415	0.516

The dependent variable is the $Log(Amount)_{i,b,t}$, which is the logarithm of the amount bought (in nominal value) by bank b of security i during quarter t, and zero otherwise. The splits are based on ratings and remaining residual maturity of the securities. Panel A shows the results for trading banks and Panel B for the other banks. 'Capital/TA$_{b,t-1}$' measures the book value of equity as a fraction of total assets (in %) for bank b in quarter $t-1$. The percentage price change of security i, 'Δprice$_{i,t-1}$', is demeaned by the sample mean and standardized using the standard deviation of the respective subset of securities in the crisis sample. All regressions are estimated using ordinary least squares. Lagged, time-varying bank controls (Size, Capital/TA, Interbank borrowing/TA, Deposits/TA) are either included ('Y') or not included ('N'). Fixed effects are either included ('Y'), not included ('N'), or spanned by another set of effects ('-'). Robust standard errors clustered at bank level following Arellano (1987) are reported in parentheses. ***: Significant at 1 percent level; **: Significant at 5 percent level; *: Significant at 10 percent level.

Table 1.7: Selling behavior during the crisis based on capital

	Dependent variable: Sells							
	Trading banks				Non-trading banks			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Capital/TA$_{b,t-1}$	0.011				0.013			
	(0.054)				(0.128)			
Capital/TA$_{b,t-1}$*Δprice$_{i,t-1}$	0.0002	-0.005	-0.003	0.008	-0.025**	-0.003	0.001	-0.024
	(0.026)	(0.033)	(0.033)	(0.018)	(0.010)	(0.009)	(0.008)	(0.054)
Cumulative gains/TA$_{b,i,t-1}$	0.054	-0.097	-0.227	-0.949	-0.248***	-0.171*	-0.221*	-2.391***
	(0.326)	(0.312)	(0.328)	(0.675)	(0.094)	(0.098)	(0.130)	(0.335)
Capital/TA$_{b,t-1}$*Cumulative			-0.136**	-0.027			-0.139	-0.419**
gains/TA$_{b,i,t-1}$			(0.064)	(0.312)			(0.119)	(0.171)
Bank controls	Y	-	-	-	Y	-	-	-
Security*Time fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
Bank fixed effects	Y	-	-	-	Y	-	-	-
Bank*Time fixed effects	N	Y	Y	Y	N	Y	Y	Y
Observations	96,033	96,033	96,033	30,877	146,708	146,708	146,708	13,781
R-squared	0.537	0.542	0.542	0.722	0.639	0.678	0.678	0.893

The dependent variable is the $Log(Amount)_{i,b,t}$, which is the logarithm of the amount sold (in nominal value) by bank b of security i during quarter t, and zero otherwise, and columns 4 and 8 report the results of the estimations conditional on selling a security. 'Capital/TA$_{b,t-1}$' measures the book value of equity as a fraction of total assets (in %) for bank b in quarter $t-1$. The percentage price change of security i, '*Δprice$_{i,t-1}$', is demeaned by the sample mean and standardized using its standard deviation in the crisis sample. All regressions are estimated using ordinary least squares. Lagged, time-varying bank controls (Size, Capital/TA, Interbank borrowing/TA, Deposits/TA) are either included ('Y') or not included ('N'). Fixed effects are either included ('Y'), not included ('N'), or spanned by another set of effects ('-'). Robust standard errors clustered at bank level following Arellano (1987) are reported in parentheses. ***: Significant at 1 percent level; **: Significant at 5 percent level; *: Significant at 10 percent level.

Table 1.8: Lending behavior during the crisis

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Trading bank$_b$	-0.050*	-0.061**	-0.058**	-0.058**				-0.022***
	(0.027)	(0.026)	(0.026)	(0.026)				(0.002)
Trading bank$_b$*Capital/TA$_{b,t-1}$		-0.014**	-0.014***	-0.014***	-0.017*	-0.018**	-0.017*	
		(0.006)	(0.005)	(0.005)	(0.009)	(0.007)	(0.010)	
Non-trading bank$_b$*Capital/TA$_{b,t-1}$		0.0041	0.0039	0.0039	0.0094	0.002	0.0094	
		(0.003)	(0.003)	(0.003)	(0.025)	(0.028)	(0.025)	
Trading bank$_b$*Future default$_{j,t}$							-0.0863	
							(0.070)	
Cumulative gains/TA$_{b,t-1}$				0.002	-0.005**	-0.003**	-0.005**	
				(0.003)	(0.002)	(0.001)	(0.002)	
Bank controls	N	N	Y	Y	Y	Y	Y	N
Borrower*Time fixed effects	Y	Y	Y	Y	Y	N	Y	N
Bank*Borrower fixed effects	N	N	N	N	Y	Y	Y	
Time fixed effects	-	-	-	-	-	Y	-	Y
Observations	502,243	502,243	502,243	501,786	501,786	501,786	501,786	228,547
R-squared	0.499	0.499	0.499	0.5	0.642	0.272	0.636	0.003

The dependent variable from columns 1 to 7 is *$\Delta Log(Credit)_{b,j,t}$, which is the change in the log of credit granted by bank b to firm j during quarter t, whereas in column 8, the dependent variable is the change in log of the total firm credit of firm j during quarter t by all banks. The independent variable for column 8 is the fraction of borrowing of a firm from banks with trading expertise before the crisis (2007:Q2). 'Trading bank' is a binary variable that equals the value of one when bank b has membership to the largest fixed income platform in Germany (Eurex Exchange), and zero otherwise. 'Non-trading banks' is a binary variable that equals the value of one when bank b does not have a direct Eurex Exchange membership and zero otherwise. 'Capital/TA$_{b,t-1}$' measures the book value of equity as a fraction of total assets (in %) for bank b in quarter $t-1$. All regressions are estimated using ordinary least squares. Lagged, time-varying bank controls (Size, Capital/TA, Interbank borrowing/TA, Deposits/TA) and fixed effects are either included ('Y'), not included ('N'), or spanned by another set of effects ('-'). Robust standard errors clustered at bank level following Arellano (1987) are reported in parentheses. ***: Significant at 1 percent level; **: Significant at 5 percent level; *: Significant at 10 percent level.

Table 1.9: Lending and Investment in the pre and post-crisis period

PANEL A: LENDING BEHAVIOR

	Pre-crisis			Post-crisis		
	(1)	(2)	(3)	(4)	(5)	(6)
Trading bank$_b$	-0.007			-0.007		
	(0.0066)			(0.005)		
Trading bank$_b$*	-0.001	0.014	0.012	-0.0001	-0.001	0.001
Capital/TA$_{b,t-1}$	(0.002)	(0.014)	(0.020)	(0.002)	(0.003)	(0.004)
Non-trading bank$_b$*	0.001	-0.016	-0.022	0.001	-0.0001	0.006
Capital/TA$_{b,t-1}$	(0.002)	(0.010)	(0.013)	(0.001)	(0.003)	(0.003)
Trading bank$_b$*			0.018			-0.004
Future Default$_{j,t}$			(0.039)			(0.021)
Cumulative Gains/TA$_{b,t-1}$	-0.795	-0.619	-0.933	0.273	-0.233	-0.002
	0.558	(1.559)	(1.930)	(0.191)	(0.355)	(0.004)
Bank controls	Y	Y	Y	Y	Y	Y
Borrower*Time fixed effects	Y	Y	Y	Y	Y	Y
Bank fixed effects	N	Y	N	N	Y	N
Observations	192,051	192,051	192,051	689,124	689,124	689,124
R-squared	0.546	0.548	0.673	0.533	0.535	0.613

PANEL B: INVESTMENT BEHAVIOR

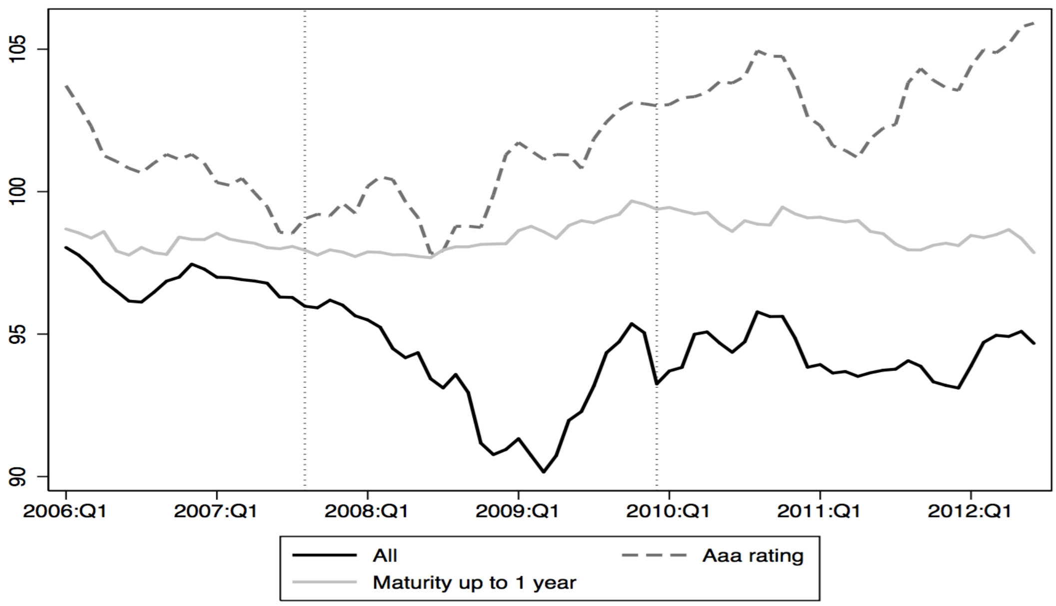
	Pre-crisis	Post-crisis
	(1)	(2)
Trading bank$_b$	-1.596	1.670
	(1.559)	(1.806)
Bank controls	Y	Y
Observations	502	501
R-squared	0.026	0.013

The dependent variable in Panel A is Δ $Log(Credit)_{b,j,t}$, which is the change in the log of credit granted by bank b to firm j during quarter t. In Panel B, the dependent variable is the change in Securities/Total Assets for each bank over the respective period. 'Trading bank' is a binary variable that equals the value of one when bank b has membership to the largest fixed income platform in Germany (Eurex Exchange), and zero otherwise, which proxies for banks with higher trading expertise. 'Non-trading banks' is a binary variable that equals the value of one when bank b has not a direct Eurex Exchange membership, and zero otherwise. 'Capital/TA$_{b,t-1}$' measures the book value of equity as a fraction of total assets (in $\%$) for bank b in quarter $t-1$. All regressions are estimated using ordinary least squares. Lagged, time-varying bank controls (Size, Capital/TA, Interbank borrowing/TA, Deposits/TA) and fixed effects are either included ('Y') or not included ('N'), or spanned by another set of effects ('-'). Robust standard errors clustered at bank level following Arellano (1987) are reported in parentheses. ***: Significant at 1 percent level; **: Significant at 5 percent level; *: Significant at 10 percent level.

Table 1.10: Definition of main independent variables

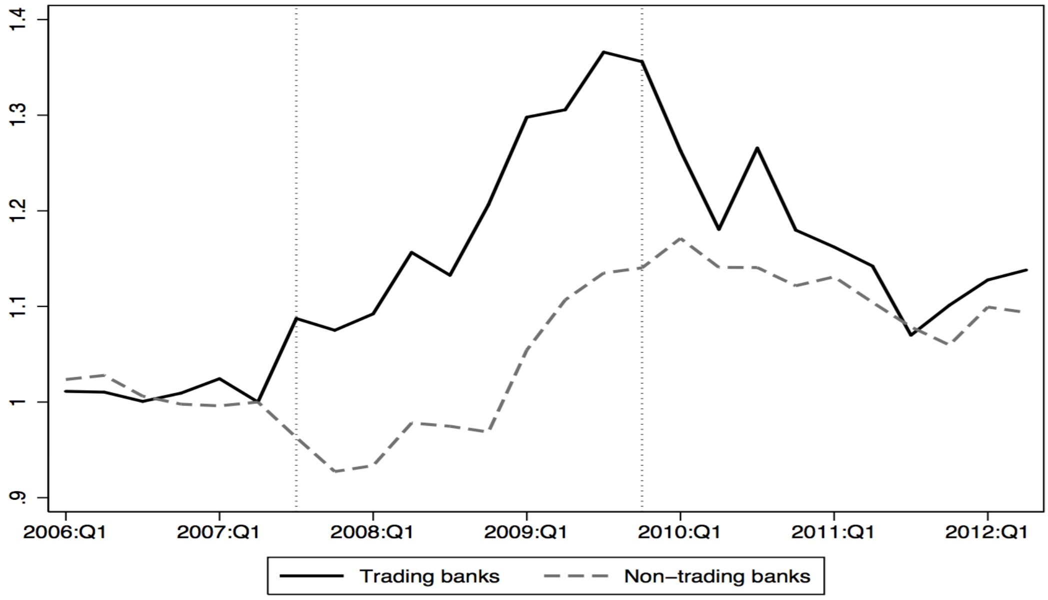
Variable name	Definition
Trading bank$_b$	Binary variable that equals the value of one when bank b has membership to the largest fixed income platform in Germany (Eurex Exchange), and zero otherwise.
Non-trading bank$_b$	Binary variable that equals the value of one when bank b does not have membership to the largest fixed income platform in Germany (Eurex Exchange), and zero otherwise.
$\Delta price_{i,t-1}$	Percentage price change of security i from $t-2$ to $t-1$.
Capital/TA$_{b,t-1}$	Measures the book value of equity as a fraction of total assets (in %) for bank b in quarter $t-1$.
Cumulative gains$_{b,i,t-1}$	Unrealized gains/losses (in EUR) as a fraction of total assets that a bank b generates with holding the security i in quarter $t-1$. We compute profits by multiplying the change of the market-to-book ratio of security i with the amount held (in nominal values) by bank b in quarter $t-1$. We further cumulate the profits of this security from the quarter, in which it has been purchased, until quarter $t-1$.
Cumulative gains$_{b,t-1}$	Unrealized gains/losses (in EUR) as a fraction of total assets that a bank generates from all its securities holdings on quarter $t-1$. We compute this by aggregating the cumulative gains for individual securities held by the bank (described above) at the bank level.
Future default$_{j,t}$	Binary variable that equals the value of one when borrower j defaults on its loan at any point in time during the lifetime of the credit contract after quarter t, and zero otherwise.
Rating$_{i,t}$	Rating of security i in quarter t, where rating equals a numeric scale of Moody's rating codes that range from category 'Aaa' through 'C'.
Maturity$_{i,t}$	Number of months remaining (residual maturity) from quarter t onwards until security i matures.

Figure 1.2: Security Prices



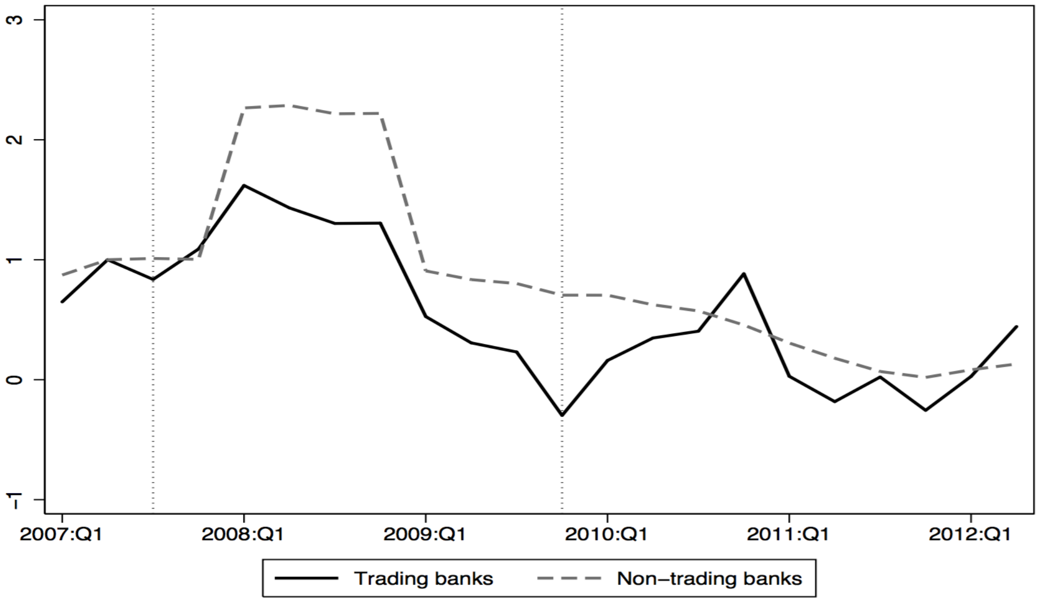
This figure depicts the monthly average price (equally weighted) of all securities in our sample (black solid line) for the period from 2006:Q1 through 2012:Q4. It also shows the average price of Aaa-rated securities (gray dashed line) and securities with remaining residual maturity below one year (gray solid line). The first vertical line refers to the start of financial crisis in 2007:Q3, and the second vertical line denotes 2009:Q4, the end of the crisis in Germany.

Figure 1.3: Security Holdings



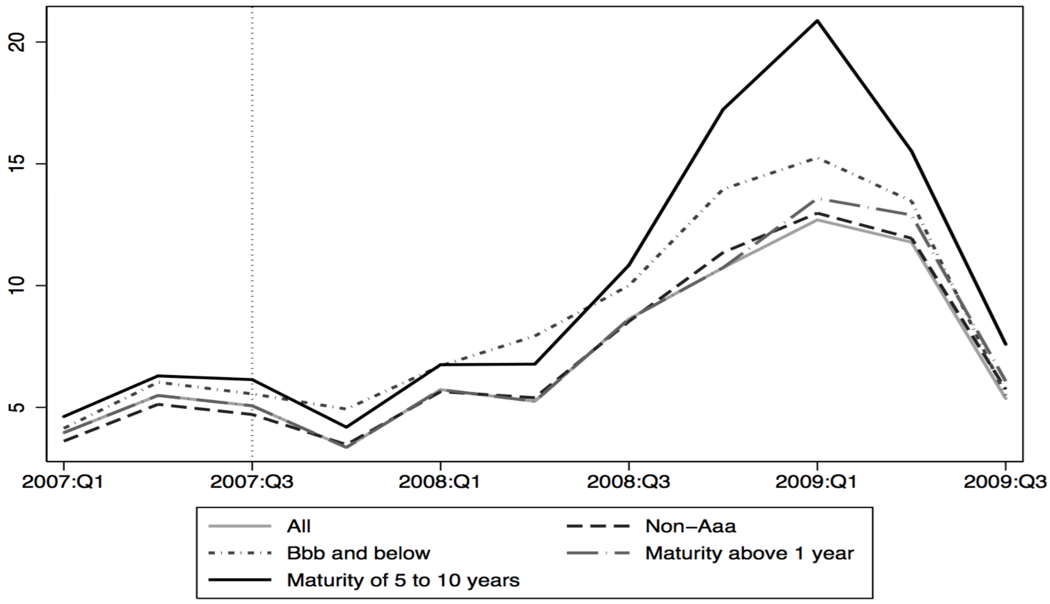
This figure presents the evolution of total security holdings as a fraction of total assets (normalized to 2007:Q2). The black solid line refers to 'Trading banks' and the gray dashed line represents 'Non-trading banks'. We classify a bank as a 'Trading bank' (higher trading expertise) when it has membership to the largest fixed income platform in Germany (Eurex Exchange). The first vertical line refers to the start of financial crisis in 2007:Q3, and the second vertical line denotes 2009:Q4, the end of the crisis in Germany.

Figure 1.4: Credit Growth



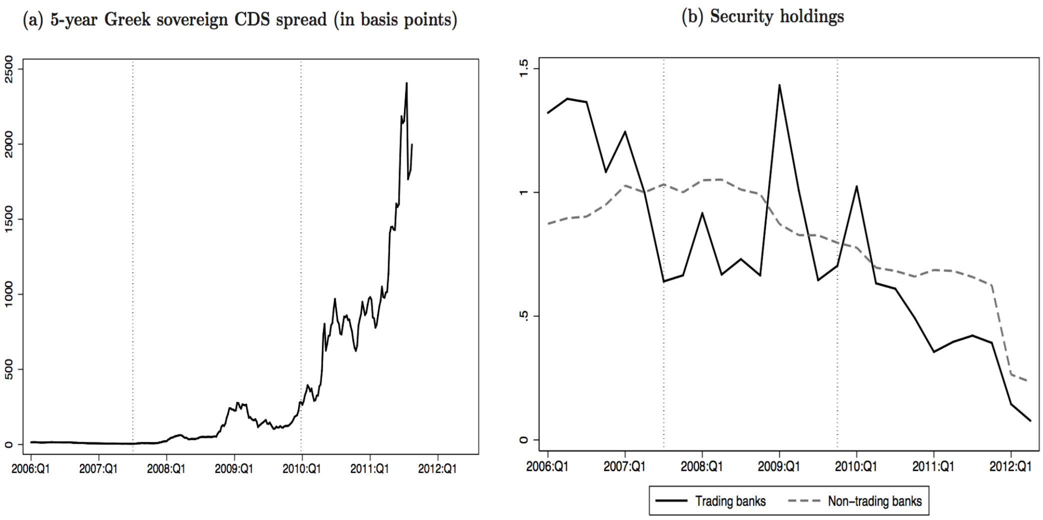
This figure shows the evolution of the annualized credit growth for borrowers (firms) across the sample period (normalized to 2007:Q2). The black solid line refers to 'Trading banks' and the gray dashed line represents 'Non-trading banks'. We classify a bank as a 'Trading bank' (higher trading expertise) when it has membership to the largest fixed income platform in Germany (Eurex Exchange). The first vertical line refers to the start of financial crisis in 2007:Q3, and the second vertical line denotes 2009:Q4, the end of the crisis in Germany.

Figure 1.5: Returns from Security Investments



This figure shows the average annualized returns from investments in securities that fell in price (in %). We compute returns by mimicking the investments of banks with (higher) trading expertise in securities that had a fall in price. We consider the buys of the securities that have fallen in price in the previous quarter and assume that banks hold these securities until 2009:Q4. The return for each security (at a point in time) equals the annualized percentage difference in price from that quarter in which it is purchased and 2009:Q4, plus the coupon of the security. The average is a simple average across all securities bought in a given quarter. We do this including securities that have different ratings and maturity. The vertical line refers to the start of the financial crisis in 2007:Q3.

Figure 1.6: Greek Government Bonds



Subfigure (a) shows the spreads (in basis points) of a 5-year Greek sovereign CDS. Subfigure (b) reflects the total notional amount of Greek sovereign bonds as a fraction of total assets for the period from 2006:Q1 through 2012:Q4 (normalized to 2007:Q2). The black solid line refers to 'Trading banks' and the gray dashed line represents 'Non-trading banks'. We classify a bank as a 'Trading bank' (higher trading expertise) when it has membership to the largest fixed income platform in Germany (Eurex Exchange). The first vertical line refers to the start of financial crisis in 2007:Q3, and the second vertical line denotes 2009:Q4, the end of the crisis in Germany..

Chapter 2

MACROPRUDENTIAL AND MONETARY POLICY: LOAN-LEVEL EVIDENCE FROM RESERVE REQUIREMENTS (JOINT WITH C. DASSATTI AND J.-L. PEYDRÓ)

2.1 Introduction

Past banking crises and also the recent global financial crisis have shown the importance of credit and monetary policy on both the aggregate economy and financial stability (Bernanke (1983); Reinhart and Rogoff (2009); Schularick and Taylor (2012)). Financial crises are preceded by bank credit booms that can be fuelled by foreign liquidity (Jorda, Schularick and Taylor (2013), Gourinchas and Obstfeld (2013)) and local domestic monetary policies through interest rates may be ineffective (Rey, 2013; Rajan (2014). Not surprisingly, many emerging countries are trying to use reserve requirements, often on non-insured non-deposit liabilities, which are very related to the new macroprudential policies that are discussed (Hanson, Kashyap, Stein, 2013) and also on liquidity requirements of Basel III. Moreover, the identification of the bank lending channel through reserve requirements (Bernanke and Blinder (1988 and 1992); Stein (1998) and Kashyap and Stein (2000)) have been elusive.

In this paper we analyze the impact of reserve requirements on the supply of credit to the real sector. Uruguay offers an excellent setup to study these effects for two main reasons: the policy changes introduced on reserve requirements on May 2008, and the exhaustive credit registry of all granted bank loans in the system. On May 2008 (binding on June), the monetary authority of Uruguay introduced changes in the regulation associated to the percentage of funds that banks must keep as reserves on the Central Bank: an increase in reserve requirements for short-term liabilities in both foreign and domestic currencies (10 and 8 percentage points respectively), an increase in the requirements for liabilities from the non-financial non-resident sector (5 pp), and the introduction of a reserve requirement for funds from foreign banks (35 pp). These changes were implemented under a context of economic growth and threats of inflationary pressures derived from the high prices of the most relevant commodities for the Uruguayan economy. The main motive behind the tightening was inflation and not financial stability. Moreover, we have access to the Credit Registry of the Central Bank of Uruguay, which is an exhaustive dataset of all the loans granted by each bank. This dataset is complemented with bank balance-sheet information from all the institutions that report to the Central Bank of Uruguay in its role as regulator and supervisor of the banking system.

To study the effects on credit availability, we first match each loan with the relevant bank balance-sheet variables and then aggregate all the different loans for each bank-firm pair in each month in order to construct a measure of total committed lending from January 2008 to December 2008. By focusing on firms' borrowing from multiple banks, we follow a difference-in-difference approach which compares lending to the same firm before (April, 2008) and after (July, 2008) the policy change among banks with different degrees of exposition to the sources of funds targeted by the policies (Jiménez, Ongena, Peydró, Saurina, 2013). This allows us to identify the effects of the new reserve requirements on the average supply of loans, both on the intensive and the extensive margins, and the heterogeneous effects of these changes among different firm and bank characteristics. In particular, on firms' heterogeneity, we analyze whether the impact is different from firms with different ex-ante risk, and on banks' heterogeneity, we analyze bank size, solvency and liquidity (Kashyap and Stein, 2000). Moreover, as we lose a significant number of firms imposing multiple banks loans, we also control for unobserved borrower fundamentals with industry fixed effects. Finally, we also analyze the period before (January to April 2008) and after (July to October 2008) to run a placebo test.

The results on the intensive margin of lending suggest that the tightening of requirements reduces the supply of credit to non-financial firms. Controlling for unobserved borrower fundamentals with the same industry, or even the same firm, we find that banks more affected by the policy cut more on credit volume. These effects are statistically and economically significant: a 10 percentage points increase on total reserve requirements translates into a cut in committed lending of 4 pp. Moreover, when we analyze the impact of the introduced policies across different firm and bank characteristics, we find that the cut in committed lending is lower for ex-ante riskier firms and that larger and more solvent banks are more capable of mitigating the effects of the policy. In addition, we find that the tightening of requirements has a positive effect on the likelihood of ending a lending relationship with a firm.

The loan-level results suggest that the increase in reserve requirements tightened the supply of bank credit. However, some firms could have mitigated the negative effects of the bank lending channel by resorting to loans from banks less affected by the policy changes. In order to address this, we analyze the change in committed lending by all banks to a given firm between July and April, 2008. The results from the firm-level analysis suggest that the loan-level results are binding at the firm-level, i.e. that firms with higher ex-ante credit from banks more affected by the policy obtain less overall bank credit ex-post. Finally, we do not find significant effects for the period before the policy (a placebo test run on January to April 2008), and for the period after (July to September 2008).

We mainly contribute to two strands of the literature. First, the bank lending channel of monetary policy through reserve requirements has been shown theoretically among others by Bernanke and Blinder (1988) and Stein (1998), however the empirical evidence has been analyzed with macro data (Bernanke and Blinder (1992)) and with bank level data (Kashyap and Stein (2000). As Khwaja and Mian (2008) among others show, loan-level data is needed to identify the supply of bank credit stemming from a bank shock. In this paper we identify the bank lending channel of monetary policy through reserve requirements with an exhaustive credit register (and the change in regulation).

Second, we contribute to the literature on macroprudential policy and capital controls. As argued by Rey (2013), domestic monetary policy through interest rates is problematic in emerging markets with capital inflows. Reserve requirements can therefore be useful for changing the stance of monetary policy, and, moreover, as reserve requirements can target differently distinctive bank liabilities, they can tighten even more short-term wholesale-uninsured foreign liabilities that may be more fragile in crisis times. This links monetary policy with macroprudential policies and policies on capital controls. Importantly, in Uruguay we find the strongest quantitative effects for the introduction of a reserve requirement for funds from foreign banks. Interestingly, the tightening of requirements cut credit supply for firms, but more affected banks reacted by concentrating more their credit supply to ex-ante riskier borrowers, probably to compensate for the reduction in bank profits stemming from the liquidity funds in the central bank at a penalized low rates.

We also contribute to the recent literature on the impact of reserve requirements on financial stability. There has been a renewed interest on this policy, mainly due to the search for new macroprudential tools (Tovar et al., 2012, Montoro and Moreno, 2011, Federico et al., 2014). While the previous papers study country-level evidence on the effectiveness of reserve requirements, our paper is, to our knowledge, the first one to identify the effect on credit by using disaggregated data on individual loans.

The rest of the paper proceeds as follows. Section 2 discusses the data and the policy change. Section 3 introduces the empirical strategy and presents the results. Section 4 concludes with a discussion on some implications for theory and policy.

2.2 Data and policy change

We have access to two datasets from the Central Bank of Uruguay in its role as banking regulator and supervisor. Both datasets cover the period from January 2008 to December 2008 and are available on a monthly frequency. The first dataset is the Credit Registry of the Central Bank of Uruguay (*"Central de Riesgos"*), which is an exhaustive record of all loans granted in the system with detailed information at the loan level. In particular, it contains information about the identity of the borrower, whether the borrower is a firm or a household, the country of residence, the economic sector to which it belongs, all the financial institutions with which it has a loan, the amount of the loan, the currency of the loan, its maturity, and the rating given by the bank to the firm. The rating given by the bank takes into account the current situation of the loan, and it can go from 1 to 5, being 5 the riskier rating. Moreover, banks provide information of whether the outstanding loan with a particular firm represents a substantial amount in terms of the firm and the bank balances (through a 'High Debt' dummy). On the other hand, we also have access to a dataset with balance sheet information for all the banks operating in the system during the period 2007-2008.

We focus on loans granted to non-financial private firms, making a total of 46.595 firms and 19 financial institutions for the total sample (years 2007 and 2008). Given that we focus only on loans granted to firms, this dataset is comprehensive, since the monthly reporting threshold is of approximately USD 1.500. The sample includes one public bank, 12 private commercial banks and 6 non-bank financial institutions. There is another public bank in the Uruguayan banking system, but it has been excluded from the sample since its main line of business are mortgages to households (while our focus is on loans granted to private firms) and it has experienced several restructures and recapitalizations.

During this period there were changes in the structure of the market. In particular, there was a fusion between two banks present in the Uruguayan banking system, and an acquisition of one bank by a foreign bank (not present in the country until that moment). Both cases were treated as if they were present from the beginning of the period (in order to avoid loosing the observations associated to the banks that disappeared), which means that the number of banks under analysis is 18.

Reserve requirements

Uruguayan prudential banking regulation dates back at least to 1865, when a type of capital requirement was introduced. In the following decades, some other forms of regulation, including reserve requirements, were introduced as well. Nevertheless, the big piece of banking legislation, called the "General Banking Law", was passed in 1938 to pursue the financial stability and safety of the banking system through three pillars: the requirement of a minimum level of capital, a minimum requirement for the relationship between capital and reserves, and a liquidity requirement. The minimum reserve requirement was set to 16% for deposits with a maturity of less than 30 days and 8% for deposits of higher maturities. Reserve requirements had to be constituted with gold, bills, public bonds and sight deposits in the National Bank, while the deposits that surpassed the limit of eight times the capital and reserve fund of the bank had to be fully backed with liquid reserves (such as public bonds, treasury bonds or current account deposits in the National Bank).

The later regulation on reserve requirements continued adapting the instrument to the reality of the financial system in each period. As a result, the current reserve requirements vary according to both maturity and currency of the liabilities in order to contemplate the dollarization of the Uruguayan financial system and the diverse stability that deposits of different maturities display. Moreover, additional requirements such as marginal reserve requirements were temporarily introduced.

Policy change

Although the negative impact of the financial crisis in 2008 led to a downwards revision of the projections about the performance of the developed economies, the growth figures for the emerging economies remained solid. Instead, the main concern for these economies were the inflationary pressures originated mainly by the higher prices of the commodities, context to which Uruguay was no stranger: the accumulated inflation rate for the year 2007 reached 8.50%. Under these conditions, the Uruguayan monetary authority introduced changes in the regulation of reserve requirements in order to reduce the amount of money in circulation.

We focus on the effects of the increase in the reserve requirements introduced in Uruguay on June 2008 but announced one month earlier, the 6th May 2008. It can be summarized in three main changes: an increase in the reserve requirements for short-term liabilities from residents, an increase in the reserve requirements for liabilities from non-residents, and the introduction of a reserve requirement for funds from foreign banks. In particular, reserve requirements for (short-term) liabilities from residents increased from 17% to 25% if they are denominated in local currency (pesos), while they increased form 25% to 35% for liabilities denominated in foreign currency (mainly dollars and Argentinean pesos). Liabilities from non-residents had an increase of reserve requirements from 30% to 35%. More importantly, before the reform liabilities from other banks were not subject to a reserve requirement. After the reform, liabilities from foreign banks were subject to a reserve requirement of 35%. [1] Hence, the different degrees of exposition of banks to these three sources of funding determines the intensity of the impact of the policy changes.

Reserve requirements in Uruguay have to be constituted of cash and deposits at the central bank. This change in reserve requirements was the first one since the beginning of 2004, as Uruguay did not actively used this policy tool until that moment (Federico et al., 2014). Moreover, as the requirements vary by maturity and currency, and are applied to all types of liabilities,[2] this policy is very related to the new liquidity standards proposed in Basel III, especially the "Liquidity Coverage Ratio".[3]

[1] The changes where introduced through the following acts of the Central Bank of Uruguay: "Circular 1991", "Circular 1992".

[2] Except borrowings from other resident banks.

[3] The two standards have also some important differences: for instance, retail demand deposits are considered to be more stable than wholesale deposits in the LCR, while borrowings from other domestic banks are not subject to reserve requirements in Uruguay.

The reason for the increase in reserve requirements was an inability to control inflation by using the policy rate alone in a dual-currency economy. The target inflation rate was 5%, the monetary policy rate was 7.25%, and the actual inflation rate had been fluctuating around 8% during the last year. The policy rate had been increased from 5% to 7% in October 2007 and then raised again 25 basis points one month later. As mentioned before, inflation remained well above the objective.

We build our policy variable of interest taking into account the change in the reserve requirements for local and foreign currency deposits, deposits from foreign non-financial sector and deposits from foreign financial sector. We hence multiply the increase in reserve requirements by each source of funding: 8% for short-term liabilities in local currency from residents, 10% for short-term liabilities in foreign currency from residents, 5% for liabilities from non-financial non-residents,[4] and 35% for liabilities from non-resident banks. We add the four increases and divide them by total liabilities to construct our dependent variable:

$$RR_{b,t-1} = \frac{TotalAdditionalReserveRequirements_{b,t-1}}{TotalLiabilities_{b,t-1}}$$

We use the actual change in reserve requirement -instead of a measure taking into account the actual reserves of the banks- for several reasons. The actual amount of reserves is an endogenous decision that takes into account the requirement[5]. Since the cost of breaching the minimum is substantial -from a reputational and potential supervisory intervention perspective-, banks target buffers rather than actual reserves. Related to this issue, we cannot observe the motivation behind the amount of deposits in the central bank that each bank has, and hence we cannot infer how much the bank will adjust by observing the actual reserves. Nevertheless, as explained in the next paragraph, we do control for the amount of term deposits at the central bank.

Until June 2008, term deposits at the central bank that were kept to satisfy the reserve requirements were remunerated. However, this remuneration changed to 0 after the policy change. Therefore, banks suffered another policy shock at the same time. Although both shocks need not be related -one refers to the increase in reserve requirements and the other to the mix of demand and term deposits at the central bank to satisfy them-, we control for this change as well. Since only term deposits at the central bank were remunerated, those banks with a higher proportion of term deposits (with respect to the reserve requirements) suffered a stronger

[4] At that time, there were also a requirement to this type of liabilities of 30%.

[5] As in Martinez-Miera and Suarez (2012) with capital requirements

drop in interest income. Therefore, we construct the following variable for each bank to control for this effect: $Remuneration_b \equiv \frac{TermdepositsatCB_{b,t-1}}{TotalReserveRequirements_{b,t-1}}$.

Summary statistics

Dependent variable The dependent variable of interest is the change in credit to firms during the reform. In particular, we use the change in (the log of) credit committed by bank b to firm i between April and July 2008. In other words:

$$\Delta logL_{bf,t+1} = logL_{bf,t+1} - logL_{bf,t-1}$$

where

$$logL_{bf,t-1} = log(Loan_{bt,t-1})$$

We remove the 1st and 99th percentiles to reduce the noise of extreme observations. Summary statistics for this variable as well as for the policy variables and the bank controls that we use (Size, Solvency Ratio, Liquidity Ratio, and Foreign Assets) can be seen in Table 2.1. The average impact of the increase in reserve requirements is 7.5% of total liabilities, which indicates the importance of this policy change.

2.3 Empirical Strategy and Results

We test different empirical models throughout this section, but we highlight here the basis of the estimations. We estimate the following model:

$$\Delta logL_{bf,t+1} = \beta RR_{b,t-1} + \alpha_f + \theta Y_{b,t-1} + \epsilon_{bf} \tag{2.1}$$

As explained before, the change in (the log of) committed credit from bank b to borrower f during the second quarter of 2008 is the dependent variable.

Following a difference-in-difference approach, we compare lending for the same firm before (April, 2008) and after (July, 2008) the policy change among banks that are more and less affected by the changes in the reserve requirements. One key aspect of the identification strategy is the focus on firms with more than one bank relationship; by analyzing the change in committed lending for the same firm, we can check if the firm experiences a higher drop in lending with the bank that is more exposed to the policy change. In addition, we analyze whether the effects of the policy changes were different across different firm and bank characteristics. That is, we want to check if the policy changes had effects, not only on the average supply of loans, but on the risk-taking behavior of banks.

2.3.1 Intensive margin

Before introducing borrower fixed effects, however, we start the empirical analysis by estimating the following model, controlling for credit demand by using observable firm characteristics only:

$$\Delta logL_{bf,t+1} = \beta RR_{b,t-1} + \eta X_{f,t-1} + \theta Y_{b,t-1} + \epsilon_{bf} \quad (2.2)$$

Where $logL_{bf,t+1}$ is the change in committed credit from bank b to borrower f between April and July 2008. The coefficient of interest is β, which corresponds to the policy variable, $RR_{b,t-1}$. $X_{f,t-1}$ are firm characteristics (in April 2008), which include industry dummies, the credit rating set by the bank, and information about the level of indebtedness of the firm. $Y_{b,t-1}$ includes bank-level characteristics, such as size, solvency, liquidity, and the amount of deposits affected by the change in reserves remuneration.

The results can be seen in Table 2.2. Column 1 includes only firm-level controls and the policy shock variable. The coefficient on the policy variable is negative and significant, meaning that a higher impact of the reserve requirement reform is associated to a higher drop in credit. The coefficient almost doubles in Column 2, where we include the mentioned bank-level variables. Since there were moments of important financial global turmoil during this period -the rescue of Bear Stearns occurred in March, two months before announcing the change in reserve requirements- we include in Column 3 the variable $ForeignAssets$ to control for the amount of foreign investment made by banks. The coefficient of interest remains negative and significant, even more than before. In terms of economic significance, the coefficient in column 3, -0.552, implies that an increase of reserve requirements equal to 10% of the total liabilities (the average is 7.5%) is associated to a higher decrease of credit by 5.5 percentage points. The results are robust to including a dummy for branches and removing the public bank.

As the dependent variable is the percentage change of credit, one concern is that the results could be driven by firms with very little credit. Moreover, from the macroprudential point of view, bigger firms might be more important to understand how to dampen the credit cycle. Hence, we repeat the same regressions in columns 4, 5 to 6 restricting the sample to firms borrowing more than $60,000. This threshold leaves less than 10% of borrowers out of the sample. The coefficients for the policy variable decrease slightly but are not significantly different from the ones in columns 1-3.

The coefficients for Ratings 3 and 4 are negative and significant in all regressions.[6] This suggests that when the rating set up by one bank to a particular firm is 3 or 4 -which are worse ratings than Rating 1-, the credit to this firm is more likely to decrease. Nevertheless, this is not the case for the worst rating, Rating 5: when looking at all loans, banks are more likely to increase the lending to these firms.

In terms of bank controls, bigger banks tend to increase lending more than smaller banks, while more solvent banks do exactly the opposite. A higher ratio of liquid assets over total assets is also associated to more credit. Finally, those banks more affected by the end of remuneration of term deposits satisfying the reserve requirements also decrease lending by more, reinforcing the 'negative' effect of the reform on credit.

Even when controlling for firm characteristics, the concern remains that, firms borrowing from banks more affected by the policy shock are fundamentally different than firms borrowing from less affected ones, and hence the coefficient could be driven, in the previous specification, by credit demand rather than credit supply. As discussed before, we make use of firm fixed effects to compare the evolution of committed credit to the same firm between April and July 2008, in order to remove the potential demand bias. In particular, we estimate the following model:

$$\Delta log L_{bf,t+1} = \beta RR_{b,t-1} + \alpha_f + \theta Y_{b,t-1} + \epsilon_{bf} \tag{2.3}$$

Where α_f is a dummy variable equal to 1 if the borrower is firm f, 0 otherwise. Note that this specification restricts the sample to those firms borrowing from two or more banks.[7] This happens because the fixed effect fully explains the dependent variable if there is only one observation for a particular borrower. For this reason, in Columns 1 and 2 in Table 2.3 we repeat the previous specification (without and with bank controls) using only firms borrowing from two or more banks. This is done to remove sample bias concerns and show the result of introducing firm fixed effects in the coefficients. Columns 3 and 4 estimate model 2.3. The only difference with columns 1 and 2 is the change of firm variables for firm fixed effects. The coefficient in column 4 is -0.490. Economically, this result indicates that a one standard deviation increase in reserve requirements translates into a one percentage point decrease in committed credit. To compare it with the actual change in credit, the mean change in credit in this period was a 1.77% decrease.

Interestingly, the introduction of firm fixed effects makes the rest of the bank con-

[6] Except for the coefficient of the Rating 4 dummy in column 1.

[7] To be precise, it restricts the sample to firms borrowing from two or more banks and that had a different change in committed credit.

trols lose their significance (also the impact of the end of remuneration, although the coefficient is always negative), which reinforces the importance of the policy change for credit supply.

As previously discussed, the variables regarding borrower credit rating and indebtedness are set by each bank individually. This implies that two banks can set different credit ratings and indebtedness for the same borrower at the same time, since these variables reflect their own exposure to it.[8] Therefore, two banks could behave differently with the same firm just because the initial conditions with the borrower are different. Hence, we also include these variables in columns 5 and 6 in order to further control for observed bank-firm heterogeneity.

The coefficients of our variable of interest barely changes. We observe, however, that after controlling for firm fixed effects, worse-rated borrowers (as well as those with a high debt with the bank) experience a bigger reduction in lending than other borrowers.

Another potential concern is the fact that the policy shock is not random, since the funding structure of each bank is an the result of an optimization problem. Even after controlling for borrower characteristics, there could be some unobserved bank heterogeneity (correlated with the impact of the change in reserve requirements) that biased the results. In order to alleviate these concerns, we run a 'placebo' test consisting in estimating the same model as if the change in regulation would have occurred in two other moments:[9] January 2008 and July 2008. In the first case (looking at the change in credit from January to April 2008) we find that the coefficient on the policy change is -0.10 with a p-value above 50%, while in the second case (change in credit from July to October 2008) the coefficient equals -0.02, with a p-value above 90%.

Summing up, we have shown that, across different samples and excluding and including firm fixed effects, banks that suffer a higher reserve requirements increase lend less to firms. The economic significance of this decrease is important: a 10 percentage points increase in reserve requirements imply a 4-5 percentage points lower credit change.

The most important -and possibly unexpected- part of the reform is the introduction of reserve requirements of 35% to all foreign bank funding. In fact, the first

[8]This situation -two banks assigning a different rating to the same firm- happens for almost half of the firms.

[9]A counterfactual 'experiment'.

announcement made the 6th of May 2008 ('Circular 1991') continued to exclude foreign bank funding from the requirements, and it was not until ten days later when the Central Bank of Uruguay amended this part by including also foreign bank funding ('Circular 1992').[10] Moreover, it is precisely this part of the requirement that is of most interest to combat the potential adverse effects of using the policy rate. For these reasons we replicate Table 2.3 by using the impact of the change in reserve requirements on foreign banks funding as the policy variable. The results can be found in Table 2.4.

The coefficients mimic the ones obtained in Table 2.3. Therefore, the negative effect from the increase in reserve requirements is driven precisely by the part of the increase that refers to foreign banks funding. This has strong implications from a macro-prudential perspective, which we discuss in the final section.

Heterogenous Effects

Once we have analyzed the average effects of the policy changes, we look at whether these results differ across different firm and bank characteristics. In order to do so, we start by estimating the following model:

$$\Delta logL_{bf,t+1} = \beta RR_{b,t-1} + \gamma RR_{b,t-1}X_{f,t-1} + \alpha_f + \theta Y_{b,t-1} + \epsilon_{bf} \quad (2.4)$$

Where now we have two coefficient of interest: β -as before- and γ, the coefficient of the interaction between the policy change and firm characteristics; in other words, we want to know whether the reduction in credit supply driven by the increase in reserve requirements depends also on the riskiness and the debt of the borrower. Several banking models (Cordella et al., 2014) suggest that increases in funding costs by banks may cause a risk-shifting behavior. If that is the case, then the effect of the policy change would be less important -or even positive- for riskier borrowers.

We present the results from estimating model 2.4 in Table 2.5, columns 1 to 3. Column 1 presents model 4 without firm fixed effects, but with industry dummies and risk and debt information. Column 2 incorporates firm fixed effects. Column 3 incorporates also all the interactions between the bank controls and the risk and debt variables, to allow for this heterogeneity to be present for other bank variables.

The coefficient for our policy variable, β, remains negative but increases in absolute value. This can be interpreted as follows: it is the effect of the policy

[10]The other amendment in 'Circular 1992' referred to the maturity of the liabilities from non-residents subject to the requirement, which went from below 181 days to include all of them.

change for firms with low risk (the first credit rating category, which is the omitted rating dummy) and low debt with the bank. Consistent with the mentioned theoretical models, we find that banks reduce credit less to the riskiest borrowers (those with rating in the fifth category). In fact, in all the three regressions the effect of the policy change for the riskiest firms is not significant (i.e., the sum between β and γ). Another potential explanation would be that banks do not want to reduce lending to the most risky firms because of a potential complete default; however, this argument is inconsistent with the results found in Table 2.3, column 6, which shows that banks indeed reduce, on average, credit more on riskier firms.

Since the coefficient of interest γ is associated to the interaction between bank and firm characteristics (i.e., a bank-firm dimension), we can further saturate the specification by using bank fixed effects. This is what we do in columns 4 and 5, which replicate columns 2 and 3 adding bank fixed effects. Therefore, we control for any firm and bank heterogeneity. The results remain consistent: more affected banks reduce credit supply less to firms with the highest risk.[11]

Our next step is to understand how bank characteristics can influence the effect of reserve requirements on credit. Our hypothesis is that some bank characteristics may alleviate the negative impact of reserve requirements on credit shown in Tables 2.2, 2.3, and 2.5. In particular, bigger banks might be able to accommodate the increase in reserve requirements by shifting more easily to cheaper sources of financing. Moreover, more solvent banks might be less reacting since they can obtain longer-term funding at a cheaper price than less solvent banks. Finally, banks that have a higher proportion of liquid assets could actually increase reserves by selling some of those liquid assets rather than reducing credit.

In order to test our hypotheses, we construct several dummies to identify the top banks in the previous variables. We create a dummy to identify those banks above the 75th percentile in terms of size in April 2008.[12] For solvency and liquidity, we choose the median in April 2008 as our threshold: the dummies equal 1 for banks above the median in terms of the solvency ratio and the liquid assets ratio, respectively.

[11] We run also a triple interaction between RR, $Solvency$ and $Risk5$, to understand whether the differentiated effect for riskier borrowers is reduced for more solvent banks (i.e., banks with lower agency problems); although the coefficient of the triple interaction is negative -and big-, in line with this intuition, it is not significant.

[12] We choose the 75th percentile because the distribution of banks' assets is very skewed to the right, and choosing a different threshold (the median, for instance) would imply that almost all observations in the credit register belong to banks labeled as 'big'.

Therefore, the model that we estimate is the following:

$$\Delta logL_{bf,t+1} = \beta RR_{b,t-1} + \delta RR_{b,t-1}Z_{b,t-1} + \gamma Z_{b,t-1} + \alpha_f + \theta Y_{b,t-1} + \epsilon_{bf} \quad (2.5)$$

where $Z_{b,t-1}$ is the corresponding dummy for bigger, more solvent, or more liquid banks.

The results can be seen in Table 2.6.[13] Column 1 shows that bigger banks are able to diminish the impact of reserve requirements on credit: for a given level of reserve requirements increase, bigger banks increase credit supply by more (or decrease it by less) than smaller banks do. We introduce the actual size, solvency, and liquidity variables in Column 2, but this does not change the result. In Columns 3 and 4 we repeat the same exercise with the solvency ratio, obtaining very similar results: better capitalized banks reduce lending by less relative to worse capitalized banks. While these results have important implications for the effectiveness of reserve requirements, we postpone the discussion for the last section. We do not observe this differentiated behavior for more liquid banks (Columns 5 and 6).[14]

2.3.2 Extensive Margin

So far we have focused on lending relations between banks and borrowers that have continued from April to July 2008. However, a potential effect of a credit supply reduction is the end of some loan relations. Therefore, we extend our analysis to understand whether higher reserve requirements can make a lending relationship less likely to continue. We estimate a regression very similar to model 2.3:

$$DEnd_{bf,t+1} = \beta RR_{b,t-1} + \delta RR_{b,t-1}C_{bf,t-1} + \gamma C_{bf,t-1} + \alpha_f + \theta Y_{b,t-1} + \epsilon_{bf} \quad (2.6)$$

where $DEnd_{bf,t+1}$ is a dummy variable that equals 1 if an existing loan relationship in April 2008 has disappeared in July 2008, and 0 otherwise. We introduce a new control variable, $C_{bf,t-1}$, which controls for the size of the loan in April 2008, since this could be related to the probability of ending a loan relation.[15]

[13] All regressions include the variable Remuneration$_b$ as well as its corresponding interaction, to make sure that we are capturing the differentiated impact of reserve requirements.

[14] Given the turmoil in the international financial markets at that time, we also study whether the reserve requirements have a different impact on credit if the bank is a branch, but we do not observe any significant difference.

[15] On one hand, higher credit outstanding could be associated to a lower probability of terminating the loan; nevertheless, bigger firms could also switch banks more easily, so the direction is not clear.

We use two different variables to control for this: the logarithm of the total credit outstanding in April, and the amount of credit over total assets, to normalize the measure.

The results can be seen in Table 2.7. Columns 1 and 2 do not include firm fixed effects: the results suggest that a higher impact of the reserve requirements reform is associated with a higher probability of ending a loan relationship. In column 2 we introduce the logarithm of the outstanding credit, which is positively related to loan termination. The interaction between the size of the loan and the policy variable is not significant, although is negative in all specifications, which would imply that banks more affected by the policy change are less likely to terminate a loan relationship if the outstanding loan is high. We introduce firm fixed effects in columns 3 to 6, but the results for the policy variable are the same: positive and significant. In column 4 we interact the rest of the bank controls with the size of the outstanding loan. In columns 5 and 6, we do the same with the $Credit/TA$ as control. In all cases, the results suggest that a 10 percentage points increase in the policy variable is associated to 2.5-4 percentage points higher probability of terminating a loan relationship. Put it differently, an average increase in reserve requirements is associated to a 1.9-3 percentage points higher probability of loan termination. This number needs to be compared with the actual probability of loan termination, which is slightly below 9%.[16] Hence, the impact of higher reserve requirements on the probability of ending the loan relation is both statistically and economically significant.

2.3.3 Firm-Level Analysis

Even if credit supply decreases, firms may be able to substitute it by going to another bank. They could also obtain other forms of financing, but in the case of Uruguay, with less developed capital markets, this possibility is less likely. We then study whether firms borrowing from banks more affected by the reform are able to obtain bank credit from another institution. In order to do so, we study how lending from all banks has evolved at firm level; i.e., we study the following variable: $\Delta logL_{f,t+1} = logL_{f,t+1} - logL_{f,t-1}$.

We transform the original bank-level variables, including the policy change, into firm-level variables. We do so by computing a weighted average of those variables for each firm, where the weights is determined by the proportion of credit

[16]This can be easily computed by looking at the different number of observations in columns 3-4 and in previous tables: there were 10,656 lending relationships in April 2008 (for firms borrowing from two or more banks), of which only 9,700 remained in July.

obtained from each bank in April 2008. Therefore, the variable of interest is:

$$RR_f = \sum_b \frac{L_{bf}}{L_f} RR_b$$

We estimate a very similar model with all variables at firm-level, although we cannot introduce borrower fixed effects. The results are shown in Table 2.8. Columns 1 and 2 show the results for the April-July 2008 period. The policy shock is negative and significantly related to the change in total bank credit for firms: borrowers that are borrowing from more affected banks are not able to fully substitute the decrease in credit supply that they suffer. This result does not change even if we restrict the analysis to firms borrowing at least \$60,000. An average increase in reserve requirements is associated with a decrease of total credit for a firm borrowing from this bank of 2 percentage points.

Since we cannot control for firm fixed effects, it could be the case that firms borrowing from more affected banks are fundamentally different from the other firms, and this difference is driving the result. To alleviate these concerns, we estimate the same specifications for the period of January to April (columns 3 and 4) and the period of July to October 2008 (columns 5 and 6). These placebo tests show that firms borrowing from more affected banks do not have a differential total bank credit evolution during the period before the policy change and the period after. In other words, the increase in reserve requirements caused firms borrowing from more affected banks to suffer a bigger reduction in total bank credit. Therefore, the reduction in credit supply was binding at firm-level.

2.3.4 Pricing analysis - loan rates

We further analyze whether the increase in reserve requirements is associated to increases in loan rates. As noted above, we do not have data on actual rates from the credit register. We obtain aggregated data on the average loan rates that individual banks apply to three different sectors (agriculture, industry, and services). We estimate the following model:

$$\Delta RL_{b,i,t} = \beta_1 RR_{b,t-1} + \gamma_i + \pi_{pol} + \theta_1 Y_{b,t-1} + \epsilon_{bi} \tag{2.7}$$

Where $\Delta RL_{b,i,t}$ is the three-month change of loan rates applied by bank b to industry i in local currency. Our coefficient of interest is, as before, β_1. We introduce industry dummies. Note that we only have 34 observations, since loan rates for some banks are missing.

Results are displayed in Table 2.9. β_1 is positive throughout the specifications, but it is never statistically significant.

2.4 Conclusions

Although the use of reserve requirements as macroprudential tools has been very popular in Latin American economies, there is little evidence about the impact of these policies. In this paper, we study the role of reserve requirements as macroprudential tools. In particular, we analyze the effects of the increase in the reserve requirements for different sources of funding on the average supply of credit and on the risk-taking behavior of banks.

Uruguay offers an excellent setting to study these effects given the changes introduced in the regulation regarding reserve requirements in June 2008 and the comprehensive datasets we have access to. We use a difference-in-difference approach comparing lending before and after the introduction of the policy changes among banks with different degrees of exposition to the funds targeted by the policies.

The results on the intensive margin suggest that the main assumptions of the bank lending channel of monetary policy hold: Modigliani and Miller propositions are not satisfied for banks. In particular, increases in reserve requirements for different sources of funding (short-term funding from residents, funds from the foreign non-financial sector and funds from foreign banks) have an impact on non-financial firms through changes in banks' lending behavior. That is, restrictions to short-term funding imply a reduction on the supply of loans. In addition, we find that more affected banks increase their exposure to riskier firms while larger and more solvent banks are more capable of mitigating the effects of the lending channel.

These policies may also have real costs for corporate firms. When we analyze the effects of the higher reserve requirements at the firm level, we find that, on average, firms were not able to insulate from the negative impact of the policy changes. This is a relevant conclusion for an economy like Uruguay, where the development of the capital market is in a very early stage and, as a consequence, bank financing plays a key role in the investment decisions of firms.

The results of this study entail policy implications for macroprudential regulation. Although restrictions to short-term funding by banks may contribute to prevent threats that can later translate into risk propagation among the banking system, the strong reliance of banks on these type of funds plays an important role on the lending behavior of these institutions. As a consequence, the new liquidity standards proposed by Basel III, which are similar to the reserve requirements in Uruguay, may have a cost in terms of credit availability, as suggested by Diamond and Rajan (2001) and Calomiris and Kahn (1991).

Nevertheless, we have shown the effectiveness of reserve requirements as a macro-prudential tool to dampen the credit cycle, especially for the part coming from the global credit cycle. While our results show clearly that reserve requirements are effective on average, they also raise three main issues. First, banks shift credit towards riskier firms: this raises concerns regarding the potential thread to financial stability that this shift represents. From the point of view of a macro-prudential regulator, a careful calibration would be necessary to make sure that the benefits of a decrease in credit growth are higher than the costs in terms higher risk-taking. The second concern is the fact that big banks are able to compensate the impact of reserve requirements: since those are typically the banks that provide more credit to the real sector, the effectiveness of reserve requirements to control the credit cycle could be lower than suggested by our results. Finally, the fact that more solvent banks are also able to mitigate the effects of the policy change points towards the need of understanding the interaction among different policy tools, in this case between reserve and capital requirements.

2.5 Tables and Figures

Table 2.1: Summary statistics

PANEL A: DEPENDENT VARIABLE						
	Mean	Std.	P25	Median	P75	Obs.
$\Delta log L_{bf,t+1}$	-0.0177	0.3493	-0.1087	-0.0005	0.0215	32,004
Credit$_{bf}$ April 08	12,100	90,393	401	922	2,740	35,596
Credit$_{bf}$ July 08	12,339	91,044	416	953	2805	36,143

PANEL B: BANK VARIABLES IN APRIL 2008						
	Mean	Std.	P25	Median	P75	Obs.
RR$_b$	0.075	0.023	0.059	0.07	0.08	18
Size$_b$	3.597	1.339	2.665	3.503	4.034	18
Solvency ratio$_b$	0.298	0.249	0.118	0.191	0.405	18
Liquidity ratio$_b$ (%)	18.13	12.17	10.45	13.58	24.43	18
Foreign assets$_b$ (%)	35.36	18.65	21.77	29.30	49.70	18

This table reports the summary statistics of the variables used in the paper. $\Delta log L_{bf,t+1}$ is the difference in the logarithm of credit received by borrower f from bank b between April and July 2008. Credit$_{bf}$ is the total credit received by borrower b from bank b, expressed in $ thousands. RR$_b$ is the increase in reserve requirements for bank b over total liabilities. Size$_b$is the logarithm of total assets of bank b. Solvency ratio$_b$ is the regulatory capital over risk-weighted assets held by bank b. Liquidity ratio$_b$ is the ratio of liquid assets over total assets of bank b. Foreign assets$_b$ is the ratio of assets held outside Uruguay over total assets for bank b. All bank-level variables are computed in their April 2008 value.

Table 2.2: Impact of Reserve Requirements on Credit

	(1)	(2)	(3)	(4)	(5)	(6)
RR_b	-0.251**	-0.443***	-0.552***	-0.215**	-0.392***	-0.505***
	(0.102)	(0.088)	(0.109)	(0.089)	(0.088)	(0.113)
$Rating2_{bf}$	0.006	0.005	0.005	-0.000	-0.001	-0.002
	(0.007)	(0.006)	(0.006)	(0.007)	(0.006)	(0.006)
$Rating3_{bf}$	-0.031***	-0.030***	-0.030***	-0.035***	-0.034***	-0.034***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
$Rating4_{bf}$	-0.014	-0.021**	-0.021**	-0.032***	-0.038***	-0.038***
	(0.010)	(0.009)	(0.009)	(0.010)	(0.010)	(0.010)
$Rating5_{bf}$	0.022**	0.020**	0.020**	0.009	0.008	0.008
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
High $Debt_{bf}$	0.000	-0.001	-0.001	-0.004	-0.005	-0.005
	(0.018)	(0.017)	(0.018)	(0.019)	(0.019)	(0.019)
$Size_b$		0.023***	0.026***		0.019***	0.022***
		(0.005)	(0.005)		(0.004)	(0.005)
$Solvency_b$		-0.177***	-0.147***		-0.150***	-0.119***
		(0.049)	(0.046)		(0.046)	(0.043)
$Liquidity_b$		0.002*	0.002*		0.001	0.002*
		(0.001)	(0.001)		(0.001)	(0.001)
$Remuneration_b$		-0.001***	-0.002***		-0.001***	-0.001***
		(0.000)	(0.000)		(0.000)	(0.000)
Foreign $Assets_b$			-0.001			-0.001*
			(0.001)			(0.001)
Observations	32,004	32,004	32,004	30,039	30,039	30,039
R-squared	0.005	0.006	0.006	0.005	0.006	0.006

The dependent variable is $\Delta Log(Credit)_{b,j,}$, which is the change in (the log of) credit granted by bank b to firm j from April to July 2008. 'RR_b' is the increase in reserve requirements for bank b due to the policy change over total liabilities. '$RatingX_{bf}$' are dummy variables that equal 1 if bank b assigns rating X to firm f in April 2008. 'High $Debt_{bf}$' is a dummy variable that equals 1 if the debt of firm f with bank b is very high, 0 otherwise. Bank controls ($Size_b$, $Solvency_b$, $Liquidity_b$, Foreign $Assets_b$) are defined in Table 2.1. All regressions are estimated using ordinary least squares. Robust standard errors clustered at bank-industry level are reported in parentheses. ***: Significant at 1 percent level; **: Significant at 5 percent level; *: Significant at 10 percent level.

Table 2.3: Impact of Reserve Requirements on Credit: Firm FE

	(1)	(2)	(3)	(4)	(5)	(6)
RR_b	-0.403***	-0.629***	-0.465***	-0.490**	-0.452***	-0.419**
	(0.142)	(0.149)	(0.132)	(0.174)	(0.140)	(0.179)
$Rating2_{bf}$	0.007	0.005			0.004	-0.001
	(0.011)	(0.010)			(0.018)	(0.019)
$Rating3_{bf}$	-0.040***	-0.040***			-0.024	-0.029
	(0.013)	(0.012)			(0.025)	(0.025)
$Rating4_{bf}$	-0.064***	-0.071***			-0.052**	-0.060***
	(0.017)	(0.017)			(0.020)	(0.020)
$Rating5_{bf}$	-0.018	-0.018			-0.039	-0.046*
	(0.012)	(0.012)			(0.028)	(0.027)
High $Debt_{bf}$	-0.031	-0.032			-0.139**	-0.141**
	(0.021)	(0.021)			(0.064)	(0.063)
$Size_b$		0.024***		0.008		0.013
		(0.006)		(0.009)		(0.010)
$Solvency_b$		-0.121**		-0.003		-0.003
		(0.057)		(0.063)		(0.066)
$Liquidity_b$		0.001		0.000		0.000
		(0.001)		(0.001)		(0.001)
$Remuneration_b$		-0.002***		-0.000		-0.001
		(0.000)		(0.001)		(0.001)
Firm FE	N	N	Y	Y	Y	Y
Observations	9,700	9,700	9,700	9,700	9,700	9,700
R-squared	0.006	0.007	0.489	0.489	0.491	0.491

The dependent variable is $\Delta\ Log(Credit)_{b,j}$, which is the change in (the log of) credit granted by bank b to firm j from April to July 2008. 'RR_b' is the increase in reserve requirements for bank b due to the policy change over total liabilities. '$RatingX_{bf}$' are dummy variables that equal 1 if bank b assigns rating X to firm f in April 2008. 'High $Debt_{bf}$' is a dummy variable that equals 1 if the debt of firm f with bank b is very high, 0 otherwise. Bank controls ($Size_b$, $Solvency_b$, $Liquidity_b$) are defined in Table 2.1. Fixed effects are either included ('Y'), not included ('N'). Robust standard errors clustered at bank-industry level are reported in parentheses. ***: Significant at 1 percent level; **: Significant at 5 percent level; *: Significant at 10 percent level.

Table 2.4: Impact of Reserve Requirements on Credit: Foreign Bank Funding

	(1)	(2)	(3)	(4)	(5)	(6)
RR foreign bank funding$_b$	-0.308***	-0.462***	-0.350***	-0.383**	-0.349***	-0.350**
	(0.090)	(0.099)	(0.099)	(0.132)	(0.105)	(0.133)
Industry dummies	Y	Y	-	-	-	-
Rating and debt dummies	Y	Y	N	N	Y	Y
Bank controls	N	Y	N	Y	N	Y
Firm FE	N	N	Y	Y	Y	Y
Observations	9,700	9,700	9,700	9,700	9,700	9,700
R-squared	0.006	0.007	0.489	0.489	0.491	0.491

The dependent variable is $\Delta\ Log(Credit)_{b,j}$, which is the change in (the log of) credit granted by bank b to firm j from April to July 2008. 'RR foreign bank funding$_b$' is the increase in reserve requirements for bank b due to the policy change of funding from foreign banks over total liabilities. Industry dummies, rating and debt dummies, bank controls, and fixed effects are either included ('Y'), not included ('N'), or spanned by other fixed effects ('-'). Robust standard errors clustered at bank-industry level are reported in parentheses. ***: Significant at 1 percent level; **: Significant at 5 percent level; *: Significant at 10 percent level.

Table 2.5: Impact of Reserve Requirements on Credit: Firm Heterogeneity

	(1)	(2)	(3)	(4)	(5)
RR_b	-0.862***	-0.738***	-1.070***		
	(0.233)	(0.276)	(0.382)		
RR_b * $Rating2_{bf}$	0.133	0.101	0.424	0.173	0.188
	(0.564)	(0.569)	(0.881)	(0.586)	(0.939)
RR_b * $Rating3_{bf}$	-0.200	-0.200	-1.451	-0.183	-1.688
	(0.352)	(0.523)	(0.970)	(0.411)	(1.048)
RR_b * $Rating4_{bf}$	-0.700**	-0.365	0.090	-0.133	0.047
	(0.342)	(0.527)	(1.018)	(0.496)	(0.981)
RR_b * $Rating5_{bf}$	0.583***	0.699**	1.225***	1.073***	1.404***
	(0.202)	(0.307)	(0.415)	(0.256)	(0.375)
RR_b * High $Debt_{bf}$	3.719***	2.336	2.458	2.593	3.413
	(1.358)	(1.447)	(2.143)	(1.633)	(2.249)
Firm FE	N	Y	Y	Y	Y
Bank controls interacted	N	N	Y	N	Y
Bank FE	N	N	N	Y	Y
Observations	9,700	9,700	9,700	9,700	9,700
R-squared	0.006	0.492	0.494	0.493	0.496

The dependent variable is $\Delta Log(Credit)_{b,j,}$, which is the change in (the log of) credit granted by bank b to firm j from April to July 2008. 'RR_b' is the increase in reserve requirements for bank b due to the policy change over total liabilities. '$RatingX_{bf}$' are dummy variables that equal 1 if bank b assigns rating X to firm f in April 2008. 'High $Debt_{bf}$' is a dummy variable that equals 1 if the debt of firm f with bank b is very high, 0 otherwise. Bank controls interacted and fixed effects are either included ('Y'), not included ('N'), or spanned by other fixed effects ('-'). Robust standard errors clustered at bank-industry level are reported in parentheses. ***: Significant at 1 percent level; **: Significant at 5 percent level; *: Significant at 10 percent level.

Table 2.6: Impact of Reserve Requirements on Credit: Bank Heterogeneity

	(1)	(2)	(3)	(4)	(5)	(6)
RR_b	-0.624***	-0.561***	-0.665***	-0.656***	-0.637***	-0.512**
	(0.193)	(0.198)	(0.234)	(0.230)	(0.214)	(0.226)
Dummy $size_b$	-0.564***	-0.582***				
	(0.179)	(0.203)				
RR_b * Dummy $size_b$	3.387***	3.689***				
	(0.960)	(1.103)				
Dummy $solvency_b$			-0.203*	-0.256**		
			(0.119)	(0.108)		
RR_b * Dummy $solvency_b$			2.273*	2.525**		
			(1.252)	(1.188)		
Dummy $liquidity_b$					-0.027	-0.169
					(0.096)	(0.121)
RR_b * Dummy $liquidity_b$					-0.274	2.113
					(1.133)	(1.615)
Firm FE	Y	Y	Y	Y	Y	Y
Bank controls	N	Y	N	Y	N	Y
Observations	9,700	9,700	9,700	9,700	9,700	9,700
R-squared	0.492	0.492	0.491	0.492	0.491	0.491

The dependent variable is $\Delta Log(Credit)_{b,j,}$, which is the change in (the log of) credit granted by bank b to firm j from April to July 2008. 'RR_b' is the increase in reserve requirements for bank b due to the policy change over total liabilities. 'Dummy $size_b$' is a dummy that equals 1 if bank b is above the 75th percentile in terms of Size, 0 otherwise. 'Dummy $solvency_b$' is a dummy that equals 1 if bank b is above the median in terms of Solvency, 0 otherwise. 'Dummy $liquidity_b$' is a dummy that equals 1 if bank b is above the median in terms of Liquidity, 0 otherwise. All regressions are estimated using ordinary least squares. All regressions include a control and interaction for 'Remuneration' and dummy variables for borrowers' ratings and debt. Bank controls (Size, Solvency, and Liquidity) are either included ('Y') or not included ('N'). Firm fixed effects are include in all regressions. Robust standard errors clustered at bank-industry level are reported in parentheses. ***: Significant at 1 percent level; **: Significant at 5 percent level; *: Significant at 10 percent level.

Table 2.7: Impact of Reserve Requirements on Credit: Extensive Margin

	(1)	(2)	(3)	(4)	(5)	(6)
RR_b	0.192***	0.246**	0.363**	0.397**	0.258*	0.247*
	(0.064)	(0.097)	(0.138)	(0.158)	(0.137)	(0.140)
$Log(Credit)_{bf}$		0.023**	0.001	0.002		
		(0.010)	(0.013)	(0.021)		
RR_b * $Log(Credit)_{bf}$		-0.124	-0.094	-0.146		
		(0.111)	(0.103)	(0.135)		
$Credit/TA_{bf}$					0.469	0.688
					(0.347)	(0.633)
RR_b * $Credit/TA_{bf}$					-4.151	-3.236
					(3.272)	(3.704)
Firm FE	N	N	Y	Y	Y	Y
Bank controls interacted	N	Y	N	Y	N	Y
Observations	35,589	35,589	10,656	10,656	10,656	10,656
R-squared	0.027	0.059	0.503	0.503	0.488	0.488

The dependent variable is $DEnd_{bf,t+1}$, which is a dummy variable that equals 1 if bank b is lending to borrower f in April 2008 but not in July 2008, and 0 otherwise. 'RR_b' is the increase in reserve requirements for bank b due to the policy change over total liabilities. $Log(Credit)_{bf}$ is the (de-meaned) logarithm of the loan from bank b to borrower f in April 2008. $Credit/TA_{bf}$ is the (de-meaned) ratio of total credit of bank b to firm f over total assets of bank b. All regressions are estimated using ordinary least squares. Bank controls interacted and fixed effects are either included ('Y') or not included ('N'). Robust standard errors clustered at the bank-industry level are reported in parentheses. ***: Significant at 1 percent level; **: Significant at 5 percent level; *: Significant at 10 percent level.

Table 2.8: Impact of Reserve Requirements on Credit: Firm-level

	(1)	(2)	(3)	(4)	(5)	(6)
RR_f	-0.274**	-0.228*	0.102	0.055	0.058	0.035
	(0.097)	(0.119)	(0.073)	(0.089)	(0.084)	(0.102)
$Remuneration_f$	-0.002***	-0.001***	-0.001***	-0.000	0.002***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
$Size_f$	0.025***	0.017***	0.023***	0.014***	0.015***	0.012***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.003)	(0.003)
$Solvency_f$	-0.268***	-0.229	-0.104**	-0.075*	0.063	0.054
	(0.043)	(0.045)	(0.043)	(0.043)	(0.041)	(0.043)
$Liquidity_f$	0.003***	0.002***	0.002***	0.002***	0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	26,586	24,981	26,574	24,961	27,664	25,027
R-squared	0.002	0.001	0.001	0.001	0.002	0.001
Sample	All firms	Above 60K	All firms	Above 60K	All firms	Above 60K

The dependent variable is $\Delta Log(Credit)_f$, which is the change in (the log of) credit granted by all banks to firm f from April to July 2008. 'RR_f' is the weighted average (where the weights are the size of the loan) increase in reserve requirements for all banks lending to firm f. The other bank controls are transformed into firm-level weighted averages in the same fashion. Columns 1 and 2 show the results for the April-July period; columns 3 and 4 refer to the January-April period; columns 5 and 6 show the results for the July-October period. Robust standard errors are reported in parentheses. ***: Significant at 1 percent level; **: Significant at 5 percent level; *: Significant at 10 percent level.

Table 2.9: Impact of Reserve Requirements on Credit: Loan Rates

	(1)	(2)	(3)	(4)
RR_f	4.937	5.085	2.933	9.314
	(8.877)	(9.788)	(10.165)	(10.404)
$Remuneration_f$			-0.007	-0.011
			(0.006)	(0.016)
$Size_b$				0.032
				(0.362)
$Solvency_b$				2.229
				(3.315)
$Liquidity_b$				-0.075***
				(0.018)
Industry FE	N	Y	Y	Y
Observations	34	34	34	34
R-squared	0.010	0.020	0.038	0.291

The dependent variable is $\Delta RL_{b,i,t+1}$, which is the change in average loan rate of bank b for industry i from April to July 2008. 'RR_b' is the increase in reserve requirements for bank b due to the policy change over total liabilities. Fixed effects are either included ('Y'), not included ('N'). Robust standard errors are reported in parentheses. ***: Significant at 1 percent level; **: Significant at 5 percent level; *: Significant at 10 percent level.

Chapter 3

ESTIMATING COMPETITION IN THE BANKING SECTOR

3.1 Introduction

The financial crisis has renewed regulators' and academics' attention to the banking sector as a whole, since focus on individual bank solvency has proven to be insufficient to ensure financial stability. In this context, understanding the dynamics of the sector as an industry, for instance in terms of competition, is crucial to apply and calibrate the appropriate prudential policies.

The degree of competition in the banking sector can have important effects on financial stability. There is a theoretical debate, however, on the direction of this effect. Since the seminal paper by Keeley (1990), the consensus was centered around the idea that increasing competition in the banking sector causes a lower franchise value for banks -by diminishing their future rents-, and as a result, increases their risk-taking and harms financial stability. The argument was reversed by Boyd and De Nicoló (2005), who argue that lower competition in the loan market leads to higher loan rates, which can in turn increase the risk taken by borrowers. Martinez-Miera and Repullo (2010) refine this result by noting that higher loan rates lead to higher risk-taking by borrowers (and thus more defaults) but also higher revenues for banks when borrowers do not default. In other words, there are two effects in place: the risk-shifting effect and the margin effect.[1] The overall relation between competition and financial stability is then inverse-U-shaped: 'too' little or 'too' much competition is harmful for financial stability.

Which effect dominates (in other words, whether a banking system is at the in-

[1]The naming is from Martinez-Miera and Repullo (2010)

creasing or decreasing part of the curve) is an empirical matter. Nevertheless, estimating the degree of banking competition is not straightforward.

The objective of this chapter is threefold. First, I review the existing methodologies to estimate the degree of competition, explain the results of the literature, in particular those papers that focus on the UK banking system, and discuss the main drawbacks of these approaches. Second, I briefly analyze competition in the UK banking system in the decade prior to the financial crisis and show that, contrary to other papers, the evidence suggests that there was an increase in competition. Finally, I propose a new approach, using the tools from the empirical industrial organization literature, to more consistently estimate the level of competition in the banking sector.

3.2 Competition in the banking sector: A critical review

Estimating competition -i.e., the degree as well as the form of this competition- in the banking sector entails several difficulties. First of all, even if we restrict the analysis to the intermediation business of banks, their production function is not the same as other non financial firms. For instance, when raising funds, which could be considered an input of the bank's production function, banks also provide services to consumers. In other words, suppliers of this input care about more than just the return on their deposits. For example, they care about the overdraft allowed in their account, or the number of ATMs available in the region. Moreover, banks typically serve different markets: credit cards, unsecured personal loans, mortgages, loans to businesses, insurance, pension plans, ... While one could restrict the attention to a particular market, this does not seem to be the question of interest: we are interested in the degree of competition in the banking sector as a whole. The fact that competition in the credit card market has increased or decreased does not seem enough if one is interested in the effects to financial stability. Furthermore, the existence of economies of scope may distort the analysis when focusing only on one market. It could be the case that banks are providing bundles of other financial products due to increased competition, which could be missed by focusing only on one market.

Even if we can correctly identify the relevant input and output prices and quantities, there is still the issue of disentangling supply and demand. The econometrician can usually only observe equilibrium prices and quantities. One way that is typically used to overcome this issue is to use variables that only affect supply and variables that only affect demand, and estimate both curves through simultaneous equations using them as instruments. A big caveat of this approach, nevertheless, is the difficulty in finding such instruments.

A potentially more complex issue, however, is the fact that the relevant characteristics of a loan are not only given by the price and quantity, but also the risk of it, which is usually unobservable by the econometrician. Think about the following situation: we may observe that banks increase on average the rates charged on new loans, and thus conclude that market power is rising, when the truth is that banks are lending to riskier borrowers and hence this behavior does not necessarily reflect a decrease in competition. Failure to account for risk-taking in the particular credit market may bring wrong conclusions from the analysis.

The methodologies described in this section do not deal with these three main problems. That said, it does not mean that one cannot learn anything from such indicators, especially when combined with additional evidence. This is the goal of this section and the next one: to review the methods used so far, point to their main limitations, but use them to understand how competition in the UK banking sector has evolved in the years prior to the financial crisis.

The Monti-Klein model

Before going into the different approaches, it can be useful to mention the Monti-Klein model of financial intermediation, since it is the underlying model in several of the papers reviewed here.

In this model, the bank is regarded as a financial intermediary that collects funds and, through a production function, supplies loans. Therefore, the production function is:

$$L_i = L(K_i, H_i, D_i)$$

Bank i collects deposits and employs labor and capital to supply loans. It maximizes the following profit function:

$$\pi_i = r_L L_i - r_D D_i - C(K_i, H_i, D_i)$$

subject to the production function.

3.2.1 Panzar and Rosse (1987)

The first approach, the so-called *H-Statistic*, was developed theoretically by Panzar and Rosse in a series of papers (Panzar and Rosse, 1977, 1982, 1987). They show a simple method to distinguish whether a firm is acting as a monopolist. It consists in estimating the elasticity of the firm's total revenues with respect to input prices (this elasticity is precisely what is called *H-Statistic*). For a monopolist firm, the optimal level of production is at the point where marginal revenue equals marginal cost. If there is an increase in the marginal cost (through an increase in input prices), the new level should imply also higher marginal revenue, which implies lower total revenues. The elasticity of total revenues with respect to input prices, hence, is negative for a monopolist.

While this is a very elegant and general result, its power is quite limited: it only allows to reject monopolistic behavior, but it does not provide more information. Understanding this limitation, Panzar and Rosse went a bit further to show which value the *H-Statistic* would take in other forms of competition. Nevertheless, the result is less general since they need further assumptions: for instance, they assume that the industry is in a long-run equilibrium, meaning that the average firm is making zero profits. They show that, under monopolistic competition, the *H-Statistic* is lower than one when the industry is in a long-run equilibrium.

The setup to derive the previous result is as follows. They assume a firm's perceived inverse demand function with the form $P(y, n, z)$, where y is the firm output, n the number of rivals, and z an exogenous component. The papers study the symmetric case, where all the competitors produce the same quantity. To the standard assumptions regarding the demand function (i.e., $\frac{\partial P}{\partial y} \equiv P_y < 0$ and $\frac{\partial P}{\partial n} \equiv P_n < 0$), they add the fact that demand elasticity increases (in absolute value) as the number of competitors increase: $\frac{\partial e}{\partial n} \geq 0$ where $e(y, n, z) \equiv \frac{-P}{y\frac{\partial P}{\partial y}}$.

Denoting the revenue function as $R(y, n, z) = yP(y, n, z)$, then individual firms maximize: $R_y - C_y = 0$. Finally, the last assumption is, as mentioned before, that the industry is in the long-run equilibrium, meaning that firms are making 0 profits: $R(y, \hat{n}, z) - C(\hat{y}, w, t) = 0$.

The final result is that

$$\psi = \sum w_i \frac{\frac{\partial R}{\partial w_i}}{R} \leq 1$$

The sum of the elasticities of the revenue function with respect to input prices is lower or equal to 1. This fact, as well as the previous result in case of a monopolist firm where the sum was non-positive, led several authors to estimate this sum and claim that a result between 0 and 1 was evidence of monopolistic competition.

The intuition of the result is as follows: if there is an increase in the input prices, the marginal cost curve will shift upwards. Firms will adjust by decreasing their production, but in the new optimization point the representative firm will be making losses. This will induce exit in the market, increasing then demand for the remaining firms until the two conditions on individual optimization and long-run industry equilibrium are satisfied again. Hence, given the exit of some firms, the resulting revenue in equilibrium can be higher than the initial one.

After all the derivations, we get that $\psi = 1 + \frac{R_y}{RD}(y^2[P_y P_n - PP_{yn}])$. The key point of the proof is the fact that the term in brackets is non-positive given the assumption on how the demand elasticity changes as n changes. In particular, $\frac{\partial e}{\partial n} = \frac{PP_{yn} - P_y P_n}{y P_y^2} \geq 0$; in other words, the more responsive demand elasticity is to an increase in the number of competitors, the more positive the numerator is and, consequently, the more negative the term between brackets from the previous expression is.

Studies using the Panzar-Rosse H-Statistic approach

The theoretical approach of Panzar and Rosse (1982) has been applied by several authors to the banking sector. The first paper to study competition in the UK banking sector by using this approach was Molyneux, Lloyd-Williams, and Thornton (1994). They study five European countries (France, Germany, Italy, Spain, and the UK) during the period 1986-1989.

They use bank-level data for each country. They estimate the *H-Statistic* by estimating the elasticity of revenues with respect to input prices. As inputs, they choose ‘labor’, ‘physical capital’, and ‘funds’, much in the same vein as the Monti-Klein model. They also include other controls, such as bank assets, loans over assets, capital ratio, and interbank deposits to total deposits, that can influence revenues. The exact regression is as follows:

$$\begin{aligned}\ln TRASS = a + b\ln PL + c\ln PK + d\ln PF + e\ln TA + \\ + f\ln LNASS + g\ln CAPASS + h\ln IBTDEP\end{aligned}$$

Where the dependent variable is $TRASS$ (total interest revenue per dollar of assets), input prices are PL (personnel expenses per dollar of assets, proxy for unit price of labor), PK (capital expenses per dollar of fixed assets as unit price of capital), and PF (ratio of annual interest expenses to total funds as unit price of funds), and other controls are ASS (bank assets), $LNASS$ (loans to asset ratio), $CAPASS$ (total risk capital to asset ratio), and $IBTDEP$ (interbank deposits to total deposits). The *H-Statistic* equals the sum of the coefficients $b + c + d$. Their results suggest the existence of monopolistic competition in the banking sectors in the different countries, which they interpret is caused by a lack of integration.

Claessens and Laeven (2004) relate the *H-Statistic* in the banking sector with other typical measures of industry competition, such as concentration. They study several countries for the period 1994-2001. Their results suggest that higher concentration is actually associated with a higher degree of competition. Moreover, they gain other insights from the exercise: a measure of 'activity restrictions' is robustly associated to a lower degree of competition (as measured by the *H-Statistic*), suggesting that in countries with more stringent restrictions on banking activities, the banking sector has a lower degree of competition. Finally, they show that the market share of foreign banks is positively related to the degree of competition.

Matthews et al. (2007) estimate the degree of competition in the UK during the period 1980-2004 by using the same approach. The last decades of the 20th century have seen a lot of changes regarding the UK banking sector: the Banking Act of 1979 reduced dramatically the barriers to entry to banking, which coupled with the abolition of exchange rate controls the same year decreased entry barriers for international competitors as well. In 1983, moreover, the Building Societies Cartel was broken, and three years later the Building Societies Act was passed. Nevertheless, their results suggest that banking sector competition has been stable during the period under study.

As mentioned earlier, one condition for the test to be valid is that the industry is in the long run equilibrium. Matthews et al. (2007) provide the following test (proposed by Shaffer (1982)), regressing the return on assets on the same controls used to estimate the *H-Statistic*:

$$\ln(\pi_{it}) = \alpha_0' + \sum_{j=1}^{J} \alpha_j' \ln(w_{jit}) + \sum_{k=1}^{K} \beta_K' \ln(X_{kit}) + \sum_{n=1}^{N} \gamma_n' \ln(z_{nt}) + v_{it}$$

More precisely, the test is whether $E = \sum_{j=1}^{J} \alpha_j = 0$, i.e., whether the return is uncorrelated with input prices (denoted by w), which would indicate a long-run equilibrium situation. They test this condition in different rolling-windows. For several of their regressions, this condition is in fact rejected.[2]

As dependent variables in the study of competition, Matthews et al. (2007) use both 'total revenue over total assets' and 'total interest income over total assets' (both ratios in logs). The idea is to study competition in two different periods,

[2] In particular, for 6 out of 17, including the one using the whole time period.

from 1980 to 1991 and from 1992 to 2004 and see whether the elasticities are significantly different. By using two different dependent variables they are trying to capture differences in the evolution of competition for the 'core' banking business (interest income) and the 'non-core' business (non interest income). Their results suggest that there has been no significant change in competition in the core business, but that competition has decreased in the non-core business. Since the elasticities estimated are between 0 and 1, they claim that the UK banking sector is best described as 'monopolistically competitive'.

The criticism to the Panzar and Rosse (1987) approach

The empirical application of the *H-Statistic* has been severely criticized. One of the main criticisms has been the inclusion of $size$ as a control variable in the regressions. The justification to include such control is that larger firms earn more revenues independently of the input prices, and therefore this effect must be controlled for. However, Bikker et al. (2012) show that the inclusion of size -or any other variable controlling for scale effects- changes the testing power of the *H-statistic*. In particular, they show that all forms of competition lead to a *H-statistic* statistic greater than zero when size is controlled for.

They provide an easy intuition for this result. In the Panzar and Rosse (1982) model, a monopolist reacts to an increase in input prices by decreasing its production (and, thus, increasing its marginal revenue). Since in the initial equilibrium demand was elastic, the monopolist is in a situation where total revenues are lower -because quantity reacts more than price. Therefore, the *H-statistic* indicator is negative. However, if one controls for size, which proxies for quantity, then one is only looking at the part of the change in revenues corresponding to a change in price. Price should go up, so the elasticity should be positive.

Furthermore, the *H-Statistic* has been interpreted in the literature as a monotonic measure of competition. It is true that, under certain market structures, the *H-Statistic* is a monotonic function of demand elasticity. Therefore, if demand elasticity is constant over time, the *H-Statistic* is a monotonic function of market power. Whether it is increasing or decreasing, however, depends on the market structure. In conclusion, the *H-Statistic* is not in general an ordinal function of the degree of competition.

Moreover, as previously highlighted, the *H-Statistic* test for detecting monopolistic competition relies on the assumption that the industry is in its long run equilibrium. Goddard and Wilson (2009), by using Monte Carlo simulations, show that if the adjustment is only partial, the estimator for the *H-Statistic* is biased towards zero.

3.2.2 Bresnahan (1982) and Lau approach (1982)

Another widely-used approach is the one proposed by Bresnahan and Lau in two papers published in the same volume. It presents three main advantages with respect to the *H-Statistic*: it does not need to assume that the industry is in long-run equilibrium, the measure can be mapped better to higher or lower competition, and it can be computed at industry-level using industry data only.

Lau (1982) shows that, as long as demand is non-linear and non separable in one of its exogenous terms, the mark-up term is identified econometrically. Therefore, the typical empirical exercise consists on estimating two simultaneous equations, a demand and a supply one.

It assumes a demand function with the following form: $Q = D(P, Y, \alpha) + \epsilon$, where P is the price, Q is the quantity, and Y a vector of exogenous variables. Banks sell in equilibrium where 'perceived' marginal revenue equals marginal cost. Denoting the 'true' marginal revenue as $P + h(Q, Y, \alpha)$, the equilibrium price will be $P = c(Q, W, \beta) - \lambda h(Q, Y, \alpha) + \eta$, where λ maps the market power of the firm: if it equals 0, price equals marginal costs and we are in a situation of perfect competition. If it equals 1, then the perceived and the true marginal revenues are equal and the firm behaves as a monopolist. Intermediate levels correspond to other oligopoly solutions. W refers to exogenous variables affecting marginal costs only.

In order for the mark-up to be identified, one needs to assume that the demand equation is non-separable in at least one exogenous variable. This means that $\frac{\partial D}{\partial P} = d(Y)$ for at least one Y. In other words, the change of some exogenous variable changes the slope, and not only the level, of the demand curve. Except for a very particular case (showed in Lau (1982)), any type of such demand function implies identification of the mark up-term. Nevertheless, in order to have identification, we need exogenous variables both for the cost function and the demand for loans.

It may be easier to illustrate the approach with a simple model. Assume that the demand for loans is $Q = \alpha_0 + \alpha_1 P + \alpha_2 Y + \alpha_3 PY + \epsilon$ (this is the first equation to estimate) and the marginal cost is $MC = \beta_0 + \beta_1 Q + \beta_2 W$. Following from the previous equation, the 'perceived' marginal revenue must equal the marginal cost. Notice that revenue is $R = QP$, so the 'true' marginal revenue is

$\frac{\partial R}{\partial Q} = P + \frac{\partial P}{\partial Q}Q = P + \frac{\partial(\frac{Q-\alpha_0-\alpha_2 Y}{\alpha_1+\alpha_3 Y})}{\partial Q}Q = P + \frac{Q}{\alpha_1+\alpha_3 Y}$. Therefore, the 'perceived' marginal revenue is $P + \lambda(\frac{Q}{\alpha_1+\alpha_3 Y})$ and the second equation to estimate is:

$$P = \frac{-\lambda}{\alpha_1 + \alpha_3 Y}Q + \beta_0 + \beta_1 Q + \beta_2 W$$

It becomes apparent the need for the demand function to be non-linear: if instead it was $Q = \alpha_0 + \alpha_1 P + \alpha_2 Y + \epsilon$, then the pricing equation would be $P = (\frac{-\lambda}{\alpha_1})Q + \beta_0 + \beta_1 Q + \beta_2 W$ and it would not be possible to distinguish $(\frac{-\lambda}{\alpha_1})$ from β_1.

3.2.3 Lerner index

Another indicator for competition, closely related to the Bresnahan and Lau approach, is the Lerner index. The Lerner index is the ratio between the difference of price and marginal cost over the price. In other words, $L = \frac{P-mc}{P}$.

The exposition here follows Angelini and Cetorelli (2003). The Bresnahan and Lau indicator is defined as $P = mc - \lambda\frac{\partial P(Q)}{\partial Q}Q$. When interpreting this relation at individual firm-level, one can write it as $p_j = mc_j - \frac{\theta_j}{\epsilon}$, where $\theta_j = \frac{\partial Q/\partial q_j}{Q/q_j}$ and $\bar{\epsilon} = \frac{\partial Q/\partial P}{Q}$. Notice that, in the individual decision, a firm must take into account also how the rest of the participants will react to a change of its quantity. As shown before in the Bresnahan and Lau approach, in order to precisely identify each term one would need to estimate a demand equation as well. In the case on the Lerner index, however, it is not necessary, since $L = \frac{P-mc}{P} = -\frac{\theta_j/\bar{\epsilon}}{P}$. In other words, we need to estimate $-\lambda\frac{\partial P(Q)}{\partial Q}Q$, not only λ.

For the Lerner Index one needs to specify a cost function. Angelini and Cetorelli (2003) assume a translog specification with deposits, labor, and capital as inputs:

$$\ln(C_j) = c_0 + s_0 \ln q_j + \frac{s_1}{2}(\ln q_j)^2 + \sum_{i=1}^{3} c_i \ln w_{ij} + \ln q_j \sum_{i=1}^{3} s_{i+1} \ln w_{ij} +$$
$$c_4 \ln w_1 \ln w_2 + c_5 \ln w_1 \ln w_3 + c_6 \ln w_2\, lnw_3 + \sum_{i=1}^{3} c_{i+6}(\ln w_{ij})^2,$$

As price they use '(total interest earned on assets + total revenues from other services) / total assets', quantity is 'total assets', the costs are 'total costs', the first input price is 'total interest paid on deposits / total deposits', the second is 'labor costs / number of employees', and the third one is '(total operating costs ? labor costs) / total assets'.

They estimate this equation along the one with the Lerner Index, now rewritten as:

$$p_j = \frac{C_j}{q_j}(s_0 + s_1 q_j + \sum_{i=1}^{3} s_{i+1} \ln w_{ij}) + (\frac{\theta_j}{\bar{\epsilon}})$$

They use 3SLS estimation. They show that the Lerner Index has decreased in the Italian banking sector during the 90s.

3.2.4 Other forms of competition: quality

Insights from Dick (2007)

Shifting the attention away from purely price competition, Dick (2007) studies quality competition in the banking sector. The paper studies different regions in the US [3] and shows how market concentration differs with the size of the market. The author finds that the number of dominant banks, as well as their market share, is roughly constant across markets; it is the number of 'fringe' (small and regional) banks that increase with market size. Moreover, product quality is higher for bigger markets, and it is higher for dominant banks as well. These results suggest that, in order to capture extra demand from bigger markets, dominant banks compete in quality, not in prices. This raises the fixed costs to enter into the market, thereby preventing other important banks to enter.

Ayuso and Martinez (2006)

Ayuso and Martinez (2006) also point out the fact that banks do not only compete on prices. Following the example of the previous work, revenues may be reacting to investment decisions on quality, which is not in the production function as an input, and thus competition may be underestimated. They estimate the following equation:

$$\log D_{it} = \phi \log D_{it-1} + \alpha_{0i} + \alpha_1 (r_{it} + X_{it}\alpha_2) + \beta_t + \epsilon_{it}$$

Where the dependent variable is the amount of deposits of bank i at time t, there are bank and time fixed effects, r_{it} is the (average) deposit rate, and X_{it} is a measure of quality (number of branches, number of ATMs per branch, and capital-to-asset ratio). The results show that competition seems to have increased in the last period of the sample (the coefficient on the deposit rate is higher) but only when

[3] She has data on Metropolitan Statistical Area level.

they control for quality, interpreting that failure to control for non price competition can lead to biased results.

An alternative: the Boone indicator

A somewhat similar indicator, called the Boone indicator, has recently been used to estimate the degree of competition. The foundations for this indicator are found in Boone (2008).

The Boone indicator is the approach taken by Van Leuvensteijn et al. (2007) to measure competition in the loan market. It is based on the idea that there should be a negative relationship between marginal costs and market share -in the sense that more efficient banks should expand and obtain a higher market share- and that this relation should be stronger for more competitive environments. Therefore, the idea of this test is to estimate the relation between marginal costs and market shares, and interpret this relation as an indicator of the degree of competition.

The first issue to deal with is the problem of not observing marginal costs. In order to solve this issue, they estimate a 'translog cost function' (TCF):

$$\ln c_{it}^h = \alpha_0 + \sum_{h=1}^{H-1} \alpha_h d_i^h + \sum_{t=1}^{T-1} \delta_h d_i + \sum_{h=1}^{H} \sum_{j=1}^{K} \beta_{jn} \ln x_{ijt} d_i^h + \\ + \sum_{h=1}^{H} \sum_{j=1}^{K} \sum_{k=1}^{K} \gamma_{jkn} \ln x_{ijt} \ln x_{ikt} d_i^h + \upsilon_{it}$$

After this complicated formulation there is just an estimation of a general cost function where input and other components affecting costs enter in a quadratic way. Costs depend on a type dummy (d_i^h) which identifies commercial, savings, or cooperative banks; a time dummy (d_t); and a series of controls (x_{ijt}): bank output components (loans, securities, other services), input prices (wage rates, deposit rates, price of other expenses), and equity ratio.

They specify some restrictions for the coefficients coming from cost exhaustion and linear homogeneity: $\beta_1 + \beta_2 + \beta_3 = 1$ (the coefficients of input prices in the linear part, $\gamma_{1,k} + \gamma_{2,k} + \gamma_{3,k} = 0$ for $k = 1, 2, 3$ and $\gamma_{k,1} + \gamma_{k,2} + \gamma_{k,3} = 0$ for $k = 4, ..., K$.

Recall that they want to know the marginal cost of the banks in their sample. In order to do so, they derive the previous equation and obtain the following equation for marginal:

$$mc_{ilt}^{h} = \frac{\partial c_{it}^{h}}{\partial x_{ilt}} = (c_{it}^{h}/x_{ilt})\frac{\partial \ln c_{it}^{h}}{\partial x_{ilt}} =$$

$$= \frac{c_{it}^{h}}{x_{ilt}}(\beta_{ln} + 2\gamma_{ilt} + \sum_{k=1,k\neq l}^{K}\gamma_{lkn}\ln x_{ikt})d_{i}^{h}$$

Therefore, with the estimation of the previous TCF, one can use the coefficients and the variables to obtain a measure of the marginal cost. Hence, the last step is to see the relation between marginal cost and market share:

$$\ln s_{ilt} = \alpha + \beta\ln(mc_{ilt}) + timedummies + u_{ilt}$$

3.2.5 Limitations of the previous approaches to estimate banking competition

All the papers reviewed so far use data only from the 'supply side' of the market. Demand is not controlled for in a rigorous way. This raises important caveats, especially when these methods are applied to the banking industry. Moreover, standard methods to control for credit demand, such using fixed effects (for instance, using region-time FE), are not valid since the dummies would capture changes in competition as well.

Banks not only compete in prices. They may compete in quality -as understood in Ayuso and Martinez (2006) and Dick (2007)- but also in the riskiness of the banking product. Failure to observe either of the two implies a failure to observe other important dimensions of banking competition. Besley, Meads, and Surico (2012) show that banks price risk in a nonlinear fashion. Therefore, failure to control for risk makes the empirical exercise biased. In particular, competition could be driving lending standards down without being reflected into the loan rates. If that were the case, one could conclude from the exercises above that competition has stayed constant when, in fact, banks were being pressured to lend to riskier borrowers at the same rate. Importantly, if these risks do not immediately materialize (Jiménez and Saurina (2006)), banks' interest income will not reflect this increase in competition.

Moreover, there are important endogeneity issues. The Panzar and Rosse (1987) and the rest of the approaches assume that changes in costs are unrelated to changes in the demand. Nevertheless, personnel expenses depend on the GDP and growth rate of an economy. Cost of funding depends on monetary policy, which in turn depends on the state of the economy. Since changes in input prices may also reflect changes in demand of banking products, the coefficients may be biased. In general, moreover, these studies do not tackle the potential problems of endogeneity in a rigorous way. They typically use GMM estimation, using the lag values of the controls as instruments. This type of estimation has been challenged, at least without proper robustness checks on the instruments (Roodman (2009)): the test to detect endogeneity has little power if the number of instruments is too large.

3.3 An empirical study of competition in the UK banking sector

In this second part of the paper, I study the evolution of competition in the UK banking system by estimating the *H-Statistic* and looking at loan rates in different markets.

I follow the previous papers in the estimation of the *H-Statistic*, except for the fact that I do not include any scale control. The regression that I estimate is the following:

$$\ln(intincome_{it} = \alpha_0 + \sum_{t=0}^{T} \alpha_{1t} \ln(pfunds_{it}) + \sum_{t=0}^{T} \alpha_{2t} \ln(pinputs_{it}) +$$
$$+\alpha_3 \ln(eqass_{it}) + \alpha_4 \ln(liqass_{it}) + \alpha_5 \ln(loanass_{it}) + \alpha_6 year_t + \gamma_i + \epsilon_{it}$$

I obtain the data from Capital IQ. The dependent variable is interest income; as inputs I use, as the literature, interest expenses (to proxy for the price of funds) and operating expenses (to proxy for the cost of labor and physical capital). I add other bank controls: the capital-to-asset ratio, the ratio of liquid assets to total assets, the ratio of loans over total assets. I also introduce time and bank fixed effects.

I interact the input prices variables with year dummies, to allow the coefficients to vary through time; the estimated *H-Statistic* for each year is hence the sum of $\alpha_1 + \alpha_2$ for each particular year. The evolution of this indicator can be observed in Figure 3.1.

The evolution of the *H-Statistic* suggests that the degree of competition in the UK banking system has increased significantly, especially since 2003. Therefore, this indicator suggests that banking competition in the UK intensified in the four years prior to the financial crisis.

To complement this indicator, I obtain information on the rates of different credit markets. All the rates are obtained from the 'Quoted Rates' data of the Bank of England, which is public but constructed from confidential individual rates.

The evolution of the different rates are plotted in Figures 3.2, 3.3, and 3.4. Figure 3.2 focuses on credit card rates. There is a clear downward trend since the beginning of the sample, which could indicate an increase in competition. A similar picture can be observed in Figure 3.3, plotting the evolution of loan spreads (i.e., the difference between loan rates and the policy rate). Figure 3.4, however, shows a flat trend for mortgage rate spreads since the end of the 20th century, for both banks and building societies.

A closer look to the mortgage market

The evolution of the *H-Statistic* and the spreads for the loan and credit card markets suggest that, in the decade prior to the financial crisis, there was an increase in competition in the UK banking sector. Nevertheless, the mortgage rate spreads appear to be flat during the whole period. While this could suggest that this particular market has not experienced an increase in competition, granting mortgages has been a source of high risk-taking in the years before the financial crisis throughout the world, so a closer look at their riskiness is important.

I use data provided by Nationwide, the largest building society in the country and one of the main players in the mortgage market, to understand the evolution of risk-taking in this sector.[4] In particular, I look at two widely used "affordability" measures: the price-to-earnings ratio and the affordability index. These indicators are averages of the building society's operations, and cover a much longer time period, from 1983 (1992) to 2013.

The evolution of the price-to-earnings ratio can be observed in Figure 3.5. This ratio is an estimate of how many annual earnings a house costs for a first-time buyer. While the ratio decreased in the first half of the 90s, it starts increasing from 1996 until the beginning of the crisis, reaching a peak at 5.5; that is, an average first-time buyer would need to work for 5 years and a half exclusively to buy the house without obtaining a loan. The big increase suggests that, even if mortgage rate

[4] http://www.nationwide.co.uk/about/house-price-index/headlines

spreads did not decrease, the riskiness of the mortgages were increasing,[5] suggesting that the expected rents for the financial institution were decreasing.

However, this ratio is influenced by the monetary policy rate at the moment. Lower rates should imply higher price-to-income ratios, since the same amount of mortgage is less costly, and hence can be afforded by a lower income borrower. The rate set up by the Bank of England experienced a clear downward trend, especially from 1998, and it lasted until 2004. In the previous figure, the ratio goes up well after 2004, which seems to suggest that it was not driven only by a reduction of mortgage rates. Nevertheless, in order to tackle this potential bias, I look at the affordability indicator in Figure 3.6, which is not subject to this criticism. This ratio shows which proportion of the borrower's income must be devoted to paying back the mortgage. Therefore, a decrease of mortgage rates (due to a decrease in the monetary policy rate) may bring higher price-to-income ratios but not higher affordability ratios.

There is a clear upward trend as well in the affordability ratio. It starts in 1996 and ends, as before, around 2007:Q3, the beginning of the financial crisis. While at the beginning of 1996 first-time borrowers only had to use slightly less than 20% of their total income to meet the mortgage payments, in the peak this share overcame 50%. This suggests that, indeed, mortgages became ex ante riskier, in the sense that ex ante observable borrower characteristics deteriorated during this period. This evidence, coupled with the fact that mortgage spreads stayed approximately constant, would be consistent with the hypothesis of increased competition also in the mortgage market.

3.4 The EIO approach to the banking sector: A proposal

The previous approaches rely on heavy assumptions regarding the way banks perform their business and they do not take into account the demand side. A more ambitious proposal for the study of banking competition is to use the recent developments in the Empirical Industrial Organization (EIO) literature.

We have highlighted the problem of not accounting for competition in risk. This is because demand of different risk groups may be different, and hence without controlling for this heterogeneity one cannot understand the degree of market power.

[5]Note that the mortgage rate spreads shown before were an average for 75% loan-to-value mortgage, but this does not include information on borrower earnings.

The approach proposed here takes into account this issue because it requires the estimation of the demand obtained through the aggregation of individual demands.

An EIO study of the banking system could follow the idea of Nevo (2001), which starts with the estimation of the demand for banking products, allowing for the existence of unobserved factors and random (individual) coefficients. After that, we would obtain estimates of how demand in different markets and different products reacts to changes in prices and quality (number of branches, investment in advertising, etc). We would also obtain a distribution of aggregate shocks. With these parameters, we could study how banks would take decisions regarding entry and exit in a market, the amount of loans to give, and the amount of investment in quality. The model that better replicates the qualitative features of actual data would be the one better describing the competitive nature of the UK banking system. With long enough time series, we could allow for the model of competition to change over time.

Demand is modeled as a discrete-choice decision of individuals. Note that demand is assumed to be a static decision, so no 'time' subscripts will appear in the exposition. The supply decision will incorporate the dynamic aspect.

The subscript i refers to the individual consumer, j is the bank, and k is the region. Individual utility, for a consumer i located in region k and consuming from bank j, can be expressed as: $U(p_{jk}, x_{jk}, \xi_{jk}, \varsigma_i; \theta)$, where p_{jk} is the price (rate) offered by bank j in region k, x_{jk} is a vector with variables regarding bank j characteristics in region k (for instance, solvency, size, number of branches, ...). ξ_{jk} are unobserved bank-region characteristics, and ς_i are individual characteristics, such as demographics.

A particular specification of this utility, following Nevo (2000), is:[6]

$$u_{ijk} = \alpha_i(y_i - p_{jk}) + x_{jk}\beta_i + \xi_{jk} + \epsilon_{ijk}$$

It may be convenient to model the unobserved bank-region characteristics in the following way: $\xi_{jk} = \xi_j + \xi_k + \Delta\xi_{jk}$, where the first term is a bank fixed effect, the second term is a region fixed effect, and the third term is a bank-region shock.

The coefficients in the previous utility equation are not common across all in-

[6]Modeling utility in this way assumes no wealth effects, which could not be appropriate to capture the demand of bank services; nevertheless, it could be easily introduced.

dividuals. In particular, we can express them as:

$$\begin{pmatrix}\alpha_i\\ \beta_i\end{pmatrix} = \begin{pmatrix}\alpha\\ \beta\end{pmatrix} + \Pi D_i + \sum v_i$$

where D_i are demographics for which we have some information about the distribution at regional level (age, employment, ...); v_i are unobserved characteristics at individual level for which we assume a parametric distribution; both terms are assumed to be independent.

We can rewrite utility as:

$$u_{ijk} = \alpha_i y_i + \delta_{jk}(x_{jk}, p_{jk}, \xi_{jk}; \theta_1) + \mu_{ijk}(x_{jk}, p_{jk}, v_i, D_i; \theta_2) + \epsilon_{ijk}$$

where $\delta_{jk} = x_{jk}\beta - \alpha p_{jk} + \xi_{jk}$ is the mean utility which is common to all consumers in the region k for the product offered by bank j, and $\mu_{ijk} = [-p_{jk}, x_{jk}](\Pi D_i + \sum v_i)$ is the mean-zero heteroskedastic individual deviation from the mean utility.

Now we can express the set of individual characteristics that implies consumption from bank j given the other factors as:

$$A_{jk}(x_{.k}, p_{.k}, \delta_{.k}; \theta_2) = (D_i, v_i, \epsilon_{i0k}, ..., \epsilon_{iJk})|u_{ijk} \geq u_{ilk} \bigtriangledown = 0, 1, ..., J$$

and hence, the predicted market share for bank f in product-market j in region k is:

$$s_{jk}(x_{.k}, p_{.k}, \delta_{.k}; \theta_2) = \int_{A_{jk}} dP^*(D, v, \epsilon) =$$

$$= \int_{A_{jk}} dP^*(\epsilon|D, v) dP^*(v|D) dP^*_D(D) =$$

$$= \int_{A_{jk}} dP^*_\epsilon(\epsilon) dP^*_v(v) d\bar{P}^*_D(D)$$

By simulation, one can obtain the parameters that approach the predicted shares to the actual ones. One should be careful because of the endogeneity of price in the equation.[7] We need instrumental variables, but they do not enter linearly into the equation. Nevo (2000) explains how to deal with this issue.

3.5 Conclusion

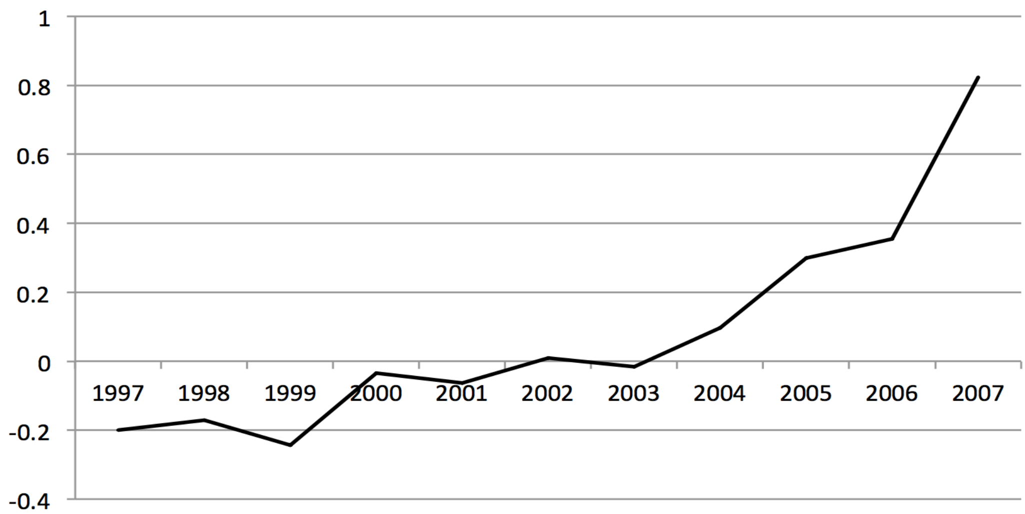
Measuring competition in the banking sector is important to move forward in understanding the potential threads to financial stability. Nevertheless, the approaches used so far in the literature present many caveats. In this chapter, I have

[7] The endogeneity comes from the 'bank-region' unobservable (for the econometrician) shock.

proposed a different approach, following the recent advanced in the EIO literature, to estimate the form of banking competition by controlling for and estimating in a rigorous way the demand for banking services. The drawback is, however, that more detailed data is required. Nevertheless, regulators and supervisors are making more detailed data available. Therefore, applying this new approach with the new data available to understand how competition changes in the banking sector is the next step.

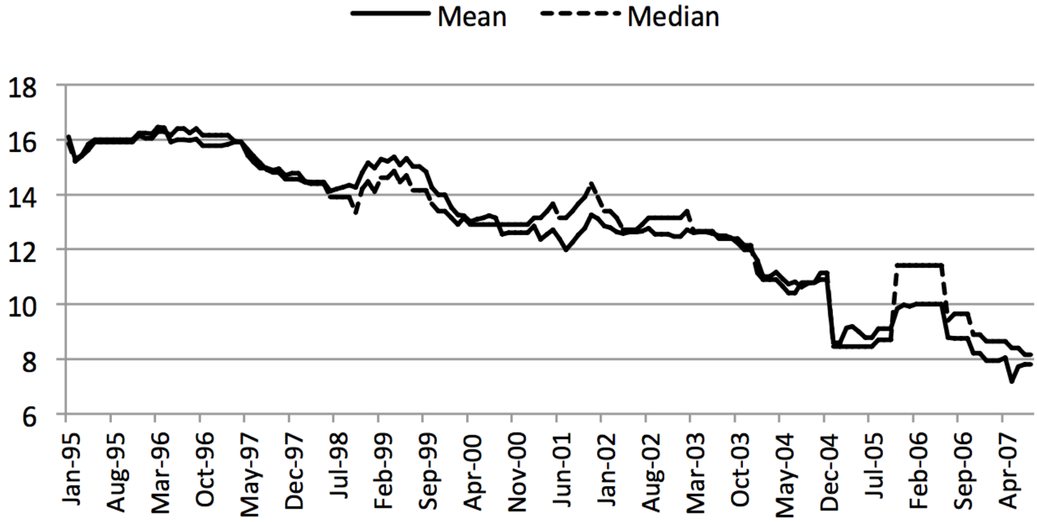
3.6 Figures

Figure 3.1: H-Statistic for the UK banking sector



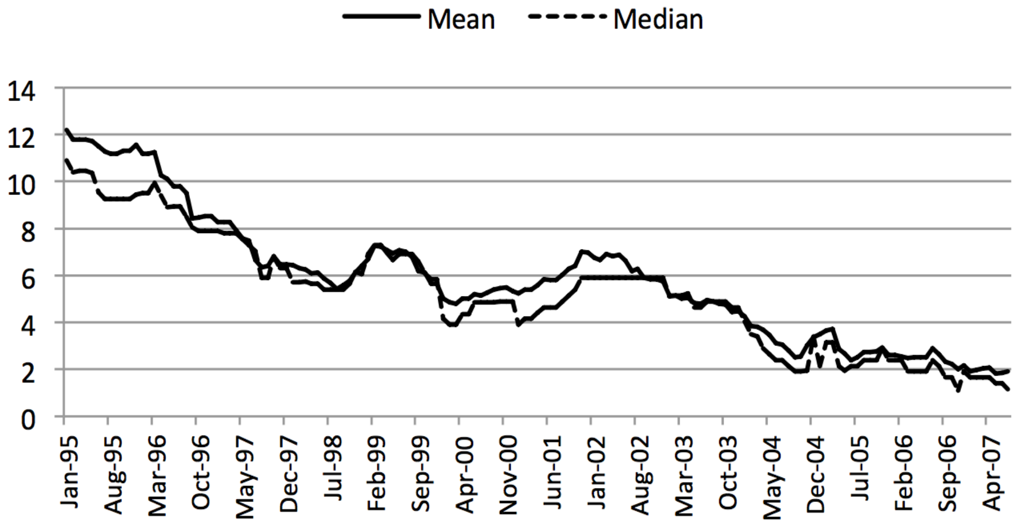
This table shows the evolution of the estimated H-Statistic for a subsample of UK banks. The bank-level data is obtained from CapitalIQ. The results are obtained from regressing the (log of) interest income on the price of inputs -interest rate expenses and non-interest rate expenses, as well as other controls, and adding up the first two coefficients. A higher *H-Statistic* implies higher competition.

Figure 3.2: Average quoted credit card rates for the UK banking sector



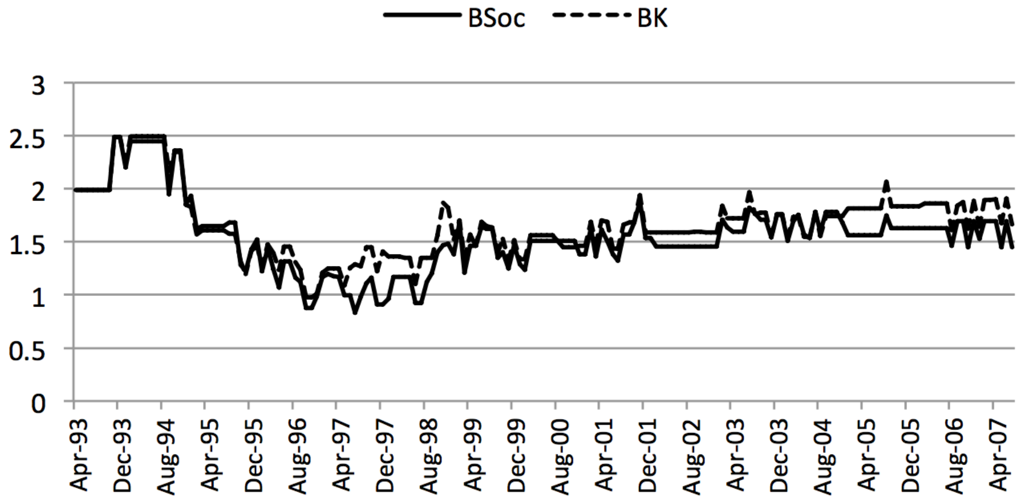
The figure plots the evolution of the mean and median of the quoted credit card rates for the UK. The data is obtained from the quoted interest rates of the Bank of England.

Figure 3.3: Average quoted loan rate spreads for the UK banking sector



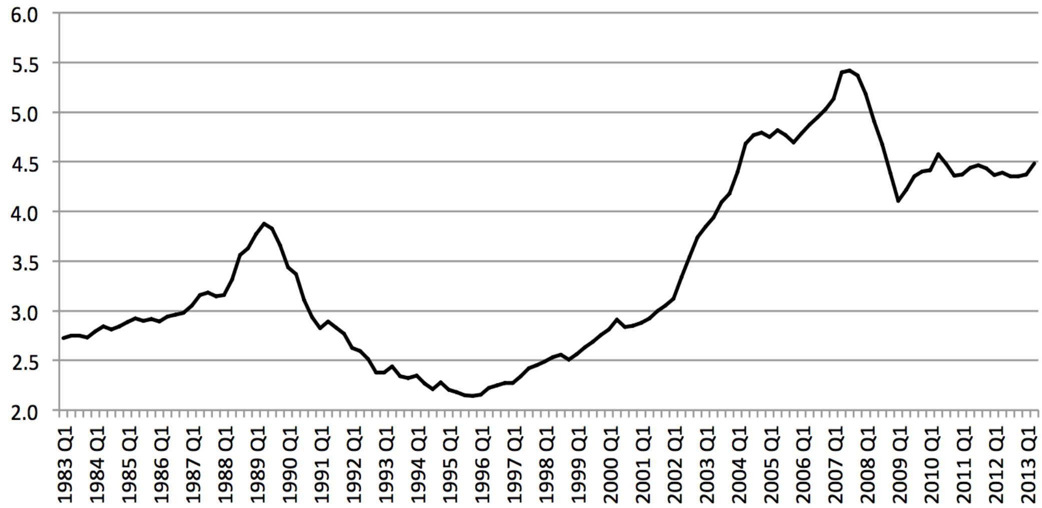
The figure plots the evolution of mean and median quoted loan rate spreads (the difference between loan rate and the policy rate). The data is obtained from the quoted interest rates of the Bank of England.

Figure 3.4: Average quoted mortgage rate spreads for the UK banking sector



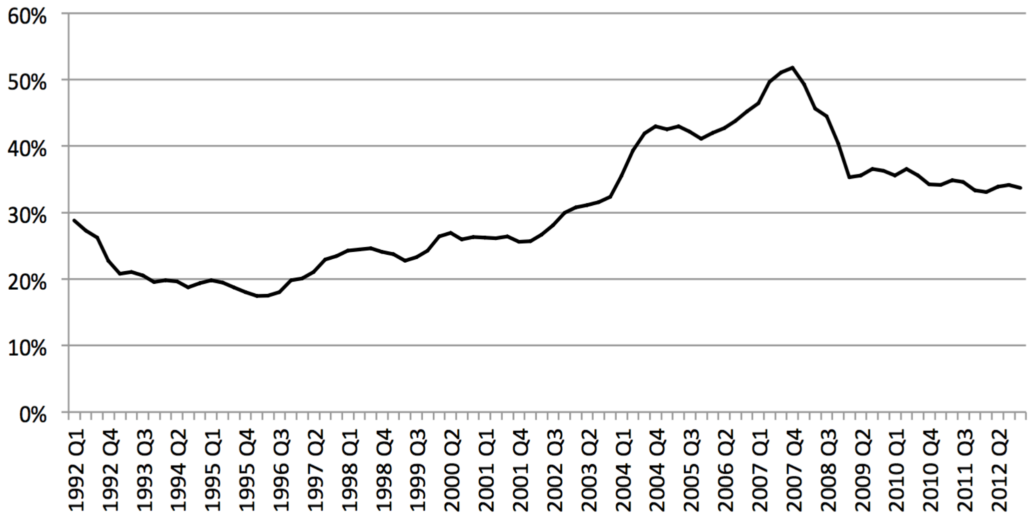
The figure plots the evolution of the average quoted mortgage rate spreads (the difference between the mortgage and the policy rates), for banks and building societies. The data is obtained from the quoted interest rates of the Bank of England.

Figure 3.5: First time buyer gross house price to earnings ratio



This figure shows the evolution of the average house price-to-earnings ratio for first-time buyers in the UK. The data is provided by Nationwide in its website: http://www.nationwide.co.uk/about/house-price-index/headlines. This index expresses the house price in terms of the annual income of the buyer.

Figure 3.6: First time buyer affordability index



This figure shows the evolution of the average affordability ratio for first-time buyers in the UK. The data is provided by Nationwide in its website: http://www.nationwide.co.uk/about/house-price-index/headlines. This index expresses the amount of monthly mortgage payments in terms of the monthly income of the buyer.

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