THE BANK LENDING CHANNEL OF UNCONVENTIONAL MONETARY POLICY: THE IMPACT OF THE VLTROS ON CREDIT SUPPLY IN SPAIN

2015

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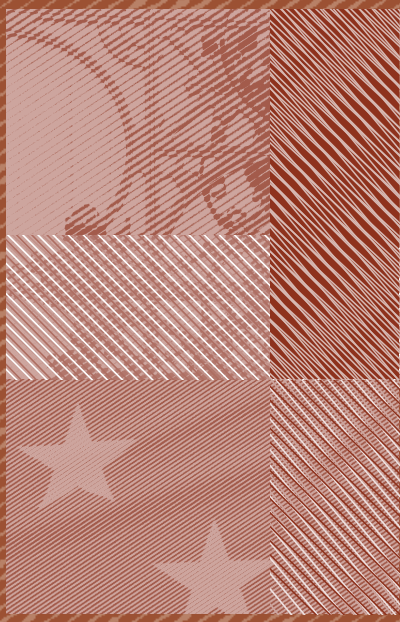

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THE BANK LENDING CHANNEL OF UNCONVENTIONAL MONETARY POLICY: THE IMPACT OF THE VLTROS ON CREDIT SUPPLY IN SPAIN [*]

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Abstract

We assess the impact on the credit supply to non-financial corporations of the two very-long-term refinancing operations (VLTROs) conducted by the Eurosystem in December 2011 and February 2012 for the case of Spain. To do so we use bank-firm level information from a sample of more than one million lending relationships over two years. Our methodology tackles the two main identification challenges: (i) how to disentangle credit supply from demand; and (ii) the endogeneity of VLTRO bids, as banks with more deteriorated funding conditions were more likely both to ask for a large amount of funds and to restrict credit supply. First, we exploit the fact that many firms simultaneously borrow from several banks to effectively control for firm-specific credit demand. Second, we exhaustively control for banks' funding difficulties by constructing several measures of balance-sheet strength and by including bank fixed effects. Our findings suggest that the VLTROs had a positive moderately-sized effect on the supply of bank credit to firms, providing evidence of a bank lending channel in the context of unconventional monetary policy. We also find that the effect was greater for illiquid banks and that it was driven by credit to SMEs, as there was no impact on loans to large firms.

Keywords: unconventional monetary policy, VLTRO, credit supply, bank lending channel.

JEL Classification: E52, E58, G21.

Resumen

El presente trabajo evalúa el impacto en el crédito a sociedades no financieras de las dos operaciones de financiación a tres años (VLTRO, en sus siglas en inglés) efectuadas por el Eurosistema en diciembre de 2011 y febrero de 2012 en el caso de España. Para ello se usa información a escala de banco-empresa de una muestra de más de un millón de relaciones de crédito durante dos años. La metodología implementada hace frente a los dos principales problemas de identificación: i) cómo separar la oferta de crédito de su demanda, y ii) la endogenidad de las peticiones de fondos en las VLTRO, puesto que es probable que los bancos con condiciones de financiación más deterioradas pidieran más fondos y contrajeran más el crédito. Primero, se usa el hecho de que muchas empresas tienen préstamos con varios bancos al mismo tiempo para controlar por la demanda de crédito específica a cada empresa. Segundo, se controla exhaustivamente por las dificultades de financiación de los bancos mediante la construcción de diversas medidas de fortaleza financiera y mediante la inclusión de efectos fijos de banco. Los resultados sugieren que las VLTRO tuvieron un efecto positivo, de tamaño moderado, en la oferta de crédito bancario a las empresas, lo que evidencia la existencia de un canal de crédito bancario en el marco de políticas monetarias no convencionales. También se encuentra que el efecto fue mayor en los bancos con menor liquidez y que dicho efecto fue principalmente impulsado por el crédito a pymes, dado que no hubo impacto alguno en la oferta de préstamos a grandes empresas.

Palabras clave: políticas monetarias no convencionales, oferta de crédito, canal de crédito bancario.

Códigos JEL: E52, E58, G21.

1 Introduction

The intensification of the European sovereign debt crisis in the second half of 2011 hampered euro area banks' access to market based-funding, both in the bond and monetary markets, especially in Greece, Portugal, Ireland, Italy and Spain. In those countries, bank CDS soared in parallel with the spreads of their sovereign bonds against the corresponding German figures, while their stock prices plummeted. Euro area banks mainly relied on the funds provided by the Eurosystem to sustain their liquidity position and their funding and deleveraging pressures raised the risk of disruptions in the credit supply to the non-financial private sector.

Against this backdrop, the ECB Governing Council decided to implement additional non-standard policy measures on 8 December 2011, which aimed to forestall a further contraction of credit through the mitigation of liquidity and funding risks. The agreed package of measures included two very long term refinancing operations (VLTROs) with a maturity of three years and the option of early repayment after one year, carried out as fixed rate tender procedures with full allotment. The interest rates of those operations were set much lower than those borne by banks in wholesale markets at the time.[1] The first VLTRO, conducted on 21 December 2011, provided €489 billion to 523 banks.[2] The second one took place on 29 February 2012 and allotted €530 billion to 800 credit institutions. Adding up the two, the total net refinancing amounted to more than €500 billion[3]. The total liquidity injection was massive: it increased the size of the Eurosystem's balance sheet by more than a fifth and accounted for 80% of the monetary base in the euro area, 20% of the total bank credit to euro area firms and almost 11% of the area's GDP (Andrade *et al*., 2015).

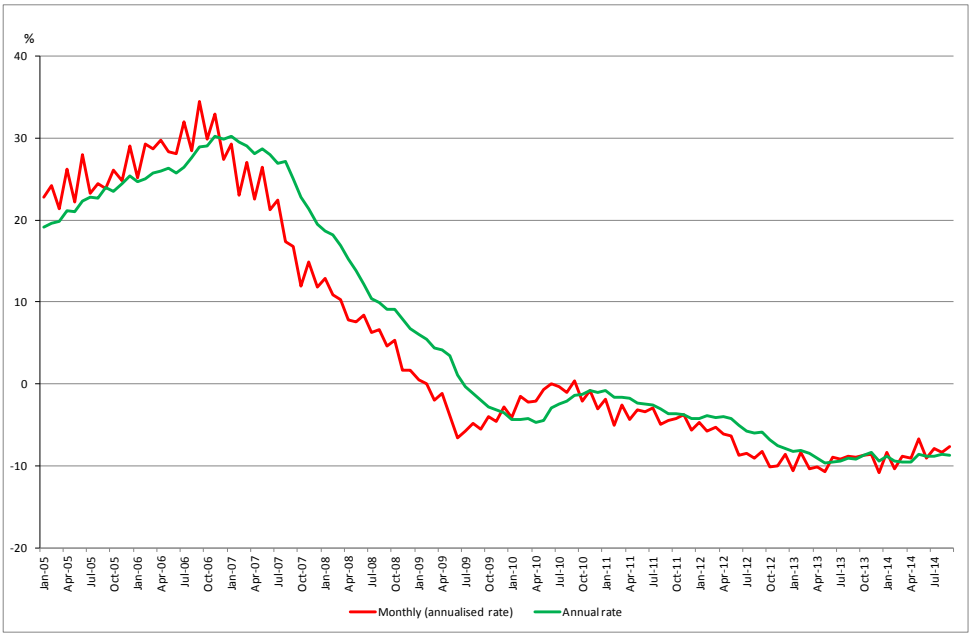
All the above figures imply that the VLTROs can be best regarded as a large positive liquidity shock to euro-area banks. But, since lending to the non-financial private sector kept declining –as shown for the case of Spanish firms in Figure 1- serious doubts about its effectiveness were raised. Nevertheless, the absence of a natural counterfactual, i.e., what would have happened had the Eurosystem not implemented the VLTROs, lead us to consider the following research question: would have lending declined much more if the VLTROs hadn't taken place? To put it differently, given the extremely weak macroeconomic conditions prevailing in that period –which reduced credit demand and increased credit risk- and the liquidity and funding risks experienced by banks –which constrained credit supply- did the VLTROs prevent a credit crunch?

1.The rate was fixed at the average rate of the main refinancing operations over the life of the respective operation. Interest had to be paid when the respective operation matured.

2. This amount included €45.7 billion transferred from the 12-month LTRO allotted in October.

3. For further details see the ECB Monthly Bulletin of January and March 2012.

Figure 1: credit growth to non-financial corporations (Spain)



Source: Bank of Spain. The yellow area corresponds to the period between December 2012-February 2013 when the two VLTROs took place.

To address those questions we use bank-firm level information from a sample of more than one million lending relationships drawn from the Credit Register of *Banco de España*. The case of Spain is particularly useful to evaluate the effectiveness of the VLTROs through the bank lending channel because it was severely hit by the financial market tensions that preceded those policies, it is one of the largest economies in the euro area and its firms largely rely on bank financing. Moreover, the bank lending channel is expected to be particularly important when banks have limited alternatives to retail deposits as a funding source (Bernanke and Gertler, 1995) and that was precisely the case, as access to wholesale capital markets was very restricted for most Spanish banks in that period.

Regarding the methodology, to assess the causal impact of the VLTROs on credit supply two main identification challenges must be addressed. First, credit supply must be disentangled from credit demand. Following the methodology first implemented by Gan (2007) and Khwaya and Mian (2008), we can identify shifts in credit supply by controlling for credit demand. This approach exploits the fact that many firms simultaneously borrow from several banks, which allows to compare credit growth across *different* lenders for the *same* firm in the *same* period. This *within-firm* comparison controls for all observable and unobservable, time-invariant and time-varying firm characteristics, including firm-specific changes in credit demand and risk.

The second identification challenge comes from the fact that the liquidity provided in those operations was not randomly allocated across banks, but freely chosen by each bidding bank and only limited by its available collateral. Hence, banks facing strong funding and deleveraging pressures were likely *both* to ask for a large amount of funds *and* to restrain credit supply, implying that the VLTRO bids would be an endogenous regressor in naïve specifications. To tackle this problem we exhaustively control for banks' funding difficulties by constructing several measures of balance-sheet strength (capital, liquidity, credit risk, etc)

using the confidential supervisory reports owned by *Banco de España* and we include bank fixed effects to account for time-invariant unobserved heterogeneity.

Our findings suggest that the VLTROs had a positive moderate-sized effect on the supply of bank credit to firms in the twelve[4] months after the first VLTRO (December 2011-November 2012), providing evidence of a bank lending channel in the context of unconventional monetary policy. Specifically, the aggregate impact of the two VLTROs on annual credit growth ranged between 0.8% and 1%. Of course, this does not mean that the VLTROs actually increased the available credit, but that they reduced the rate of contraction of lending: if they had not been implemented, credit to non-financial corporations would have decreased at a rate 0.8% higher than it did[5].

We also study whether the VLTROs had a heterogenous impact on banks depending of their balance-sheet strength. We find that, as in Jiménez *et al.* (2012),[6] the impact was greater on illiquid banks but, unlike their work, we find no differential effect regarding capital. We have two complementary explanations to this finding. First, as argued by Albertazzi *et al*. (2014), during systemic crises the nature of the bank lending channel may change. Second, regulatory capital, rather than leverage, may be the appropriate variable to look at during those crises[7].

Finally, we find that the VLTROs had a sizeable impact on the credit to SMEs, while they had no effect on the loans to large firms. This is an important aspect to take into account when assessing the effectiveness of the VLTROs because SMEs are much more vulnerable to a credit crunch than larger companies, as they often do not have access to alternative sources of external finance (debt and equity markets).

Nevertheless, a limitation of our study is that it only evaluates the *direct* impact of the VLTROs on bank credit, but there may be important *indirect channels* we ignore. For instance, by bolstering investors' confidence, the VLTROs may have improved banks' access to wholesale markets, which may have been translated into more lending to the private sector. Consistent with this idea, Dubecq *et al.* (2014) find that the VLTROs helped to ease the euro interbank market. In addition, according to Acharya and Steffen (2014), the VLTROs, by increasing the demand for sovereign debt by banks, helped to reduce sovereign spreads. Due to the positive correlation between sovereign spreads and private sector interest rates (Pancrazi *et al.*, 2014), the VLTROs would have indirectly reduced the borrowing costs borne by households and non-financial corporations. Finally, it cannot be ruled out that the VLTROs helped to repair banks' balance sheets, which could have had an indirect further impact on lending.

The rest of the paper is organised as follows. Section 2 reviews the most relevant literature on the subject. Section 3 discusses the identification strategy in detail. Section 4 explains the data sources and the sample selection and Section 5 describes the variables used in the empirical analyses. Section 6 comments on the main results, while Section 7 displays some robustness analyses. Section 8 concludes.

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4. Notice that, as the VLTROs had a maturity of 36 months with the option of early repayment after one year, any potential effect on the supply of credit is likely to be temporary. We restrict our study to the twelve months after the first VLTRO to identify the full liquidity shock implied by the VLTROs, i.e., before any possible repayment.

5. The average annual growth rate of the credit to non-financial corporations in the twelve months after the first VLTRO (between December 2011 and November 2012) was -5.1%,

6. Jiménez et al. (2012) also use the Spanish Credit Register to analyse the bank lending channel. However, they focus on monetary shocks measured by changes in money market rates, rather than on unconventional monetary policies.

7. In fact, Albertazzi et al. (2014), who use the supervisory Tier 1 capital ratio, find that the VLTROs were more effective in improving lending supply to SMEs (compared to larger firms) for illiquid but well-capitalised banks.

2 Literature review

While there is a large body of literature on unconventional monetary policy (see, *inter alia*, reviews in Cecioni *et al*. 2012 and Joyce *et al.* 2012) few works have specifically studied the impact of the VLTROs. Darracq-Paries and De Santis (2013) use (aggregate) information on credit supply conditions from the ECB's Bank Lending Survey (BLS) to identify the credit supply shock implied by the VLTROs in a panel-VAR for euro area countries. Their counterfactual experiments point to a relevant increase in bank loans to non-financial corporations and a moderate narrowing of lending rate spreads, together with a significant increase in the euro area real GDP and a somewhat higher inflation over the next two-to-three years. With more disaggregated information, Casiraghi *et al*. (2012) use bank-level data and the individual answers of the Italian banks to the BLS to assess the impact of the ECB's Securities Markets Programme (SMP), the VLTROs and the Outright Monetary Operations (OMT) on government yields, money market interest rates and credit availability. Then they use their estimations, together with the Bank of Italy model of the Italian economy, to gauge their macroeconomic impact. In the specific case of the VLTROs, using both regression and event-study methodologies, they find that the VLTROs significantly eased credit supply conditions –as proxied by the BLS index of credit supply- and substantially reduced the interest rates paid by Italian banks in the interbank market[8]. They also find that the overall impact of the three policies on GDP growth, mainly via the credit channel, was a cumulative increase of 2.7 pp over the period 2012-2013.

Besides our paper, there are only two other works that –to the best of our knowledge- study the impact of VLTROs on credit growth using bank-firm level data. Albertazzi *et al.* (2014) make use of the loan-level information of the Italian Credit Register and the fact that many firms borrow from several lenders to identify shifts in credit demand from shifts in credit supply, following the methodology first implemented by Gan (2007) and Khwaya and Mian (2008). They also control for the endogeneity of the VLTROs take-up (weaker banks are likely to borrow more funds and to restrict more credit supply) using an IV approach and bank fixed effects. While they do not find significant effects on lending growth for the average bank-firm lending relationship, they do find that the VLTROs were more effective in improving lending supply for SMES (compared to larger firms) for banks characterised by both a relatively large funding gap[9] and a relatively favourable capitalization. Andrade *et al.* (2015) use the loan-level information of the French Credit Register and individual bank balance-sheet information, as well as data on credit-risk rating and balance sheets for a subsample of firms, to tackle the same identification issues. Their main finding is that the VLTROs had a positive and sizeable impact on the supply of banking credit. They also find that the first VLTRO (December 2011) was more effective than the second one (February 2012) and that there was substantial heterogeneity in their impact across borrowers and lenders. Specifically, the VLTROs had a greater impact for larger companies, with the smallest firms not benefiting at all. Moreover, the effect was higher for firms whose loans were eligible to the Additional Credit Claim (ACC) program and for firms with more banking relationships, and lower for companies with long relationships with their banks. Finally, more capitalised banks lent marginally more.

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8. A similar result is found by Dubecq et al. (2014) in their analysis of the impact of the SMP, the VLTROs and the OMT on both liquidity and credit risks in the interbank market. Specifically, the VLTROs reduced liquidity premia by around 50 bp, while their effect on credit risk was much smaller.

9. Defined as the difference between retail loans and retail funding over retail loans.

3 Identification strategy

We can express our identification strategy with the following equations:

$$\Delta Credit_{ijt} = \beta VLTRO_{it} + a_{jt} + b_i + \sum_{k=1}^{K} b^k BANK\_VAR_{it-1}^k + e_{ijt} \quad (1)$$

$$VLTRO_{it} = VLTRO_i \cdot I(t \geq 2011M12) \quad (2)$$

where *i* refers to bank, *j* to firm and *t* to year:month; $VLTRO_{it}$ is our key regressor, the product of the gross amount of funds borrowed at the two VLTROs scaled by the bank's total assets ($VLTRO_i$) and an indicator variable $I(t \geq 2011M12)$ that equals 1 since December 2012 (when the first VLTRO took place); a_{jt} are time-varying firm fixed effects, b_i are bank fixed effects, BANK_VAR are time-varying bank characteristics and $e_{ijt}$is a regression disturbance. Following Jiménez *et al* (2012) BANK_VAR are lagged one period to alleviate endogeneity concerns.

Our goal is to identify the *causal* impact of the provision of liquidity via the two VLTROs on the supply of credit by Spanish banks to Spanish firms. The first identification challenge is to disentangle changes in credit supply from changes in credit demand, as what we observe is the equilibrium outcome, credit growth, and those changes are often correlated (Bentolila *et al*., 2013). For instance, a credit contraction in the midst of a financial crisis can be due to a reduction in credit supply (banks reduce credit supply to increase their capital and liquidity buffers) and to a downward shift of credit demand (firms reduce their demand for credit as they find less profitable investment opportunities).

The second identification challenge arises from the possible correlation between banks' recourse to non-standard measures such as VLTROs and supply problems. As banks with more deteriorated funding conditions are more likely both to borrow more funds in the VLTROs and to cut loan supply, our variable of interest, the liquidity provided by the VLTROs, may be endogenous.

We address the first problem by exploiting the fact that firms often borrow from several lenders, a strategy first implemented by Gan (2007) and Khwaja and Mian (2008). This allows us to include in the regression time-varying firm fixed effects a_{jt} (i.e., a dummy for every firm-year:month combination) that control for all (observed and unobserved) firm heterogeneity, including credit demand. Not controlling for demand would imply an omitted variable bias if $corr(VLTRO_{it}, a_{jt}) \neq 0$, which is likely to be case, as the same factors that influence banks' recourse to VLTROs (economic downturn, financial distress) are expected to affect firm's borrowing behaviour, as captured by a_{jt}. The sign of the bias cannot be ascertained a priori, as it depends on the borrowing behaviour of firms during recessions. Two scenarios can arise. First, *if* firms demand less credit during recessions (because of less positive NPV projects), then we should expect a downward bias in our estimates because there would be a negative correlation between $VLTRO_{it}$ and the omitted variable a_{jt} (the deeper the recession, the higher the bids by banks in the VLTROs and the lower the demand by firms). Second, *if* firms demand more credit during recessions (to avoid financial distress or having to sell core assets to offset their operating losses), then we should expect an upward bias in our estimates because there would be a positive correlation between $VLTRO_{it}$ and the

omitted variable a_{jt} (the deeper the recession, the higher the bids by banks in the VLTROs and the higher the demand by firms)[10].

To address the second problem we need to control for banks' funding conditions in our regressions to ensure $corr(VLTRO_{it}, e_{ijt}) = 0$. To do so we include a very comprehensive set of time-varying bank characteristics that capture factors such as liquidity, capital, loan quality, diversification of the credit portfolio, profitability and size (see their description in section 5) as well as bank fixed effects. Even if this approach did not fully remove this bias, we would know its sign: we would expect a downward bias in the coefficient on the VLTRO uptake, as banks with more (less) deteriorated funding conditions are expected to borrow more (less) funds in the VLTROs and to exhibit a lower (higher) credit growth. Hence our identification strategy would estimate the *lower bound* of the true causal impact.

10. Another source of bias would occur if firms are not randomly assigned to banks and banks' bids at the VLTROs depend on their financial strength. If weaker firms tend to match with weaker banks (Gertler and Gilchrist, 1994) and weaker banks borrow more funds in the VLTROs, the sign of the bias will depend on the borrowing behaviour of weak firms.

4 Data and sample selection

The main data sources are the Spanish Credit Register (CIR) and individual monthly bank balance sheets, both from *Banco de España.* The CIR contains monthly information on *all* bank-firm relationships over a reporting threshold of 6,000 € for credit institutions operating in Spain. We focus on credit[11] granted[12] to all non-financial Spanish companies.[13] As loans to companies are normally much larger than the reporting threshold, we can claim that we have the whole population of loans to those firms. Unconsolidated bank balance sheet data are drawn from the supervisory reports that banks have to file every month. We also use the gross amount of funds borrowed at the two VLTROs by each Spanish bank, which come from the Bank of Spain's Operations Department.

We collect data referring to the 11 months before and after the first VLTRO, i.e., from January 2011 to November 2012. We do not extend our sample period beyond November 2012 because of two reasons. First, in December 2012 there was a transfer of assets –mainly loans to construction and real estate companies- from the four nationalised Spanish financial institutions[14] to the SAREB (Company for the Management of Assets proceeding from Restructuring of the Banking System) but the CIR does not identify those loans, which are not inside banks' balance sheets any longer[15]. Second, as after one year banks had the option to repay any part of the amounts they were allotted in the operations, finishing our sample period in November 2012 allows us to identify the full liquidity shock implied by the VLTROs.

Concerning sample selection, we exclude sole proprietorships because some loans for those businesses may be smaller than the CIR's reporting threshold, potentially leading to a selection bias. To include firm fixed effects in our regressions we only keep those borrowing from at least two banks: those companies accounted for 38% of the total number of firms and 75% of the credit to non-financial companies registered in the CIR in December 2011. As for credit institutions, we keep all commercial banks, savings banks and credit cooperatives (around 95% of the Spanish financial system) while we remove financial credit establishments.[16] Non-Spanish branches and subsidiaries are excluded because the former could not obtain funds in the VLTROs and the latter could give them to their parent banks, which could use those funds to grant loans outside Spain. We also discard some specialised subsidiaries of Spanish banks because they did not participate in the VLTROs but obtained those funds indirectly through intra-group loans. Small credit institutions that only report quarterly information, as well as private banking institutions, are also dropped. Finally, we take out Spain's public bank, *Instituto de Crédito Oficial* (ICO) because a major part of the funds it channels to the private sector are *indirectly* provided through mediation facilities, in which ICO provides the funds to credit institutions, which grant the loans and assume the credit risk

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11. We include any instrument through which banks can provide credit to firms: financial loans, commercial loans, documentary credit, leasing, factoring, repos, securities lending and loans or credits transferred to a third party.

12. We include undrawn credit facilities to better capture the supply of credit by banks, as credit drawn is largely affected by the borrower's need for funds and, consequently, it is also determined by demand shifts.

13. Specifically, we include publicly limited companies, limited liability companies, unlimited liability companies and companies with a hybrid nature. We do not include sole proprietorships.

14. BFA-Bankia, Catalunya Banc, NCG Banco-Banco Gallego and Banco de Valencia.

15. Another asset transfer, of smaller magnitude, took place in February 2013, involving other four banks: Banco Mare Nostrum, CEISS, Caja3 and Liberbank.

16. Financial credit establishments are prohibited from receiving repayable funds from the public in the form of deposits, loans, temporary assignment of financial assets or other comparable instruments. This restriction makes it possible to release them from the obligation to be covered by a deposit guarantee fund. Their main activities are usually leasing, factoring and consumer credit.

associated with each operation under the conditions established by ICO. Hence the inclusion of ICO would lead to a downward bias in the estimation of the relationship between VLTRO uptake and credit growth.[17] The remaining 42 banks accounted for 84% of the total credit to firms in December 2011.

After applying all these filters and some outlier deletion, we end up with a sample of more than 12 million observations, with 42 banks, 315,000 firms, more than one million firm-bank relationships and 23 months.

A final issue that deserves some comments is our treatment of the M&A that took place during the sample period. We always treat them as an acquisition by the largest bank.[18] The alternative option, regarding them as the birth of a new bank, would imply breaks in the series and, in some cases, having observations for some banks only after the VLTROs took place, which could seriously undermine our identification strategy.[19] But, since our preferred option generates jumps in the series, we deal with them by deleting the outliers of credit growth[20] -as drastic increases in that variable may be due to a firm having outstanding loans with several banks that merge- and by the inclusion of intervention dummies to control for jumps in some financial ratios (e.g., capital). Nevertheless, the paper's main results do not change when we treat a merger as the birth of a new bank, as displayed in Appendix B.

17. In any case, ICO's balance sheet only accounted for a 2.4% of the Spanish financial sector in December 2010.
18. Measured by total assets in the month before the event.
19. As our key regressor is the product of the gross amount of funds borrowed at the two VLTROs scaled by the bank's total assets ($\mathrm{VLTRO_i}$) and an indicator variable $\mathrm{I(t \geq 2011M12)}$ that equals 1 since the implementation of the first VLTRO, for those banks the value of the regressor would be constant over time. As we also include bank fixed effects in our regressions, those banks would have to be excluded.
20. Specifically, we delete observations whose annualised monthly credit growth rates are above the 99th percentile of the distribution.

5 Variables

The dependent variable is the monthly credit growth rate, displayed in annualised terms, which is computed as changes in the stock of bank loans. Our key regressor ($VLTRO_{it}$) is the product of the gross amount of funds borrowed at the two VLTROs scaled by the bank's total assets ($VLTRO_i$) and an indicator variable $I(t \geq 2011M12)$ that equals 1 since December 2012 (when the first VLTRO took place).

The bank controls aim to capture bank characteristics associated with lending behaviour. Liquidity Ratio is the ratio of net liquid assets (i.e., net of their respective short-term liabilities) to total assets, where by liquid assets we mean cash, deposits with central banks and other credit institutions and debt securities net of deposits payable to central banks.[21] For robustness, we also use Liquidity Ratio 2, in which we use a more narrow definition of liquid assets and we only include cash and net deposits with central banks and other credit institutions.[22] To take into account the possible different impact of sovereign debt holdings from other types of liquid assets, we also compute the ratio of domestic sovereign debt to total assets (Sovereign Debt). Other variables that proxy liquidity risk are the Loan-To-Deposit Ratio and residents' and non-residents' deposits to total assets.

Capital Ratio is the ratio of the bank's core capital (total equity plus retained earnings) to total assets. For robustness, we also use Capital Ratio 2, in which bank's net worth substitutes for core capital. Notice that we do not use risk-weighted assets, so that ours is not a supervisory capital ratio, but a leverage ratio. We also include the non-performing loan ratio (NPL ratio) to measure loan quality, the Herfindahl-Hirschman Index (HHI) of the bank's credit portfolio by industry to capture diversification, the return on assets (ROA) and bank's total assets (in 2011 euros) to proxy size.

As firm-bank relationship variables we include Relationship Length, the number of months the firm had a working relationship with the bank, and Number Relations, the number of banks the firm operates with.

Finally, we also use intervention dummies to control for jumps in capital, liquidity, deposit and npl ratios and several sets of fixed effects, as discussed in section 3.

Table 1 provides a thorough description of the variables and the data sources. Descriptive statistics of the variables can be found in Table 2. The average bank in the sample borrowed an amount of funds equivalent to almost 9% of its balance sheet at the two VLTROs, while the bank that borrowed the most relative to its size obtained a 36.7%. 11 banks did no borrow any funds. We can also see that there is substantial variation across banks and time periods in their levels of liquidity (Liquidity Ratio, Liquidity Ratio 2, Sovereign Debt) and capital. In order to correct for high skewness some of these variables will be expressed in logs in our regressions. The correlation matrix of the variables is displayed in Appendix B.

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21. We include all debt securities net of deposits payable to central banks to proxy the remaining assets that can posted as collateral to get funds from the Eurosystem.

22. For further robustness, we have also computed another ratio in which the liquid assets are cash, net deposits with central banks and other credit institutions and public debt with a maturity up to one year. The correlations between this variable and Liquidity Ratio and Liquidity Ratio 2 are 0.96 and 0.99, respectively.

Table 1: description of variables

Variable	Definition	Variation	Source
Credit Growth	Monthly annualised growth rate of outstanding loans.	By bank-firm	Credit Register Banco de España
VLTRO	Funds borrowed at the two VLTROs to total assets.	By bank	Operations Department Banco de España
Liquidity Ratio	Cash, net deposits with central banks and other credit institutions and debt securities net of deposits payable to central banks to total	By bank	Supervisory reports Banco de España
Liquidity Ratio 2	Cash and net deposits with central banks and other credit institutions to total assets.	By bank	Supervisory reports Banco de España
Sovereing Debt	Domestic sovereign debt to total assets.	By bank	Supervisory reports Banco de España
Loan to Deposits	Ratio between the loans to the private sector and deposits.	By bank	Supervisory reports Banco de España
Capital Ratio	Core capital (total equity plus retained earnings) to total assets.	By bank	Supervisory reports Banco de España
Capital Ratio 2	Net worth to total assets.	By bank	Supervisory reports Banco de España
NPL Ratio	Non-performing loans to total loans to the private sector.	By bank	Supervisory reports Banco de España
Resident Deposits	Deposits by non-financial private residents to total assets.	By bank	Supervisory reports Banco de España
Non-resident Deposits	Deposits by non-financial private non-residents to total assets.	By bank	Supervisory reports Banco de España
ROA	Net income to total assets.	By bank	Supervisory reports Banco de España
Real Total Assets	Total Assets in 2011 euros.	By bank	Supervisory reports Banco de España
Relationship Length	Number of months the firm had a working relationship with the bank.	By bank-firm	Credit Register Banco de España
Number Relations	Number of banks the firm operates with.	By firm-time	Credit Register Banco de España
HHI	Herfindahl-Hirschman Index of the bank's credit portfolio by industry (2 digits)	By bank-time	Credit Register Banco de España

Table 2: descriptive statistics

Variable	Scale	Obs	Mean	Std.Dev.	Min	Max
Credit Growth (i,j,t)	% (annualised)	12,181,556	-13.37	28.57	-100	91.33
VLTRO (i)	%	42	9.69	8.15	0	36.61
Liquidity Ratio (i, t-1)	%	12,181,556	1.97	6.44	-65.36	36.07
Liquidity Ratio 2 (i, t-1)	%	12,181,556	-4.81	4.25	-65.36	45.35
Sovereign Debt (i, t-1)	%	12,181,556	6.14	2.38	0.00	25.05
Loan to Deposits (i, t-1)	%	12,181,556	188.70	35.43	80.08	471.29
Capital Ratio (i, t-1)	%	12,181,556	5.89	1.90	1.14	14.09
Capital Ratio 2 (t-1)	%	12,181,556	6.12	2.37	-11.35	14.15
NPL Ratio (i, t-1)	%	12,181,556	7.75	4.29	0.09	28.03
Resident Deposits (i, t-1)	%	12,181,556	31.17	10.42	0.63	74.37
Non-resident Deposits (i, t-1)	%	12,181,556	8.39	6.39	0.00	24.12
ROA (i, t-1)	%	12,181,556	-6.10	31.93	-629.19	18.90
Real Total Assets (i, t-1)	Millions €	12,181,556	192,312.00	153,743.20	1,623.72	487,297.40
Relationship Length (i,j, t-1)	months	12,181,556	9.56	6.15	1.00	23.00
Number Relations (i, t-1)	# banks	12,181,556	3.75	2.40	2.00	33.00
HHI (i, t-1)	%	12,181,556	17.09	8.32	5.69	46.48

6 Main results

Our first set of results is displayed in Table 3. Column (1) is just an OLS regression, whose estimates are expected to be biased and inconsistent because of the identification challenges explained in section 3. The coefficient on $VLTRO_{it}$ (henceforth, VLTRO) is negative but insignificant. The coefficient on VLTRO turns positive but insignificant when we add time-invariant firm fixed effects in column (2) and when we include firm-month fixed effects in (3). The coefficient becomes positive and significant at a 5% in column (4), which is consistent with the intuition that bank fixed effects mitigate the downward bias that arises from not fully controlling banks' balance-sheet strength and its correlation with VLTRO uptake. Moreover, as we know the sign of that bias, in case our strategy did not fully remove it, we could claim that *the coefficient on VLTRO is the lower bound of the true causal effect.*

Regarding statistical inference, the standard errors are always clustered at the bank level to deal with serial correlation within banks over time, one of the solutions advocated by Bertrand *et al.* (2004)[23], as we cannot rule out that the regression errors are serially correlated even after controlling for bank fixed effects. Alternatively, we have clustered at the bank-time level, the level in which the regressor of interest varies, as suggested by Angrist and Pischke (2009).[24] This would imply a large number of available clusters, a necessary condition for the consistency of clustered standard errors[25], but at the expense of not accounting for within-bank serial correlation. The results –available upon request- are very similar, just displaying a less conservative standard error for our key variable (0.024 vs. 0.029 in specification (4)), which renders VLTRO significant at 1%.

To estimate the aggregate impact of the two VLTROs on credit growth we make a weighted sum of the individual impact of those VLTROs on the credit growth of each bank, where the weights are computed as the ratio of the bank's outstanding loans to all loans in the sample. Algebraically:

$$Agg\_Impact = \sum_{i=1}^{I} \frac{\partial \Delta Credit_{ijt}}{\partial VLTRO_{it}} \cdot VLTRO_{it} \cdot \omega_i \quad (3)$$

where $$\frac{\partial \Delta Credit_{ijt}}{\partial VLTRO_{it}} = \beta \quad (4)$$

and

$$\omega_i = \frac{Credit_i}{\sum_{i=I}^{I} Credit_i} \quad (5)$$

Using the estimate of the coefficient on VLTRO of our preferred method (firm-month fixed effects and bank fixed effects), the aggregate impact of the two VLTROs on annual

23. Bertrand et al. (2004) show that this technique works well when the number of clusters is large, meaning by "large" 50 U.S. states in their empirical application. Similar numbers are suggested by Angrist and Pischke (2009). As in our application we have 42 clusters (banks), we believe that the number of clusters is large enough.

24. Moulton (1986) shows that, in the presence of intragroup correlation, conventional OLS standard errors or standard errors clustered at a level below the group underestimate the population standard errors.

25. The asymptotic justification of cluster-robust standard errors assumes that the numbers of clusters goes to infinity. With a small number of clusters the cluster-robust standard errors are downwards biased. But, in any case, Cameron et al. (2008) consider "few" five to thirty clusters, while in our application we have 42 clusters.

credit growth was 0.8%. Of course, this does not mean that the VLTROs actually increased the available credit, but that they reduced the rate of contraction of lending: if they had not been implemented, credit to non-financial corporations would have decreased at a rate 0.8% higher than it did. As the average annual growth rate of the credit to non-financial corporations in the twelve months after the first VLTRO (between December 2011 and November 2012) was -5.1%[26], we consider that the VLTROs had a moderate-sized effect.

With respect to the controls, column (4) shows that a higher Loan-To-Deposit Ratio is associated with higher credit growth *within* the same bank (as we include bank fixed effects).[27] Higher residents' deposits to total assets also lead to higher credit growth, while the opposite occurs in the case of non-residents' deposits, probably because more stable retail funding incentivises banks to lend more. A longer relationship between the firm and the bank (Relationship Length) also implies more credit, consistent with the findings on relationship lending (e.g., Petersen and Rajan, 1994). By contrast, more industry concentrated loan portfolios (higher HHI) are related with lower credit growth. Finally, notice that Capital Ratio is negative (and significant) in column (1), at variance with the conventional wisdom. This finding confirms our intuition that, in the period of analysis (2011-2012), strong deleveraging pressures and weak credit demand forced under-capitalised banks to increase their capital and reduce lending at the same time. Hence the need to control for credit demand and bank unobserved heterogeneity, as progressively done in columns (2)-(4).

26. Source: Banco de España.

27. By contrast, the coefficient on the Loan-To-Deposit Ratio is negative when bank fixed effects are not included [columns (1)-(3)] so that variability across banks is also exploited. In other words, banks with higher LTD ratios exhibit lower credit growth, probably because they are exposed to higher liquidity risk.

Table 3: impact of VLTROs on credit

	Dep. Var. Credit Growth			
	(1)	(2)	(3)	(4)
VLTRO*I(t>2011M11)	**-0.002**	**0.033**	**0.020**	**0.076****
	(0.065)	**(0.035)**	**(0.038)**	**(0.029)**
Liquidity Ratio (t-1)	0.042	-0.005	-0.006	0.027
	(0.059)	(0.039)	(0.042)	(0.021)
Log [Loan to Deposits (t-1)]	-3.194	-8.928***	-8.230***	3.228*
	(3.893)	(2.107)	(2.070)	(1.709)
Capital Ratio (t-1)	-0.260**	-0.076	-0.091	-0.076
	(0.113)	(0.107)	(0.114)	(0.088)
NPL Ratio (t-1)	0.071	0.059	0.045	-0.001
	(0.064)	(0.039)	(0.045)	(0.041)
Resident Deposits (t-1)	0.047	-0.042	-0.026	0.073
	(0.089)	(0.056)	(0.049)	(0.044)
No Resident Deposits (t-1)	-0.029	-0.011	-0.001	-0.057**
	(0.065)	(0.052)	(0.054)	(0.026)
ROA (t-1)	0.004	0.001	0.003	0.001
	(0.003)	(0.002)	(0.002)	(0.002)
Log [Total Assets (t-1)]	0.132	0.013	0.016	0.940
	(0.332)	(0.299)	(0.268)	(1.201)
Relationship Length (t-1)	0.664***	0.091**	0.249***	0.324***
	(0.093)	(0.036)	(0.043)	(0.039)
Log [HHI (t-1)]	2.370***	0.656	0.719	-1.379**
	(0.685)	(0.545)	(0.544)	(0.567)
Log [Number Relations (t-1)]	-1.336***	-3.731***		
	(0.231)	(0.197)		
Firm fixed effects	NO	YES	NO	NO
Firm-month fixed effects	NO	NO	YES	YES
Bank fixed effects	NO	NO	NO	YES
Month Dummies	YES	YES	NO	NO
Cluster level	Bank	Bank	Bank	Bank
# Observations	12,181,556	12,181,556	12,181,556	12,181,556
# Banks	42	42	42	42
# Months	23	23	23	23
R-squared	0.01	0.21	0.48	0.48

Estimator: OLS. Clustered standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: monthly annualised growth rate of outstanding loans. HHI is the Herfindahl-Hirschman Index of the bank's credit portfolio by industry. NPL ratio is the non-performing loan ratio.

We also wish to study whether the transmission of non-conventional monetary policy such as the VLTROs may be heterogeneous and it may depend on banks' characteristics. For that purpose, Table 4 shows the results of the most complete specification (whole set of fixed effects) in which we add the interactions of our key regressor with the liquidity and capital ratios. In column (1) the negative coefficient on the interaction between liquidity and VLTRO means that the positive impact of VLTROS on credit growth was higher on illiquid banks, consistent with previous evidence on the bank lending channel (e.g. Jiménez *et al*., 2012). By contrast, the coefficient on the interaction between capital and VLTRO is not

significant, implying that there was no differential impact regarding capital, at variance with what documented in previous works on the transmission of conventional monetary policy (Jiménez *et al*., 2012). We have two complementary explanations to this finding. First, as argued by Albertazzi *et al*. (2014), during systemic crises the nature of the bank lending channel may change. Second, regulatory capital, rather than leverage, may be the appropriate variable to look at during those crises. In fact, Albertazzi *et al.* (2014), who use the supervisory Tier 1 capital ratio, find that the VLTROs were more effective in improving lending supply to SMEs (compared to larger firms) for illiquid but *well-capitalised* banks. By contrast, Jiménez *et al.* (2012), in their study of conventional monetary policy mostly before the economic crisis (2002-2008), find that both illiquid and low-capitalised banks reacted more to changes in short-term interest rates.

Column (2), in which we drop the interaction between capital and VLTRO to rule out multicollinearity issues, confirms the result regarding liquidity. The results of column (2) can also be used to compute the aggregate impact of VLTROs on annual credit growth when accounting for the heterogenous impact regarding liquidity. To do so we replace equation (4) by equation (6):

$$\frac{\partial \Delta \mathrm{Credit}_{ijt}}{\partial \mathrm{VLTRO}_{it}} = \beta + \gamma \overline{\mathrm{LIQ}_i}$$

where $\overline{\mathrm{LIQ}_i}$ is the average liquidity of each bank in the 3 months prior to the first VLTRO.[28] We then compute equation (3), obtaining 0.85%, a very similar figure to the previous estimate

28. We use average liquidity values to deal with the volatility of the liquidity ratio.

Table 4: impact of VLTROs on credit
(capital and liquidity interactions)

	Dep. Var. Credit Growth	
	(1)	(2)
VLTRO*I(t>2011M11)	**0.055**	**0.083*** **
	(0.052)	**(0.030)**
VLTRO*I(t>2011M11) X Liquidity Ratio (t-1)	**-0.002***	**-0.002** **
	(0.001)	**(0.001)**
VLTRO*I(t>2011M11) X Capital Ratio (t-1)	**0.006**	
	(0.006)	
Liquidity Ratio (t-1)	0.037*	0.040*
	(0.022)	(0.021)
Log [Loan to Deposits (t-1)]	3.431*	3.218*
	(1.824)	(1.798)
Capital Ratio (t-1)	-0.123	-0.079
	(0.109)	(0.092)
NPL Ratio (t-1)	-0.016	-0.022
	(0.045)	(0.042)
Resident Deposits (t-1)	0.084*	0.075*
	(0.045)	(0.043)
No Resident Deposits (t-1)	-0.049*	-0.052*
	(0.027)	(0.026)
ROA (t-1)	0.001	0.001
	(0.002)	(0.002)
Log [Total Assets (t-1)]	1.023	1.118
	(1.209)	(1.240)
Relationship Length (t-1)	0.325***	0.325***
	(0.039)	(0.040)
Log [HHI (t-1)]	-1.496***	-1.597***
	(0.552)	(0.544)
Firm fixed effects	NO	NO
Firm-month fixed effects	YES	YES
Bank fixed effects	YES	YES
Month Dummies	NO	NO
Cluster level	Bank	Bank
# Observations	12,181,556	12,181,556
# Banks	42	42
# Months	23	23
R-squared	0.48	0.48

Estimator: OLS. Clustered standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: monthly annualised growth rate of outstanding loans. HHI is the Herfindahl-Hirschman Index of the bank's credit portfolio by industry. NPL ratio is the non-performing loan ratio.

Finally, another important research question that may be addressed is whether the impact that the VLTROs had on credit to non-financial corporations depended on the size of the companies. This is an important issue because SMEs depend much more on bank credit than larger companies as they often do not have access to alternative sources of external finance (debt and equity markets), which makes them much more vulnerable to a credit crunch.

In order to answer that question, we add to the previous dataset an indicator variable constructed by Martínez Carrascal and Mulino (2014) that distinguishes between SMEs and larger firms. Specifically, they use the balance sheet and the income statement of each firm from the *Central de Balances (CBI),* a database owned by *Banco de España.* With those data, in the case of firms that are both in the Spanish Credit Register (CIR) and in the CBI, they assess whether they are SMEs or not by following the criteria of the European Commission recommendation 2003/361: a company is an SME if it has less than 250 employees and its turnover does not exceed 50 million Euro or its balance sheet total is not greater than 43 million Euro. With those firms they also run several probit models to estimate the relationship between size category and total outstanding bank credit for each industry.[29] As the information on outstanding credit and industry is available in the CIR as well, they the use the predicted probabilities for each firm that is not the CBI (around 30%) to estimate its size category.[30]

We use the values of the variable at the end of December 2011, i.e., when the first VLTRO took place. The sample has around 307,700 firms, from which 305,000 are SMEs and the rest are large companies. We estimate our most complete specification (4) –time-varying firm fixed effects and bank fixed effects- for the two size categories separately. The results, presented in Table 5, indicate that the VLTROs had no impact on the credit to large firms, but they had a sizeable effect on the loans to SMEs. In fact, the coefficient on the key regressor in the subsample of SMEs is very similar to the coefficient that was estimated using the whole sample (see Table 3).

29. Specifically, for 99 industries following the NACE classification.

30. Specifically, they classify as an SME those firms that have a predicted probability of being an SME greater than 90% and they classify as a large company those that have a predicted probability lower than 40%. Those firms that have a probability between 40% and 90% are left unclassified. For details about the goodness of fit and classification errors of the model see Martínez Carrascal and Mulino (2014).

Table 5: impact of VLTROs on credit to large firms and SMEs

	Dep. Var. Credit Growth	
	Large	SMEs
	(1)	(2)
VLTRO*I(t>2011M11)	**0.001**	**0.077****
	(0.033)	**(0.031)**
Liquidity Ratio (t-1)	0.094**	0.026
	(0.035)	(0.021)
Log [Loan to Deposits (t-1)]	7.896***	3.024*
	(2.657)	(1.747)
Capital Ratio (t-1)	-0.257	-0.072
	(0.310)	(0.084)
NPL Ratio (t-1)	-0.076	0.004
	(0.094)	(0.041)
Resident Deposits (t-1)	0.209**	0.070
	(0.103)	(0.044)
No Resident Deposits (t-1)	-0.049	-0.056**
	(0.050)	(0.027)
ROA (t-1)	-0.004	0.001
	(0.004)	(0.002)
Log [Total Assets (t-1)]	-2.414	1.065
	(3.322)	(1.123)
Relationship Length (t-1)	0.768***	0.309***
	(0.123)	(0.039)
Log [HHI (t-1)]	-3.232	-1.299**
	(2.275)	(0.595)
Log [Number Relations (t-1)]		
Firm fixed effects	NO	NO
Firm-month fixed effects	YES	YES
Bank fixed effects	YES	YES
Month Dummies	NO	NO
Cluster level	Bank	Bank
# Observations	232,175	11,818,378
# Banks	42	42
# Months	24	24

Estimator: OLS. Clustered standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: monthly annualised growth rate of outstanding loans. HHI is the Herfindahl-Hirschman Index of the bank's credit portfolio by industry. NPL ratio is the non-performing loan ratio. Columns (1) and (2) show the estimations of separate regressions run on sub-samples of large companies and SMEs, respectively, following the classifications of European Commission (2003) and Martínez Carrascal and Mulino (2014).

7 Robustness analyses

7.1 Alternative liquidity and capital measures

Our first robustness check is to use alternative measures of liquidity and capital. Specifically, we substitute Liquidity Ratio by Liquidity Ratio 2 in our main regressions and we include the ratio of domestic sovereign debt to total assets (Sovereign Debt) to account for the possible different impact of sovereign debt holdings from other types of liquid assets. We also replace Capital Ratio by Capital Ratio 2.[31] The results, which are displayed in Table 6, are very similar to those from Table 3. The coefficient on our regressor of interest, VLTRO, is again insignificant in specifications (1) to (3) and its magnitude and significance level in our favourite estimation (4) are very similar. Like Liquidity Ratio, neither Liquidity Ratio 2 nor Sovereign Debt has a significant impact on credit growth. Like Capital Ratio, Capital Ratio 2 is negative (and significant) in our inconsistent estimation (1).

31. For brevity of exposition, we only show the results for Liquidity Ratio 2 and Capital Ratio 2, but the analyses with the other two possible combinations (Liquidity Ratio and Capital Ratio 2; Liquidity Ratio 2 and Capital Ratio) have also been carried out, yielding similar results, which are available upon request.

Table 6: impact of VLTROs on credit
(alternative liquidity and capital measures)

	Dep. Var. Credit Growth			
	(1)	(2)	(3)	(4)
VLTRO*I(t>2011M11)	**0.017**	**0.051**	**0.044**	**0.066****
	(0.087)	**(0.051)**	**(0.059)**	**(0.030)**
Liquidity Ratio 2 (t-1)	0.025	-0.008	-0.004	0.009
	(0.060)	(0.041)	(0.046)	(0.024)
Sovereign Debt (t-1)	-0.081	-0.057	-0.080	0.041
	(0.112)	(0.072)	(0.083)	(0.048)
Log [Loan to Deposits (t-1)]	-5.502	-9.368***	-8.713***	3.072*
	(3.401)	(1.981)	(1.906)	(1.781)
Capital Ratio 2 (t-1)	-0.306***	-0.108	-0.124	-0.090
	(0.107)	(0.100)	(0.108)	(0.063)
NPL Ratio (t-1)	0.013	0.040	0.022	-0.024
	(0.069)	(0.037)	(0.043)	(0.045)
Resident Deposits (t-1)	-0.001	-0.054	-0.041	0.087*
	(0.080)	(0.052)	(0.045)	(0.050)
Non-resident Deposits (t-1)	-0.018	-0.007	0.005	-0.055*
	(0.067)	(0.055)	(0.058)	(0.028)
ROA (t-1)	0.009**	0.003	0.004*	0.003*
	(0.004)	(0.002)	(0.003)	(0.002)
Log [Total Assets (t-1)]	0.014	-0.025	-0.039	1.081
	(0.340)	(0.305)	(0.272)	(1.147)
Relationship Length (t-1)	0.665***	0.093***	0.254***	0.324***
	(0.092)	(0.033)	(0.040)	(0.039)
Log [HHI (t-1)]	2.384***	0.645	0.737	-1.398**
	(0.687)	(0.538)	(0.550)	(0.647)
Log [Number Relations (t-1)]	-1.341***	-3.735***		
Firm fixed effects	NO	YES	NO	NO
Firm-month fixed effects	NO	NO	YES	YES
Bank fixed effects	NO	NO	NO	YES
Month dummies	YES	YES	NO	NO
Cluster level	Bank	Bank	Bank	Bank
# Observations	12,181,556	12,181,556	12,181,556	12,181,556
# Banks	42	42	42	42
# Months	23	23	23	23
R-squared	0.01	0.21	0.48	0.48

Estimator: OLS. Clustered standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: monthly annualised growth rate of outstanding loans. HHI is the Herfindahl-Hirschman Index of the bank's credit portfolio by industry. NPL ratio is the non-performing loan ratio.

We also use these alternative measures of liquidity and capital to assess whether the transmission of the VLTROs depended on banks' characteristics via interactions with our key regressor, as displayed in Table 7. As in Table 4, we find that the impact of VLTRO on credit growth does not depend on capital heterogeneity. Regarding liquidity, the interaction between VLTRO and Liquidity Ratio 2 is not significant, but that between VLTRO and Sovereign Debt is significant and negative: the impact of VLTRO on credit growth is higher for lower sovereign debt holdings relative to total assets. This finding suggests that not all types of liquid assets played the same role in the transmission of the funds provided by the VLTROs to the real economy.

Table 7: impact of VLTROs on credit

(capital and liquidity interactions, alternative measures)

	Dep. Var. Credit Growth	
	(1)	(2)
VLTRO*I(t>2011M11)	**0.150****	**0.142*****
	(0.062)	**(0.051)**
VLTRO*I(t>2011M11) X Liquidity Ratio 2 (t-1)	**-0.001**	**-0.001**
	(0.001)	**(0.001)**
VLTRO*I(t>2011M11) X Sovereign Debt (t-1)	**-0.009****	**-0.009****
	(0.004)	**(0.004)**
VLTRO*I(t>2011M11) X Capital Ratio 2 (t-1)	**-0.002**	
	(0.006)	
Liquidity Ratio 2 (t-1)	0.028	0.027
	(0.026)	(0.026)
Sovereign Debt (t-1)	0.144*	0.139*
	(0.076)	(0.071)
Log [Loan to Deposits (t-1)]	3.740*	3.764**
	(1.880)	(1.795)
Capital Ratio 2 (t-1)	-0.080	-0.092
	(0.088)	(0.063)
NPL Ratio (t-1)	-0.037	-0.035
	(0.050)	(0.047)
Resident Deposits (t-1)	0.107**	0.108**
	(0.050)	(0.050)
Non-resident Deposits (t-1)	-0.052	-0.050*
	(0.032)	(0.029)
ROA (t-1)	0.003*	0.003*
	(0.002)	(0.002)
Log [Total Assets (t-1)]	1.225	1.185
	(1.196)	(1.128)
Relationship Length (t-1)	0.326***	0.326***
	(0.039)	(0.039)
Log [HHI (t-1)]	-1.645**	-1.618**
	(0.640)	(0.652)
Firm fixed effects	NO	NO
Firm-month fixed effects	YES	YES
Bank fixed effects	YES	YES
Month dummies	NO	NO
Cluster level	Bank	Bank
# Observations	12,181,556	12,181,556
# Banks	42	42
# Months	23	23
R-squared	0.48	0.48

Estimator: OLS. Clustered standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: monthly annualised growth rate of outstanding loans. HHI is the Herfindahl-Hirschman Index of the bank's credit portfolio by industry. NPL ratio is the non-performing loan ratio.

7.2 Sample without credit cooperatives

A second robustness check consists of running the same regressions in a sub-sample of credit institutions that excludes credit cooperatives. While many of them did not ask for funds in the VLTROs, anecdotal evidence suggests that they might have obtained the liquidity indirectly, through inter-bank loans, which would have allowed them to grant more credit to the private sector. If that was indeed the case, their inclusion would generate a downward bias in the coefficient on VLTRO. In addition, the credit cooperatives of our sample only account for a 3% of the total loans, implying that taking them out does not jeopardise the external validity of our results. However, a disadvantage of this strategy regards statistical inference: as we have less banks, we also have less clusters (28 vis-à-vis 42 with the whole sample). As cluster-robust standard errors are downwards biased when there are few clusters (Cameron *et al*., 2008), we may over-reject the null hypothesis concerning the significance of the regression coefficients.

The results for this subsample, which are presented in Table 8, are slightly different from those with the whole sample. The coefficient on VLTRO is insignificant in specifications (1) and (3) but, unlike in previous analyses, it is significant and positive in (2), when time-invariant fixed effects are included. More remarkably, its magnitude in our favourite estimation (4) is larger than with the whole sample (0.096 vs. 0.076), which corroborates our intuition that the inclusion of credit cooperatives could have generated a downward bias. Using this coefficient the aggregate impact of the two VLTROs on annual credit growth is 1%, 2 pp. higher than the one estimated with the whole sample.

Table 8: impact of VLTROs on credit
(sample without credit cooperatives)

	Dep. Var. Credit Growth			
	(1)	(2)	(3)	(4)
VLTRO*I(t>2011M11)	**0.081**	**0.083***	**0.071**	**0.096****
	(0.082)	**(0.045)**	**(0.048)**	**(0.038)**
Liquidity Ratio (t-1)	0.148**	0.072	0.076	0.045**
	(0.072)	(0.044)	(0.046)	(0.022)
Log [Loan to Deposits (t-1)]	4.784	-4.008	-2.831	3.640**
	(4.967)	(2.555)	(2.401)	(1.717)
Capital Ratio (t-1)	-0.251*	-0.086	-0.095	-0.093
	(0.132)	(0.116)	(0.128)	(0.093)
NPL Ratio (t-1)	0.066	0.060	0.053	-0.009
	(0.074)	(0.039)	(0.039)	(0.048)
Resident Deposits (t-1)	0.169*	0.028	0.054	0.093**
	(0.095)	(0.059)	(0.047)	(0.044)
No Resident Deposits (t-1)	-0.053	-0.027	-0.016	-0.068**
	(0.058)	(0.048)	(0.052)	(0.030)
ROA (t-1)	0.001	-0.000	0.001	0.001
	(0.003)	(0.002)	(0.002)	(0.002)
Log [Total Assets (t-1)]	0.776*	0.468	0.478	0.680
	(0.415)	(0.330)	(0.294)	(1.211)
Relationship Length (t-1)	0.700***	0.111***	0.278***	0.339***
	(0.101)	(0.038)	(0.046)	(0.041)
Log [HHI (t-1)]	3.117***	1.239**	1.291**	-1.212*
	(0.759)	(0.562)	(0.551)	(0.615)
Log [Number Relations (t-1)]	-1.390***	-3.695***		
	(0.235)	(0.204)		
Firm fixed effects	NO	YES	NO	NO
Firm-month fixed effects	NO	NO	YES	YES
Bank fixed effects	NO	NO	NO	YES
Month Dummies	YES	YES	NO	NO
Cluster level	Bank	Bank	Bank	Bank
# Observations	11,435,407	11,435,407	11,435,407	11,435,407
# Banks	28	28	28	28
# Months	23	23	23	23
R-squared	0.01	0.22	0.50	0.50

Estimator: OLS. Clustered standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: monthly annualised growth rate of outstanding loans. HHI is the Herfindahl-Hirschman Index of the bank's credit portfolio by industry. NPL ratio is the non-performing loan ratio.

We can also use this subsample to analyse the heterogeneity in the transmission of the VLTROs via interactions with our key regressor, as displayed in Table 9. As with the whole sample, the interaction with capital is not significant while the interaction with liquidity is negative and significant: the positive impact of VLTROS on credit growth was higher on illiquid banks, while there was no differential impact regarding capital.

Table 9: impact of VLTROs on credit
(capital and liquidity interactions, sample without credit cooperatives)

	Dep. Var. Credit Growth	
	(1)	(2)
VLTRO*I(t>2011M11)	**0.074**	**0.101****
	(0.055)	**(0.039)**
VLTRO*I(t>2011M11) X Liquidity Ratio (t-1)	**-0.001**	**-0.002***
	(0.001)	**(0.001)**
VLTRO*I(t>2011M11) X Capital Ratio (t-1)	**0.008**	
	(0.007)	
Liquidity Ratio (t-1)	0.048**	0.054**
	(0.023)	(0.021)
Log [Loan to Deposits (t-1)]	3.814**	3.584*
	(1.800)	(1.821)
Capital Ratio (t-1)	-0.150	-0.093
	(0.114)	(0.096)
NPL Ratio (t-1)	-0.028	-0.028
	(0.050)	(0.049)
Resident Deposits (t-1)	0.103**	0.090**
	(0.045)	(0.043)
No Resident Deposits (t-1)	-0.058*	-0.064**
	(0.032)	(0.030)
ROA (t-1)	0.001	0.001
	(0.002)	(0.002)
Log [Total Assets (t-1)]	0.788	0.855
	(1.199)	(1.248)
Relationship Length (t-1)	0.340***	0.339***
	(0.041)	(0.041)
Log [HHI (t-1)]	-1.346**	-1.395**
	(0.612)	(0.593)
Firm fixed effects	NO	NO
Firm-month fixed effects	YES	YES
Bank fixed effects	YES	YES
Month Dummies	NO	NO
Cluster level	Bank	Bank
# Observations	11,435,407	11,435,407
# Banks	28	28
# Months	23	23
R-squared	0.50	0.50

Estimator: OLS. Clustered standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: monthly annualised growth rate of outstanding loans. HHI is the Herfindahl-Hirschman Index of the bank's credit portfolio by industry. NPL ratio is the non-performing loan ratio.

8 Conclusions

The intensification of the European sovereign debt crisis in the second half of 2011 hampered euro area banks' access to market based-funding, especially in Greece, Portugal, Ireland, Italy and Spain. The funding and deleveraging pressures borne by those credit institutions risked curtailing lending to euro area households and non-financial firms. Against this background, the ECB carried out two very long term refinancing operations (VLTROs), characterised as fixed rate tender procedures with full allotment and a maturity of three years, in December 2011 and February 2012, with the aim to forestall a further contraction of credit through the mitigation of liquidity and funding risks. The participation in these operations by banks was very large, implying a massive liquidity injection in the financial sector.

The goal of this paper is to assess the effectiveness of the VLTROs in the case of Spain. While lending to the non-financial private sector kept declining after the implementation of those measures, would it have declined much more if the VLTROs hadn't taken place? The Spanish experience is particularly informative because Spain was severely hit by the European sovereign debt crisis, it is one of the largest economies in the euro area and it has a bank-based financial system.

To answer that question two main identification challenges must be addressed. First, credit supply must be disentangled from credit demand, as the extremely weak macroeconomic conditions prevailing in that period reduced credit demand and increased credit risk, leading to a contraction of credit growth. Second, as banks facing strong funding and deleveraging pressures were likely *both* to ask for a large amount of funds *and* to restrain credit supply, the VLTRO bids are expected to be an endogenous regressor in naïve specifications.

To tackle those identification challenges we use a sample on more than one million bank-firm relationships drawn from the Credit Register of *Banco de España.* Following Gan (2007) and Khwaya and Mian (2008), we exploit the fact that many firms simultaneously borrow from several banks, which allows to compare credit growth across *different* lenders for the *same* firm in the *same* period. This *within-firm* comparison controls for all observable and unobservable, time-invariant and time-varying firm characteristics, including firm-specific changes in credit demand and risk. Regarding the second problem, we exhaustively control for banks' funding difficulties by constructing several measures of balance-sheet strength (capital, liquidity, credit risk, etc) using the confidential supervisory reports owned by *Banco de España* and we add bank fixed effects to account for time-invariant unobserved heterogeneity.

Our findings suggest that VLTROs had a positive moderate-sized effect on the supply of bank credit to firms in the twelve months after the first VLTRO (December 2011-November 2012), providing evidence of a "bank lending channel" in the context of unconventional monetary policy. Specifically, the aggregate impact of the two VLTROs on annual credit growth ranged between 0.8% and 1%[32]. We also study whether the VLTROs had a heterogeneous impact on banks depending of their balance-sheet strength. We find, as

32. Due to our empirical approach, notice that we only measure the temporary impact of the VLTROs on the supply of credit. As the VLTRO uptakes were essentially long-term loans to banks, which had to be repaid at some time, the existence of a permanent effect seems unlikely.

in previous literature, that the impact was greater on illiquid banks, but we find no differential effect regarding capital. We have two complementary explanations to this finding. First, as argued by Albertazzi *et al*. (2014), during systemic crises the nature of the bank lending channel may change. Second, regulatory capital, rather than leverage, may be the appropriate variable to look at during those crises. Finally, we find that the VLTROs had a sizeable impact on the credit to SMEs, while they had no effect on the loans to large firms. This is an important aspect to take into account when assessing the effectiveness of the VLTROs because SMEs are much more vulnerable to a credit crunch than larger companies, as they often do not have access to alternative sources of external finance.

Since our identification strategy relies in the use of firms with multiple bank relationships, a limitation of our study is that we must exclude firms that only operate with one bank. As those firms account for around 62% of the total number of firms but they only account for 25% of the outstanding credit[33], we may infer that they are smaller (and probably younger) than those with multiple bank relationships[34]. As argued by Gan (2007), small and young firms are more affected by the information asymmetry in the credit markets due to higher "information costs", so we should expect the lending channel to be stronger in their case. This is also consistent with the findings of Kwhaja y Mian (2008, pp. 1426-1427), who find the lending channel to be stronger in firms that only operate with one bank.[35] Hence, by excluding those firms, we may consider our estimates the *lower bound* of the aggregate effect on the credit on *all* companies.

Another limitation of our study is that it only evaluates the *direct* impact of the VLTROs on bank credit, ignoring some important *indirect channels,* such as their positive effect on investors' confidence, on the euro interbank market, on sovereign spreads and on banks' balance sheets. All these channels may have been translated into more lending to the private sector.

33. Source: Spanish Credit Register, December 2011.

34. .This conclusion is consistent with the findings of Hernández-Cánovas and Köeter-Kant (2008) and Ongena and Smith (2000): the larger (and the older) the firm, the higher the likelihood of having multiple banking relationships.

35. The same conclusion can be drawn from Jiménez et al. (2012, pp. 2313-2317), if one compares the results of Table 2 (all firms) with those of Table 3 (only firms with more than one banking relationship).

9 Appendix A: variables' correlation matrix

	Credit Growth (t)	VLTRO*I (t>2011M11)	Liquidity Ratio (t-1)	Liquidity Ratio 2 (t-1)	Sovereign Debt (t-1)	Log [Loan to Deposits (t-1)]	Capital Ratio (t-1)	Capital Ratio 2 (t-1)	NPL Ratio (t-1)	Resident Deposits (t-1)	Non-resident Deposits (t-1)	ROA (t-1)	Log [Total Assets (t-1)]	Relationship Length (t-1)	Log [Number Relations (t-1)]	Log [HHI (t-1)]
Credit Growth (t)	1															
VLTRO*I(t>2011M11)	0.022	1														
Liquidity Ratio (t-1)	-0.003	-0.366	1													
Liquidity Ratio 2 (t-1)	0.002	0.148	0.546	1												
Sovereign Debt (t-1)	0.014	0.436	0.063	-0.044	1											
Log [Loan to Deposits (t-1)]	-0.050	-0.035	-0.227	-0.213	0.116	1										
Capital Ratio (t-1)	-0.034	-0.091	0.116	0.185	-0.230	0.065	1									
Capital Ratio 2 (t-1)	-0.040	-0.215	0.267	0.218	-0.277	0.065	0.923	1								
NPL Ratio (t-1)	0.038	0.579	-0.468	-0.122	0.238	-0.054	-0.338	-0.497	1							
Resident Deposits (t-1)	0.048	-0.048	0.081	0.055	-0.209	-0.892	-0.175	-0.171	0.015	1						
Non-resident Deposits (t-1)	-0.055	-0.328	0.132	-0.093	-0.033	0.676	0.294	0.349	-0.329	-0.724	1					
ROA (t-1)	-0.016	-0.309	0.292	0.096	-0.189	0.011	0.166	0.389	-0.439	0.022	0.162	1				
Log [Total Assets (t-1)]	-0.046	-0.106	-0.014	0.098	-0.076	0.567	0.183	0.256	-0.260	-0.698	0.672	0.093	1			
Relationship Length (t-1)	0.050	0.609	-0.377	0.071	0.271	-0.020	0.122	0.019	0.375	-0.118	-0.164	-0.242	0.052	1		
Log [Number Relations (t-1)]	-0.013	0.035	-0.023	-0.027	0.045	0.031	-0.049	-0.056	0.041	-0.023	-0.008	-0.030	-0.039	0.079	1	
Log [HHI (t-1)]	0.061	0.257	-0.143	-0.139	0.126	-0.414	-0.454	-0.515	0.516	0.463	-0.602	-0.245	-0.506	-0.041	0.031	1

10 Appendix B: robustness check for M&A

As explained in the paper, we have treated all M&A as acquisitions by the largest bank because the alternative option, regarding them as the birth of a new bank, would imply breaks in the series. Nevertheless, a potential caveat of our approach is that we are implicitly assuming that the acquiring bank and the bank that arises after the merger is the same credit institution (conditional on observables such as credit growth or balance-sheet ratios). This assumption may seem pretty reasonable when the merger takes place between a very large (acquiring) bank and one or more very small (acquired) banks, as the new credit institution is likely to have the business model and the management of the former. But the assumption may be too strong when the merger occurs among several banks of similar size and very different characteristics, implying that the credit institution created by the merger may be a very different from any of their predecessors. This issue may be especially problematic in our case, as we rely on bank fixed effects in our regressions.

To check the sensitivity of the results to this assumption we have eliminated the observations of *all* the banks involved in a merger *before* the merger actually takes place. By doing so we don't have to impose that assumption in our identification strategy and we also avoid any jumps in the series (at the expense, of course, of losing some observations). The main caveat of this alternative approach is that we lose two banks in our sample, as two mergers occurred after the VLTROs took place. As our key regressor is the product of the gross amount of funds borrowed at the two VLTROs scaled by the bank's total assets ($\mathrm{VLTRO_i}$) and an indicator variable $\mathrm{I(t \geq 2011M12)}$ that equals 1 since the implementation of the first VLTRO, for these two banks the value of the regressor is constant over time. As we also include bank fixed effects in our regressions, the observations on these banks have to be excluded.

Nevertheless, the main results, shown in Tables B1 and B2, are very similar to those reported in the main text.[36]

36. We have also carried out the robustness analyses shown in the main text (alternative capital and liquidity ratios, sample without credit cooperatives) using this dataset. The results, available upon request, are also very similar.

Table B1: impact of VLTROs on credit

	Dep. Var. Credit Growth			
	(1)	(2)	(3)	(4)
VLTRO*I(t>2011M11)	**0.001**	**0.039**	**0.029**	**0.076****
	(0.066)	**(0.036)**	**(0.039)**	**(0.032)**
Liquidity Ratio (t-1)	0.043	-0.004	-0.004	0.002
	(0.064)	(0.040)	(0.044)	(0.024)
Log [Loan to Deposits (t-1)]	-2.897	-8.473***	-7.717***	2.380*
	(3.891)	(2.087)	(2.077)	(1.266)
Capital Ratio (t-1)	-0.283**	-0.071	-0.094	0.071
	(0.119)	(0.106)	(0.117)	(0.062)
NPL Ratio (t-1)	0.085	0.078**	0.061	0.023
	(0.065)	(0.038)	(0.044)	(0.043)
Resident Deposits (t-1)	0.053	-0.034	-0.018	0.066**
	(0.089)	(0.055)	(0.049)	(0.033)
No Resident Deposits (t-1)	-0.042	-0.030	-0.021	-0.056**
	(0.064)	(0.051)	(0.053)	(0.027)
ROA (t-1)	0.004	0.001	0.002	0.001
	(0.003)	(0.002)	(0.002)	(0.002)
Log [Total Assets (t-1)]	0.197	0.095	0.094	3.003***
	(0.331)	(0.291)	(0.263)	(0.998)
Relationship Length (t-1)	0.704***	0.111***	0.279***	0.351***
	(0.092)	(0.033)	(0.042)	(0.039)
Log [HHI (t-1)]	2.219***	0.382	0.426	-1.182*
	(0.670)	(0.496)	(0.486)	(0.623)
Log [Number Relations (t-1)]	-1.440***	-3.770***		
	(0.224)	(0.185)		
Firm fixed effects	NO	YES	NO	NO
Firm-month fixed effects	NO	NO	YES	YES
Bank fixed effects	NO	NO	NO	YES
Month Dummies	YES	YES	NO	NO
Cluster level	Bank	Bank	Bank	Bank
# Observations	11,858,404	11,858,404	11,858,404	11,858,404
# Banks	40	40	40	40
# Months	23	23	23	23
R-squared	0.01	0.21	0.49	0.49

Estimator: OLS. Clustered standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: monthly annualised growth rate of outstanding loans. HHI is the Herfindahl-Hirschman Index of the bank's credit portfolio by industry. NPL ratio is the non-performing loan ratio.

Table B2: impact of VLTROs on credit

	Dep. Var. Credit Growth	
	(1)	(2)
VLTRO*I(t>2011M11)	**0.090***	**0.082****
	(0.053)	**(0.032)**
VLTRO*I(t>2011M11) X Liquidity Ratio (t-1)	**-0.002****	**-0.002****
	(0.001)	**(0.001)**
VLTRO*I(t>2011M11) X Capital Ratio (t-1)	**-0.002**	
	(0.006)	
Liquidity Ratio (t-1)	0.014	0.014
	(0.025)	(0.025)
Log [Loan to Deposits (t-1)]	2.264	2.371*
	(1.549)	(1.374)
Capital Ratio (t-1)	0.091	0.073
	(0.104)	(0.063)
NPL Ratio (t-1)	0.000	0.002
	(0.047)	(0.044)
Resident Deposits (t-1)	0.067*	0.070**
	(0.035)	(0.031)
No Resident Deposits (t-1)	-0.050*	-0.050*
	(0.027)	(0.026)
ROA (t-1)	0.001	0.001
	(0.002)	(0.002)
Log [Total Assets (t-1)]	3.438***	3.355***
	(1.156)	(1.053)
Relationship Length (t-1)	0.352***	0.352***
	(0.040)	(0.040)
Log [HHI (t-1)]	-1.423**	-1.407**
	(0.619)	(0.601)
Firm fixed effects	NO	NO
Firm-month fixed effects	YES	YES
Bank fixed effects	YES	YES
Month Dummies	NO	NO
Cluster level	Bank	Bank
# Observations	11,858,404	11,858,404
# Banks	40	40
# Months	23	23
R-squared	0.49	0.49

Estimator: OLS. Clustered standard errors in parenthesis. *** p<0.01, ** p<0.05, * p<0.10. Dependent variable: monthly annualised growth rate of outstanding loans. HHI is the Herfindahl-Hirschman Index of the bank's credit portfolio by industry. NPL ratio is the non-performing loan ratio.

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