Surviving the perfect storm: the role of the lender of last resort

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Abstract
When banks are hit by a severe liquidity shock, central banks have a key role as lenders of last resort. Despite the well-established importance of this mechanism, there is scarce empirical evidence that allows analyzing this key role of central banks. We are able to explore a unique setting in which banks suddenly lost access to market funding due to contagion fears at the onset of the euro area sovereign debt crisis. Using monthly data at the loan, bank, and firm level, we are able to test the role of the central bank in a scenario of imminent collapse. We find that the liquidity obtained from the central bank played a key role in supporting the supply of credit to the real economy.

JEL: E44, E5, G21

Keywords: lender of last resort, monetary policy, credit channel, financial crisis, fixed rate full allotment.

1. Introduction

One of the critical functions of central banks is to act as lenders of last resort. When liquidity suddenly dries up, the central bank should stand ready to supply liquidity to distressed banks as long as their solvency is not at risk (Freixas *et al.* 2000, 2004; Repullo 2005; Rochet and Vives 2004). Otherwise, banks may be unable to replace their funding sources and therefore be forced to undertake fire sales and reduce credit supply. Despite this critical role, there is scarce empirical evidence on this topic. In this paper we explore a unique large-scale event that might be the perfect lab to assess the role of the lender of last resort in avoiding the collapse of credit supply in an economy.

We focus on a large unanticipated shock that hit the Portuguese banking system in the early days of the sovereign debt crisis in the euro area. In May 2010 Portuguese banks suddenly lost access to international medium and long-term wholesale debt markets, which represented around 46% of their total liabilities. This sudden stop scenario was mainly linked to investors' concerns about contagion from the sovereign crisis that was then emerging in Greece. Despite this large scale sudden stop, there were no apparent implications in terms of aggregate credit conditions. We argue that this outcome was due to the role of the ECB as a lender of last resort to banks. In October 2008, the ECB had introduced a fixed-rate full allotment policy in all refinancing operations. Under fixed rate full allotment counterparties had their bids fully satisfied, against a broad range of eligible assets as collateral. This policy allowed Portuguese banks to escalate their recourse to Eurosystem monetary operations in the aftermath of the sudden stop, from around 9% of GDP in March 2010 to around 27% of GDP in August 2010.

Against this background, we aim to identify the role played by this increased intermediation through the ECB. Our empirical analysis takes advantage of a unique combination of detailed and extensive datasets available for the Portuguese economy. The main dataset used is the Portuguese Central Credit Register (CRC), which has monthly data on virtually all bank loans granted by Portuguese financial institutions to non-financial corporations. Further, we collect monthly information on banks' liquidity, capital, and balance sheet items, as well as on their holdings of Portuguese government bonds. Finally, we also collect bank-level data on the recourse to monetary policy operations and standing facilities, and the collateral pool.

Ensuring an adequate identification of the impact of the enhanced liquidity provision by the Eurosystem raises considerable challenges. In this respect, several features of the data help in the identification. First, the liquidity shock was arguably exogenous and unanticipated. When Portuguese banks lost access to markets, there were no explicit concerns about financial stability in Portugal. The shock was due to changes in the perception of market players regarding long standing structural vulnerabilities of the Portuguese economy, amidst heightened uncertainty due to the Greek crisis. This explains why the liquidity

shock hit all banks irrespective of their underlying financial position. Second, there was high heterogeneity in the individual banks' funding sources, including the recourse to the Eurosystem, both before and after the liquidity shock. In this respect, exploring the heterogeneity across banks at the micro level is helpful in the identification of the main transmission channels. In particular, we are able to precisely quantify the exposure of each bank to the liquidity shock, given that we have unique information on the residual maturity of every security held by each bank. Third, the richness of the data allows for a careful identification of demand and supply in the loan market. In particular, we select only firms that have a relationship with more than one bank and employ firm fixed-effects estimation in order to control for firm-specific loan demand effects (Khwaja and Mian 2008). Further, bank variables are included at their levels prior to the liquidity shock, in order to mitigate endogenous effects. With this identification strategy, we are able to assess the effect of the expanded liquidity provision on banks' loan supply to non-financial corporations in a sudden stop scenario.

Our empirical strategy analyses differences in banks' credit supply behavior during this period, by exploiting the heterogeneity in (i) the drop in wholesale funding experienced by each bank; (ii) the ex-ante exposure of each bank to the liquidity shock and (iii) the individual change in ECB funding. These approaches yield consistent results. In particular, after controlling for several banks' characteristics, we are not able to find significant differences in credit supply behavior across banks depending on their level of exposure to the liquidity shock. This result is robust to several alternative measures of banks' exposure to the shock or to their interaction with other banks' characteristics. Further, changes in ECB funding across banks were also not related with differences in their credit supply behavior. We thus conclude that, despite the sudden loss of access to wholesale markets, the virtually unlimited access to central bank funding was instrumental in avoiding a collapse in Portuguese credit markets.

To further establish the role of the lender of last resort on banks' balance sheets we design a simple counterfactual analysis. The main idea is to show what could have happened to banks' assets if there had been no alternative source of funding when access to wholesale markets suddenly disappeared in May 2010. This allows us to more precisely quantify the magnitude of the shock. Given the strong dependence of the largest Portuguese banks on market funding, we show that a collapse in credit would be unavoidable without the support of a lender of last resort.

Even though credit supply remained unscathed after this unprecedented shock, banks' balance sheets were significantly changed. The increase in ECB funding during this period largely surpassed the liabilities that needed to be refinanced. This led to a (temporary) expansion of banks' balance sheets. We show that at least part of this excess liquidity was channeled to an increase in holdings of domestic sovereign bonds. This is consistent with the idea that there

was financial repression in this period, with sovereigns in distress encouraging banks to buy their debt (Becker and Ivashina 2018; Ongena *et al.* 2018). We also show that there was some recomposition within loan portfolios, with banks more exposed to the shock preferring to lend to less risky borrowers.

Our paper contributes to the empirical literature on the role of the lender of last resort, which is scarce. The paper by Drechler *et al.* (2016) is one important recent contribution. These authors use bank-level data on ECB borrowing and find that euro area banks used this liquidity to engage in risk-shifting strategies, rather than lending to the real economy. Garcia-de-Andoain *et al.* (2016) also analyze the ECB's role as a de facto lender of last resort. They show that the central bank played a key role in ensuring the functioning of interbank markets. During the global financial crisis, the ECB was able to replace the demand for liquidity in the interbank market. Later, during the euro area sovereign debt crisis, the ECB actually increased the supply of liquidity in the most affected countries.

In contrast to the scarce empirical evidence, there is an extensive theoretical literature on the role of the lender of last resort, with an emphasis on potentially pervasive moral hazard problems that arise out of this insurance mechanism (Freixas *et al.* 2004; Gorton and Huang 2004; Ratnovski 2009; Rochet and Tirole 1996; Rochet and Vives 2004; Wagner 2007).

More generally, our study is also somewhat related to the flourishing recent line of research on the impact of unconventional measures. Some examples in this literature using loan-level data are Acharya and Mora (2015); Acharya *et al.* (2016); Alcaraz *et al.* (2014); Andrade *et al.* (2018); Berger *et al.* (2017); Cahn *et al.* (2017); Cantero-Saiz *et al.* (2014); Carpinelli and Crosignani (2018); Chakraborty *et al.* (2016); Chodorow-Reich (2014); Crosignani *et al.* (2016); Daetz *et al.* (2016); Darracq-Paries and De Santis (2015); Ferrando *et al.* (2015); Garcia-Posada and Marchetti (2016); Jasova *et al.* (2018); Morais *et al.* (2018); Ramcharan and Yu (2014). However, our paper distances itself from this literature, as it focuses on what a central bank is "conventionally" designed to do, i.e. to act as a lender of last resort in a situation of liquidity dry up, rather than on unconventional measures adopted during a crisis.

This paper is organized as follows. In Section 2 we discuss the role of a central bank as a lender of last resort, providing also a timeline of the main events in the period analyzed. In Section 3 we describe the data used and in Section 4 we present an overview of what happened with banks during this unique period. In Section 5 we use loan-level data to examine the role of access to central bank funding in the supply of credit to firms. In Section 6 we take an additional step in establishing clearly the role of the lender of last resort in avoiding a collapse of the banking system, by attempting to design a counterfactual scenario. In Section 7 we explore whether banks used ECB funding to buy sovereign debt, amidst an environment of financial repression. In Section 8 we summarize our main findings.

2. The role of a central bank under a sudden stop scenario

Bagehot (1873) was among the first to acknowledge the role of the lender of last resort, arguing that "theory suggests, and experience proves, that in a panic the holders of the ultimate bank reserve (whether one bank or many) should lend to all that bring good securities quickly, freely, and readily. By that policy they allay a panic; by every other policy they intensify it." Since then, the consensus has been to lend freely, usually at penalty rates and against good collateral, to all solvent but illiquid banks (Bordo 2014).

Several models have been designed to better understand the role of the lender of last resort, focusing in particular in the moral hazard problem created by this mechanism (Freixas *et al.* 2000, 2004; Gorton and Huang 2004; Ratnovski 2009; Rochet and Tirole 1996; Rochet and Vives 2004; Wagner 2007). While the lender of last resort, together with deposit insurance, are crucial to avoid runs and promote financial stability, these two institutional mechanisms need to be complemented with regulation (Rochet and Vives 2004). These two backstop mechanisms create moral hazard due the weakened incentives of depositors to monitor the banks (Calomiris and Kahn 1991). Banks might also become too-big-to-fail, to ensure that they will be more likely to benefit from government support in case of distress (Stern and Feldman 2004).

Acharya *et al.* (2012) show that a lender of last resort plays a crucial role if it credibly provides liquidity to needy banks, thus avoiding a collapse in interbank markets. This role can be better performed if the central bank is able to act both as a lender of last resort and a bank supervisor, as its monitoring ability becomes superior. This can be especially important if we recall Bagehot's advice to lend to illiquid but otherwise solvent banks.

However, despite these extensive theoretical underpinnings, to the best of our knowledge, there are only a few papers empirically looking at the role of central banks as lenders of last resort during the global financial crisis. The paper that is closest to ours is Drechler *et al.* (2016). Using weekly data on bank-level borrowing from the ECB between August 2007 and December 2011, these authors find that euro area banks used central bank funding to invest in high-yield sovereign debt. This risk-shifting behavior was stronger for weakly-capitalized banks. These findings are inconsistent with the classical predictions of the lender of last resort theory, according to which banks borrow from the lender of last resort to avoid fire sales of their existing asset holdings. This should allow banks to continue lending to the economy, thereby preventing a credit crunch.

Garcia-de-Andoain *et al.* (2016) examine the role of the ECB as a lender of last resort during the global financial crisis. Using data from interbank payments, these authors show that the ECB was able to satisfy the demand for liquidity in the interbank market in the aftermath of the failure of Lehman Brothers. Further, the ECB increased the supply of liquidity in stressed countries during the euro sovereign debt crisis.

Looking into the past, Carlson and Wheelock (2018) examine the consequences of the creation of the Federal Reserve (with a lender of last resort mandate) on the interbank market's exposure to risk. They find that the creation of an institution with power to act as a lender of last resort made the interbank market more resilient to liquidity shocks, but less to solvency shocks. Simultaneously, banks reduced their holdings of liquid assets, thus illustrating the negative effects on moral hazard of the lender of last resort.

Acharya *et al.* (2016) contrast the role of the ECB as a lender of last resort to that of a buyer of last resort. This amounts to comparing the effect of central bank lending through Long Term Refinancing Operations (LTRO) to the effect of buying assets through Outright Monetary Transactions (OMT). The effects of the announcement of these operations are assessed on sovereign bond yields, sovereign credit default swap spreads, banks' holdings of sovereign bonds, banks' equity prices, banks' credit default swap spreads, and US money market funds' investments in European banks. The authors find that buying assets proved more effective than lending to banks by containing pervasive bank-sovereign feedback loops.

Though de Haan *et al.* (2017) do not look explicitly at the role of the lender of last resort, these authors do find that borrowing from central banks allowed euro area banks to mitigate the impact of wholesale funding shocks on lending to the real economy.

In this paper we are able to perform a more targeted test of the role of the lender of last resort in a crisis setting. Since the early days of the global financial crisis, the ECB, together with central banks worldwide, actively intervened to restore the transmission of monetary policy and fulfill its mandate. This included not only a series of policy interest rate cuts, but also a large set of unconventional monetary policy measures. In the Fall of 2008, immediately after the failure of Lehman Brothers, the ECB adopted a fixed rate full allotment procedure at its regular refinancing operations, ensuring that all the liquidity needs of banks were met at a fixed interest rate, as long as banks had enough eligible collateral to pledge. Importantly, the ECB accepts as counterparts for monetary policy operations a vast range of credit institutions, thus mitigating the stigma effect (Bignon and Jobst 2017). The fixed rate full allotment helped banks to avoid the stigma effect often associated with borrowing from the lender of last resort, as discussed by Anbil and Vossmeyer (2017).

Around the same time, the list of assets eligible as collateral was expanded, with several increments in the difficult period that would follow. To some extent, we might argue that in this setting the ECB's role as a lender of last resort was significantly expanded. [1] Garcia-de-Andoain *et al.* (2016) discuss how

1. Calomiris *et al.* (2016), Choi *et al.* (2016) and Nyborg (2017) discuss the relevance of central banks' collateral policy in its lender of last resort role.

this policy was crucial in enabling the ECB to act as a lender of last resort, even though that role is not explicitly mentioned in any official documentation about the functioning of the euro area.

The unlimited access to liquidity for a large set of counterparts, against a large list of eligible collateral, created a safety net that allowed the ECB to effectively act as a lender of last resort in the euro area. In this paper, we examine what happened to Portuguese banks when they suddenly became entirely unable to rollover any debt in wholesale debt markets. This sudden loss of access to markets could have jeopardized the survival of many Portuguese banks, which operated with high loan-to-deposit ratios. However, despite the large and unforeseen nature of the shock, lending to firms remained largely unscathed, as documented in Section 4. The answer to this apparent puzzle lies in the lender of last resort support by the ECB. The ample liquidity framework defined by the ECB early in the crisis (most notably the fixed rate full allotment) allowed Portuguese banks to easily substitute market funding by ECB loans and thus maintain the financing to the real economy.

3. Data

We collect monthly data from January 2005 to December 2013 from several datasets. The main dataset has bank loan level data from the Portuguese Central Credit Register (CRC), which is a database managed by Banco de Portugal. The CRC covers virtually all bank loans granted in Portugal (all financial institutions granting credit in Portugal are required to report to the CRC on a monthly basis all loans above 50 euro). We consider only loans granted to non-financial corporations.[2] The CRC has information on the type of loan, the debtor, and the amount, while also including information on loan defaults and renegotiations, as well as potential credit liabilities associated with irrevocable commitments.

The data on loans are merged with data on banks' characteristics coming from supervisory reports. There were 29 credit institutions eligible to participate in Eurosystem operations that were active in the corporate loan market between March and December 2010.[3] All institutions report monthly balance sheet data, with the exception of the branches of credit institutions with head office in the EU, which report on a quarterly basis. For these, we consider data at end of quarter for the missing months. These branches do not report regulatory capital ratios. We run a regression of regulatory capital ratios

2. de Haan *et al.* (2017) shows that lending to non-financial firms is more sensitive to wholesale funding shocks than lending to households.

3. In March 2010 there were 42 credit institutions that were eligible to participate in Eurosystem operations. However, 13 were investment banks or credit institutions specialized in consumer credit, thus not granting loans to non-financial corporations.

on banks' leverage ratios (defined as equity as a percentage of total assets), which is available for all the credit institutions in the sample. We then use the predicted values of these regressions as proxies for the regulatory capital ratio of the five branches of credit institutions with head office in the EU in our database.

We collect monthly data on banks' supervisory liquidity reports. These reports include information that is rarely available, including details on banks' assets and liabilities in several maturity brackets, thereby allowing us to compute liquidity gaps between assets and liabilities in different time horizons. More importantly, we also use this data source to compile information on all the liabilities maturing in the months after the shock, thereby having a very precise measure of the exposure of each bank to the refinancing shock. The information included in these reports also allows us to identify the value of eligible assets for Eurosystem operations on banks' balance sheets (including those that are not currently part of the collateral pool).

We collect data at the bank level on the recourse to Eurosystem liquidity by type of operation (both liquidity provision and absorption), and on the pool of eligible assets to refinancing operations. We also collect data on banks' holdings of Portuguese government debt during this period, given its large increase and its relevance in the context of the sovereign debt crisis.

Finally, in order to control for firms' characteristics, we also used data on firms' balance sheet and income statements reported through *Informação Empresarial Simplificada* (*IES*). This database covers the entire universe of Portuguese non-financial corporations, given its mandatory nature. The frequency of the data is annual.

Table 1 summarizes the variables used in the analysis of the period in which Portuguese banks lost access to wholesale markets, using loan level data.[4] *Ln(assets)* is the logarithm of the total assets of the bank. *Loan-to-dep* is the ratio between total credit granted by the bank and resources from customers. *Liq ratio* is the amount of liquid assets (cash, loans and advances to credit institutions, and other loans and advances) over total assets. *Solv ratio* is the prudential total capital ratio, defined as total own funds over risk-weighted assets. For branches of credit institutions with head office in the EU, which do not report prudential capital ratios, we use the predicted values of a regression of capital ratios on leverage ratios. *ECB funding* is the total amount of liquidity provided by the Eurosystem net of liquidity deposited at the Eurosystem, over total assets of the bank. *Liq gap 1M-3M* is the difference between liquid assets and liabilities with residual maturity between 1 and 3 months as a percentage of stable funding. A higher gap thus represents more liquidity. *Liab.res.mat.<6M* is the share of total liabilities with residual maturity below 6 months as a percentage of total assets. *Sec.res.mat.<6M* is the share of debt

4. Table A.1 in the Appendix shows the descriptive statistics for bank level data.

securities with residual maturity below 6 months as a percentage of total assets. *Collateral* is the amount of reported assets in the bank's balance sheet eligible for Eurosystem operations over total assets of the bank. *loan growth* is the log change of the total amount of effective loans granted by the bank to the borrower. *(loans + lines) growth* is the log change of the loans including unused credit lines. *Securities* is the outstanding amount (book-value) of securities issued by each bank.

Variable	T	Unit	Obs	Mean	Std.Dev.	P25	Median	P75
Ln(assets)_j	Mar/2010	ln(euro)	218 283	24.27	1.11	23.35	24.72	25.23
Loan-to-dep_j	Mar/2010	ratio	218 283	164.80	30.27	144.40	161.00	180.50
Liq ratio_j	Mar/2010	ratio	218 283	16.60	7.81	10.26	15.46	22.00
Solv ratio_j	Mar/2010	ratio	218 283	9.43	11.95	11.47	12.10	13.90
ECB funding_j	Mar/2010	ratio	217 291	3.02	2.45	0.98	2.21	4.81
collateral_j	Mar/2010	ratio	218 283	10.82	6.03	7.45	9.20	12.87
Liq gap 1M-3M_j	Mar/2010	ratio	218 283	-3.27	6.36	-4.55	-3.53	-0.72
$\text{Liab.res.mat.}{<}6\text{M}_j$	Mar/2010	ratio	208 464	35.87	16.03	29.02	31.56	34.69
$\text{Sec.res.mat.}{<}6\text{M}_j$	Mar/2010	ratio	208 464	8.66	9.93	1.09	7.15	9.82
$\Delta\text{ECB funding}_j$	Mar-Aug/10	p.p. change	220 688	6.19	5.53	0.00	7.00	10.90
$\Delta\text{Securities}_j$	Mar-Aug/10	p.p. change	201 828	-2.19	5.11	-3.36	-3.05	0.00
loan growth_{ij}	Mar-Dec/10	p.p. change	168 469	-11.12	75.40	-29.59	-5.77	5.18
$\text{(loan+lines) growth}_{ij}$	Mar-Dec/10	p.p. change	188 796	-10.94	67.18	-24.70	-2.54	1.09
$\Delta\text{Ln(assets)}_j$	Mar-Dec/10	p.p. change	199 993	1.69	11.75	-4.37	5.49	8.65
$\Delta\text{Loan-to-dep}_j$	Mar-Dec/10	p.p. change	191 729	-4.98	17.15	-13.89	-4.59	0.20

TABLE 1. Descriptive statistics of the variables used in the analysis

Notes: The index j stands for bank and the index i stands for firm. T is the moment in time to which the statistics refer. Variables description: *Ln(assets)* is the logarithm of the total assets of the bank. *Loan-to-dep* is the ratio between total credit granted by the bank and resources from customers. *Liq ratio* is the amount of liquid assets (cash, loans and advances to credit institutions, and other loans and advances) over total assets. *Solv ratio* is the prudential total capital ratio, defined as total own funds over risk-weighted assets. For branches of credit institutions with head office in the EU, which do not report prudential capital ratios, we use the predicted values of a regression of capital ratios on leverage ratios. *ECB funding* is the total amount of liquidity provided by the Eurosystem net of liquidity deposited at the Eurosystem, over total assets of the bank. *Liq gap 1M-3M* is the difference between liquid assets and liabilities with residual maturity between 1 and 3 months as a percentage of stable funding. A higher gap thus represents more liquidity. *Liab.res.mat.<6M* is the share of total liabilities with residual maturity below 6 months as a percentage of total assets. *Sec.res.mat.<6M* is the share of debt securities with residual maturity below 6 months as a percentage of total assets. *Collateral* is the amount of reported assets in the bank's balance sheet eligible for Eurosystem operations over total assets of the bank. *loan growth* is the log change of the total amount of effective loans granted by the bank to the borrower. *(loans + lines) growth* is the log change of the loans including unused credit lines. *Securities* is the outstanding amount (book-value) of securities issued by each bank. Loan growth rates were winsorized at the 1st and 99th percentiles, while the liquidity variables were winsorized at the 5th and 95th percentiles.

4. What happened at the bank level?

We argued in Section 2 that the ECB's role as lender of last resort was substantially enhanced due to the implementation of the fixed rate full allotment policy and the enlargement of the list of eligible collateral for monetary policy operations. These two crucial measures were adopted in the Fall of 2018, immediately after the failure of Lehman Brothers, to ensure that banks would be able to borrow all the liquidity they needed from the central bank.

These measures implied a considerable expansion of the ECB balance sheet. However, Portuguese banks recorded only a mild increase in their access to ECB funding in this early period of the crisis (2007-08). Indeed, Portuguese banks were not hardly hit by the global financial crisis that followed the collapse of Lehman Brothers, as their exposure to subprime markets and, more generally, to US markets, was residual. Constraints in access to interbank funding during this period were accommodated with occasional access to monetary policy operations and to the issuance of bonds with government guarantees.[5] In turn, loan supply was barely affected during this period, with credit growth rates remaining far above those of the euro area, despite the declining trend. In December 2008 the annual growth rate of loans to non-financial corporations stood at 10.5%.

This relatively benign scenario in Portugal suffered a blow in May 2010. Suddenly, Portuguese banks entirely lost access to funding in international wholesale debt markets (Figure 1).[6] This sudden stop scenario was not directly due to intrinsic fragilities in the Portuguese banking system. Instead, it reflected the environment of heightened uncertainty in the beginning of the sovereign euro area crisis, when investors were wary of potential contagion from Greece. This sudden loss of access to markets was sizable enough to threaten the survival of many Portuguese banks, which operated with relatively high loan-to-deposit ratios (around 160%, on average, in early-2010, as shown in Table 1). Their heavy reliance on market funding made them especially vulnerable to a rise in funding uncertainty (Ritz and Walther 2015). However, despite the high dependence on access to wholesale markets, when we look at credit growth during this period it seems that nothing extraordinary happened (Figure 1). The annual growth rate of loans to non-financial corporations was stable at around 1% during 2010, thus implying that banks were refinancing most loans

5. Interbank markets remained severely impaired for a long period (Acharya and Merrouche 2013; Afonso *et al.* 2011; Brunnermeier 2009). Iyer *et al.* (2014) examine the 2007 shock on interbank markets using Portuguese data.

6. "From May 2010 on, Portuguese banks lost access to international medium and long-term wholesale debt markets." Financial Stability Report Banco de Portugal, May 2012.

and even extending some new credit.[7] Figure 1 also shows that banks' total assets actually increased somewhat during 2010. This shows that despite the collapse in funding markets for Portuguese banks, not only did firms continue to have access to bank loans, but actually banks increased the total volume of assets held.

The answer to this apparent puzzle lies in the lender of last resort support by the ECB. Portuguese banks were able to benefit from a safety net that had been created during the previous years, including the fixed rate full allotment procedure and the extended list of eligible collateral. These two measures allowed banks to access all the liquidity they wished from the ECB at a fixed rate, using an expanded list of assets that could be used as collateral. Indeed, the collateral constraint was not binding at the time, thus allowing banks to use ECB's monetary policy operations without major limitations.

Against this background, in just a few months, the recourse of Portuguese banks to the Eurosystem increased from around 9% of GDP in March 2010 to around 27% of GDP in August 2010. The evolution of this variable clearly illustrates the unanticipated nature of this shock (Figure 1). If banks were anticipating that they would get into distress, we would expect a gradual increase in this variable over a few months. However, access to Eurosystem funding clearly spiked in May 2010. Note that in this period the Eurosystem did not implement new monetary policy measures and the Eurosystem aggregate excess liquidity remained broadly stable. The nature of the shock thus helps to create the perfect lab to examine the role of the lender of last resort.

The sudden loss of access to wholesale markets by Portuguese banks was largely unexpected, reflecting a sudden rise in investors' risk aversion, amidst growing concerns about the Greek sovereign debt crisis spreading to other vulnerable euro area countries. Given the fragilities of the fiscal and economic situation of the Portuguese economy in that period, investors perceived Portugal to be the next "victim". These concerns actually materialized, but only one year later, with the government asking for international financial assistance. This shock is thus an example of the pervasiveness of sovereign-bank links, namely of how a weak sovereign can suddenly compromise financial stability if markets' perceptions shift suddenly.

We should recall that according to Bagehot's principles, the lender of last resort should lend to illiquid but otherwise solvent banks. The line between the two is not always clear. The global financial crisis has shown that the former can easily lead to the latter and that a bank with strong capital ratios might nonetheless fail in a very rapid succession of events.

In the Spring of 2010, the understanding of the domestic and international authorities (and the assessment of market participants based on their pricing

7. Loan growth rates became negative later, in 2011, when the country was under an international financial assistance program.

of risk) was that the distress in the banking system was entirely related with liquidity problems, coming from the contagion from the sovereign distress, which became especially acute after Greece's request for financial assistance.[8] At the time there were not any signs of solvency problems in the Portuguese banking system. With hindsight, several Portuguese banks had to be bailed out or bailed in later in time (Beck *et al.* 2017). However, these problems became apparent only much later and to a large extent they were exacerbated by the prolonged financial and economic problems in the Portuguese economy.[9]

In Figure 2 we summarize the change in the most relevant balance sheet items of Portuguese banks between March 2010, i.e. immediately before they lost access to markets, and the end of that year, December 2010. On the asset side, we can see that the explanation for the increase in banks' total assets during this period comes from the expansion of the portfolio of sovereign bonds. Even though before the shock Portuguese banks were among the ones with a smaller exposure to debt issued by its sovereign (1.5% of total assets in December 2009), that situation started to change in 2010.[10] In Section 7 we will analyze how this is related with access to ECB funding. Loans granted to firms and to households remained broadly stable during this period. There is a slight increase in interbank assets, suggesting that banks hoarded some liquidity, which is reasonable in a context of heightened uncertainty.

On the liabilities side, the changes were deeper. The figure shows that the drop in wholesale market funding was more than compensated by increased access to ECB funding. This means that banks were able to benefit from the ample liquidity support provided by the ECB within its regular monetary policy operations to continue lending to firms and households and, on top of that, to also lend to the sovereign, who had also lost access to funding. Deposits showed a mild increase during this period, showing that depositors' trust was unscathed at the time, thus confirming the importance of coupling two institutional pillars: the lender of last resort and deposit insurance (Rochet and Vives 2004).

8. For an external assessment, please see Eichenbaum *et al.* (2016)

9. Most of the bailouts were implemented in 2012, two years after our period of analysis. These bailouts were driven by the exposure to the sovereign that banks accumulated between 2010 and 2011. The EBA capital exercise released in the Fall of 2011 forced Portuguese banks to build a capital buffer to account for potential losses coming from their sovereign exposure and the bailouts using the financial assistance program funds were designed to help banks address these capital shortfalls, rather than to deal with losses in their lending portfolios. These only assumed larger proportions later and to a large extent reflecting the deep recession experienced by the Portuguese economy during the euro area sovereign debt crisis. Later in the crisis, two larger banks were bailed-in: Banco Espírito Santo (2014) and Banif (2015). To be sure that our results are not somehow contaminated by weaknesses in these two banks which were still not apparent at the time of our shock, we also exclude these two banks from the estimations presented later in the paper. All the conclusions hold.

10. Further, most of these sovereign exposures were held to maturity, implying that any loss in value was not affecting banks' profitability and solvency at the time.

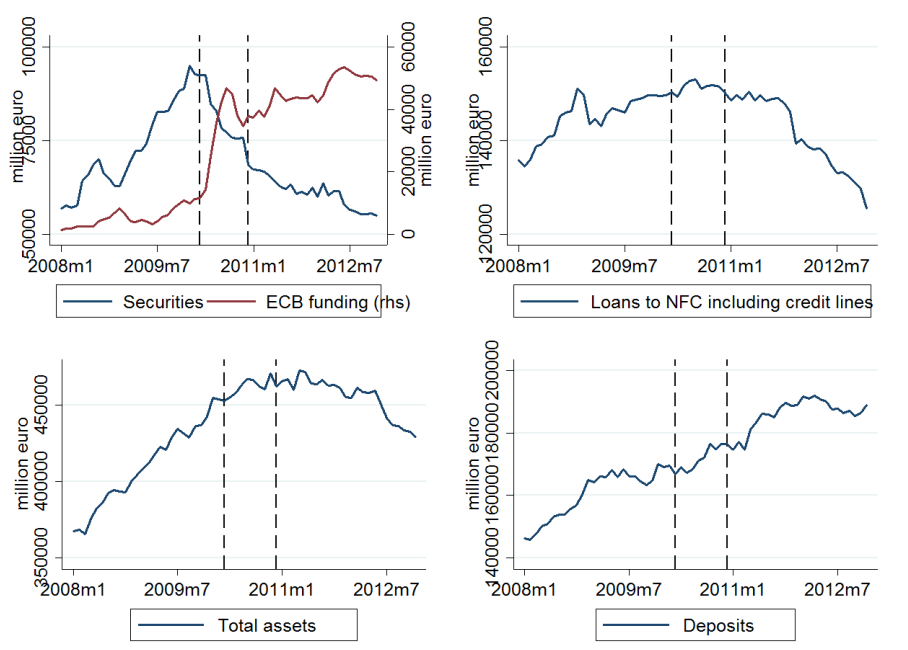

FIGURE 1: Evolution of relevant balance sheet items of the Portuguese banking system. The vertical lines refer to March and December 2010.

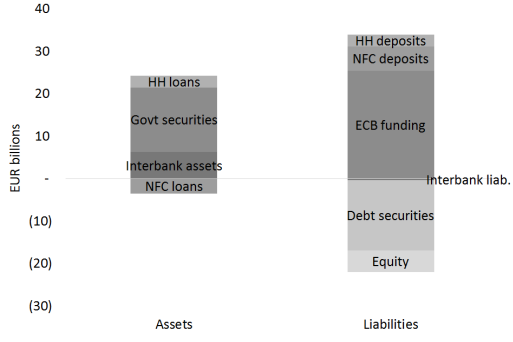

FIGURE 2: Change in banks' main balance sheet items between March and December 2010.

Figures 1, 2 and 3 characterize the aggregate implications of the shock. There was, however, substantial heterogeneity within Portuguese banks. Figures 4 to 9 inform us about this heterogeneity, focusing only on potentially

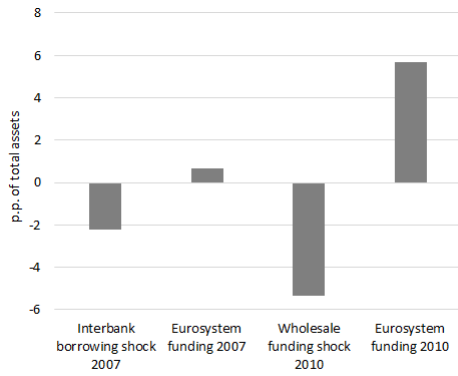

FIGURE 3: Comparison of shocks.

Note: Interbank borrowing shock - change in net interbank borrowing (deposits - loans from MFI) between May and September 2007. Wholesale funding shock - change in debt securities in the liability side between March and December 2010. Eurosystem funding - change in net Eurosystem funding via regular operations and facilities in the two periods of the shocks.

exposed banks, i.e., those that issued securities at least once prior to 2010.[11] These figures depict the empirical distributions of several bank characteristics using estimated kernel densities weighted by banks' total assets.

Figure 4 shows that even though the average loan-to-deposit ratio was high by international standards, pointing to a strong reliance on access to wholesale debt markets, there is a great deal of dispersion in this measure. Figure 5 complements this idea of dependence from wholesale markets, showing the funding by securities as a percentage of total assets. Moreover, it shows how important the shock was, as the estimated density shifted considerably to the left and became much more concentrated between March and December 2010. This shows that all Portuguese banks were affected by this shock, regardless of their financial soundness. Simultaneously, the density of the ECB funding shifted to the right, illustrating the funding substitution (Figure 6).

However, despite the remarkable heterogeneity in the way the shock was felt and in the banks' reaction, the share of loans (including credit lines) on banks' balance sheets barely changed (Figure 7). Moreover, between March and December 2010 the remaining balance sheet items of the banks also remained relatively stable across the entire sample. Figure 8 shows that deposits as a percentage of banks' total assets almost did not change during this period. Further, Figure 9 reveals that the change in banks' total assets was positive for most banks, confirming the aggregate picture provided in Figure 1.

11. These 24 banks represented 60% of the sample of banks and 94% of the total assets of the sample in March 2010.

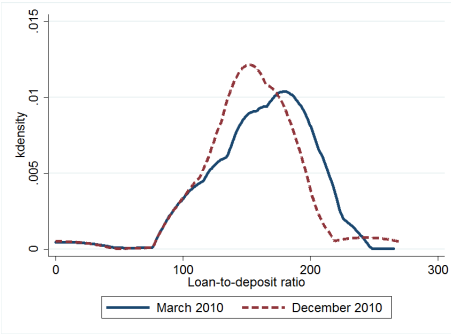

FIGURE 4: Estimated kernel density of the loan-to-deposit ratio weighted by banks' assets

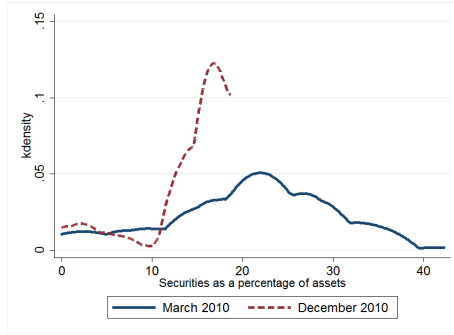

FIGURE 5: Estimated kernel density of the funding by securities as a share of total assets, weighted by banks' assets

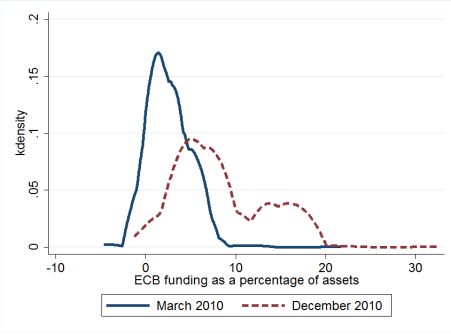

FIGURE 6: Estimated kernel density of the ECB funding as a share of total assets, weighted by banks' assets

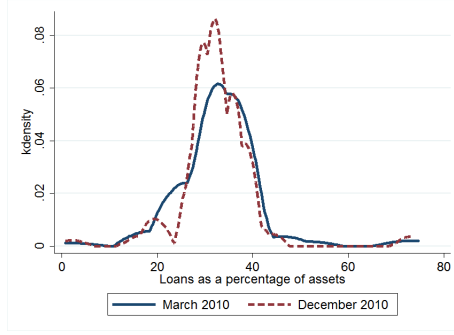

FIGURE 7: Estimated kernel density of loans to non-financial firms including credit lines as a share of total assets, weighted by banks' assets

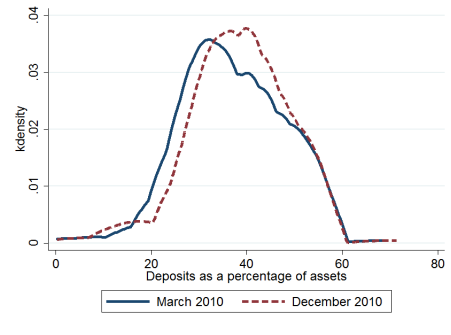

FIGURE 8: Estimated kernel density of deposits as a share of total assets, weighted by banks' assets

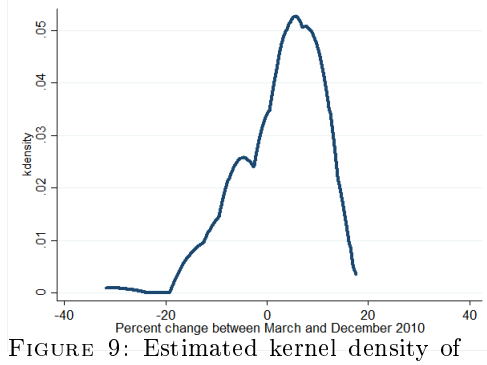

FIGURE 9: Estimated kernel density of the percent changes in assets between March and December 2010, weighted by banks' assets

It is important to benchmark our results against those of a closely related paper that also uses data on Portuguese banks, Iyer *et al.* (2014). These authors show that the interbank market freeze in the summer of 2007 led to a contraction in loan supply. Their conclusions provide further support to our argument that our empirical setting provides a unique opportunity to illustrate the role of the lender of last resort. In Figure 3 we depict interbank shock observed in the Summer of 2007 and we compare it to the wholesale funding shock that we examine in 2010 (and to the simultaneous increase in ECB funding). Even though the shock in 2007 was considerably smaller than the one experienced in 2010, the effect on loan supply was much more significant in the first case. This was only possible due to ample support provided by the ECB, most notably through the fixed rate full allotment policy that started in October 2008 (together with the enlargement of the list of eligible collateral to monetary policy operations). While in 2007 banks were not able to easily make up for the lost funding, being forced to constrain their lending, in 2010 the bank level analysis suggests that this was not the case. In the next section we explore loan-level data to confirm this.

5. Loan level evidence on the role of the lender of last resort

5.1. Identification strategy

In a crisis environment, in which many things may be happening simultaneously, it is quite challenging to design a proper identification strategy to establish a causal relationship between variables. We do this by exploring the richness of the dataset available in the quasi-natural experimental setting that we are examining. The nature of the shock itself helps to create the perfect lab to examine the role of the lender of last resort.

For identification purposes, it is also worth highlighting the heterogeneity within Portuguese banks. Their situation diverged substantially in terms of their recourse to the Eurosystem, both before and after the liquidity shock. Moreover, banks' dependence on wholesale markets was also heterogeneous, meaning that banks were hit differently by this shock. The same can be said for liquidity and capital buffers. In this respect, exploring the heterogeneity at the micro level is helpful in the identification of the main transmission channels.

Finally, the richness of the data allows for a careful identification of demand and supply in the loan market. Though exploring this event using only bank-level data would allow us to establish some relationships between access to ECB funding and credit dynamics, it is important to note that at this level it would not be possible to control for changes in the demand for bank loans. However, given that we have loan-level data, we are able to select only firms that have

a relationship with more than one bank.[12] This selection, together with firm fixed-effects estimation, allows us to control for firm-specific loan demand effects (Khwaja and Mian 2008), thereby allowing us to explicitly identify credit supply effects at the bank-firm level. This approach allows to control for borrower specific loan demand, evaluating how a firm that borrows from at least two banks is affected by a shock that hits those banks differentially. This allows us to claim that the loan variation that we observe comes from loan supply rather than from loan demand (Carpinelli and Crosignani 2018; Morais *et al.* 2018) are examples of this approach in similar settings).

Importantly, to further mitigate endogeneity concerns, all bank variables are included at their levels prior to the liquidity shock.

Our empirical strategy is anchored on three complementary specifications.

First we look into the magnitude of the shock. We examine the link between a larger drop in access to wholesale funding markets and lending to firms. The goal is to confirm the evidence shown in Section 4, but now using loan level data. We showed that despite the large shock in banks' funding lending to firms (and households) was broadly unscathed, but the bank-level analysis might be contaminated by changes in loan demand.

We estimate the following equation:

$$loan\_growth_{jT} = c + \alpha_i + \beta shock_{jT} + \delta X_{jT-9} + \varepsilon_{ijT} \quad (1)$$

where T refers to December 2010, α_i are firm fixed effects and $loan\_growth_{ijT}$ refers to the log change of loans between March 2010 and December 2010 granted by bank j to firm i. The $shock_{jT}$ is captured by $\Delta Securities/Assets_{jT}$, i.e. the change in the amount outstanding in securities issued by banks in wholesale debt markets as a percentage of banks' assets between March and December 2010. Finally, X_{jT-9} are a set of bank controls measured before the shock, in March 2010, to mitigate endogeneity concerns.

Second, the bulk of our analysis is focused on understanding how the exposure to the shock affected loan supply to firms. What might ultimately matter is not the size of the shock per se, but how relevant was the shock for the banks' funding structure. We estimate the following equation:

$$loan\ growth_{ijT} = c + \alpha_i + \beta exposure_{jT-9} + \delta X_{jT-9} + \varepsilon_{ijT} \quad (2)$$

The $exposure_{jT-9}$ to the shock is assessed in three different ways, all of them referring to March 2010. We first consider the relative importance of

12. More than 70% of the observations in the CRC in 2010 refer to firms with multiple bank relationships. If we exclude micro firms, the percentage goes up to 93%. If we consider the number of firms instead of the number of relationships, 53% of the firms borrow from more than one bank (81% if we exclude micro firms).

wholesale debt markets for each bank ($Securities/Assets_{jT}$), as in Carpinelli and Crosignani (2018). Banks that were more reliant on this type of financing were more affected by the shock and should thus be more likely to constrain lending. Second, we explore the unique granular data on the maturity of bank liabilities to build a finer measure: $Liabilities < 6m/Assets_{jT}$. Banks that had more liabilities to refinance in the coming 6 months were certainly more exposed to the sudden dry up in funding markets. Finally, we focus on a subset of these liabilities, looking only into securities issued with residual maturities below 6 months in March 2010($Securities < 6m/Assets_{jT}$). These were the banks that were clearly in the eye of the storm.

Our third and final approach is to focus on the role of ECB funding. In Section 4 we showed that access to ECB funding under the fixed rate full allotment scheme seems to have allowed banks to easily accommodate this large shock in their funding structures, allowing them to smoothly continue to finance the economy. We estimate the following equation:

$$loan\ growth_{ijT} = c + \alpha_i + \beta \Delta ECBfunding_{jT} + \delta X_{jT-9} + \varepsilon_{ijT} \quad (3)$$

$\Delta ECB_funding_{jT-4}$ is the change in ECB funding as a percentage of total assets between March and December 2010.

5.2. Testing in the perfect lab

In Table 2 we report the results of the first step in our empirical strategy. As shown before, the shock had a very large magnitude and banks were unable to rollover their financing in wholesale debt markets from the Spring of 2010 onwards. How did the decrease in this crucial source of funding for Portuguese banks at the time affect lending to firms?

The results of the estimation of equation 1 reported in column 1 suggest that, as we could expect, there is a positive association between the change in funding through securities between March and December 2010 and loans granted by banks to firms. This also holds when we add firm fixed effects in our cross-sectional specification, thus controlling for firm-specific loan demand (column 2). However, in both cases, the effect is only marginally statistically significant.

Indeed, when we control for potentially relevant bank characteristics, the magnitude of the shock is no longer associated with changes in lending. More specifically, we control for bank size ($LnAssets$), the ratio between total loans and total deposits from customers ($Loan - to - deposit$), liquid assets as a proportion of total assets ($Liquidityratio$), and a regulatory capital ratio ($Solvencyratio$). The results are not significant regardless of whether firm fixed effects are used or not (columns 3 and 4) or whether we exclude unused credit lines or not (column 5). While including unused credit lines allows us to control for the full exposure of a bank to a firm, excluding them allows us to look at

the effective outstanding debt of the firm. This latter measure is affected by demand, as firms actively choose to drawdown credit lines, most notably in stress scenarios (Carpinelli and Crosignani 2018; Ippolito *et al.* 2016). When adding bank characteristics, we find that banks' solvency has a key role in the banks' ability to keep lending to the economy during a crisis.

Even though the magnitude of the shock, as measured by the change in outstanding securities, is no longer significant when other bank characteristics are controlled for we also observe that there is a negative coefficient associated to the loan-to-deposit ratio. Banks with higher ratios, i.e. banks that were more reliant on wholesale market funding, were the ones that cut down lending to firms more, which is consistent with the theoretical predictions of Ritz and Walther (2015). This suggests that even though the magnitude of the shock did not materially affect banks' credit supply, their initial exposure to the shock might have done so.

To further explore this, in Table 3 we show the results for the second step in our empirical strategy (equation 2). We look into three different ways to capture each bank's exposure to the shock in March 2010: i) the importance of wholesale debt markets, in columns 1 to 5 ($Securities/Assets_{jT}$); ii) liabilities that had to be refinanced until September 2010, in columns 6 to 10 ($Liabilities < 6m/Assets_{jT}$); and iii) a finer measure, looking only into securities which had residual maturities below 6 months in March, in columns 11 to 15 ($Securities < 6m/Assets_{jT}$).

The results on our broadest exposure measure show that there is no significant relationship between banks' reliance on wholesale market funding before the shock and lending to firms after this funding market entirely dried up for the Portuguese banks (columns 1-5). The coefficients are negative, but the lack of precision in the estimates does allow us to claim any statistically significant relationship.

We then use a more refined measure of exposure to the shock, where we consider only the set of liabilities that would have to be rolled over between March and September 2010 to keep the remaining components of banks' balance sheets (columns 6-10). When we do not control for other bank characteristics, we find that firms that were more exposed to the shock because they had a larger proportion of liabilities to refinance, were the ones that constrained more their lending decisions (column 6). This holds even when using firm fixed effects to control for firm-specific loan demand (column 7). However, similarly to what we had seen when looking into the effect of the shock (Table 2), once we control for other potentially relevant bank characteristics, the exposure to the shock becomes statistically insignificant in explaining banks' lending decisions. Banks with more capital and liquidity are able to maintain their role in financing the economy better than weaker banks, when faced with an adverse funding shock. Smaller banks also lend more than larger ones. As seen before, banks with a higher loan-to-deposit ratio constrain more their lending during this period. However, now we are controlling for a much more precise measure of exposure

to the shock, i.e. the total volume of liabilities maturing between April and September 2010. We thus see that banks that showed a larger gap between resources obtained through retail customers and credit granted tightened their lending supply, but not because their were immediately exposed to the shock.[13] The banks that had to refinance more debt in the aftermath of the shock did not distinguish themselves from the other banks operating in Portugal at the time.

To be sure, we consider an even more refined measure of exposure to the shock: instead of considering the whole amount of liabilities coming due in the 6 months after the shock, we consider only debt securities with a residual maturity of 6 months. The results are reported in columns 11-15 and are very similar to those reported in columns 6-10, when all liabilities are considered.

In sum, the results reported in Table 3 show that despite the magnitude of the shock that affected Portuguese banks in the Spring 2010, rendering them unable to rollover any kind of market financing, the size of the exposure of each bank to the shock does not seem to play a role in banks' lending decisions. This is consistent with the aggregate evidence reported earlier in the paper, where we show that despite the dramatic drop in wholesale funding, loan growth remained broadly stable.

As shown above, there is substantial heterogeneity in the way banks were affected by the sudden loss of access to wholesale debt markets. Furthermore, Acharya *et al.* (2015) show that during crises, the transmission of central bank liquidity is impaired, affecting banks differently depending on their soundness. As such, it is quite likely that there are important differences between banks. Thus, in what follows we run additional regressions with subsamples defined according to bank characteristics (bank size, capital, liquidity and collateral availability).

To be sure that the lack of impact of the exposure to the shock on banks' lending is not coming from opposite bank reactions, we interact our stricter measure of exposure to the shock (securities with a residual maturity below 6 months as a percentage of banks' assets, reported in columns 11-15 of Table 3) with five bank characteristics that might be potentially relevant in linking the shock to banks' lending behavior: i) loan-to-deposit ratio; ii) liquidity gap between 1 and 3 months; iii) available collateral for Eurosystem funding; iv) solvency ratio; and v) bank size. The results are reported in Table 4.

We begin by exploring the interaction with the loan-to-deposit ratio, given the important role that this variable seems to have in explaing banks' lending decisions during this period. However, the interaction between this variable and our measure of exposure to the shock is not statistically significant (column 1).

13. If we exclude loan-to-deposit ratios from the regressions, the results remain entirely consistent.

Neither banks with high nor low loan-to-deposit ratios changed their lending behavior as a consequence of their exposure to the shock.

In column 2 we report a similar exercise, but for the liquidity gap between 1 and 3 months. This variable captures the difference between liquid assets and liabilities with residual maturity between 1 and 3 months, as a percentage of each banks' stable funding. It is reported under the same detailed liquidity supervisory report that allows us to have detailed information on the maturity structure of all asset and liability categories. We could expect that banks with larger liquidity buffers could somehow avert the impact of the shock and lend more than other banks similarly hit. However, the results show that this is not the case, as there are no significant differences for banks with different liquidity gaps.

There is another dimension that could also lead to heterogeneous responses. The only plausible way to explain that such a dramatic shock did not influence banks' ability to meet loan demand is that they somehow were able to compensate the funding shortage in wholesale debt markets with other immediately available funding source. Our bank level analysis shows that the ECB, by acting as lender of last resort in a fixed rate full allotment setting, was able to help banks maintain their intermediation function without disruptions. However, despite the flexibility of the fixed rate full allotment setting, there was one potentially binding constraint: the ECB only lends in these regular operations against good quality collateral. Banks that did not have enough collateral that met the eligibility criteria determined by the ECB could not borrow through this mechanism. In column 3 we report the results of interacting available collateral for ECB's operations with the exposure to the shock. Once again, we do not find any material differences.

Bank capital might also be an important shock absorber. We saw in previous regressions that banks with more capital were generally able to lend more during this period. In column 4 of Table 4 we interact bank capital with the exposure to the shock. We do not find any statistically significant relationship. Banks with more capital were able to lend more, but there is no link between banks' exposure to the shock and their lending behavior through this channel.

Finally, in column 5 we show the results of the interaction with bank size. Some of the previous estimations suggest that larger banks granted less loans during this period. However, this does not seem to be linked to exposure of each bank to the shock, as the interaction term is not statistically significant.

The results displayed in Table 4 show that bank heterogeneity did not play a role in banks' ability to withstand the shock without compromising their lending activity to firms in Portugal. However, it is possible that there is some heterogeneity in lending decisions behind these aggregate patterns. Banks that were more exposed to the shock might have reacted by keeping the same levels of loans, but catering to different types of firms. In Table 5 we explore this, by interacting banks' exposure to the shock with a few bank characteristics: i)

firm size; ii) firm riskiness; iii) type of relationship between the bank and the firm; and iv) loan maturity.

The results show that even though aggregate lending was not affected by the exposure to the shock, there was some recomposition in banks' portfolios. The results reported in column 1, where we add an interaction of the exposure to the shock with firm size categories, we find that small firms had more difficulties in obtaining new loans. Banks more exposed to the shock apparently preferred to refinance loans to larger firms. In column 2 we find that more affected banks also decreased their exposure to observationally riskier firms, which might be linked to the previous result. Firms in default became significantly less likely to obtain a new loan from a more exposed bank. At least for this immediate effect, there is not evidence supporting risk-shifting in credit, in contrast to Drechler *et al.* (2016). However, in column 3 we find that banks are more likely to grant a loan to firms that end up defaulting afterwards, even though this result is only marginally significant. Taken together, the two last results may suggest that banks take less risk based on firms' current loan performance, but their ability to accurately screen firms might be somewhat impaired, as the loans approved during this period by the more exposed banks are marginally more likely to default in the future.

The strength of the lending relationship does not seem to matter (columns 4 and 5). When we add an interaction term that takes into account if the bank is the main lender of the firm or not, we do not find any significant effect coming from that. The same holds for an interaction with the loan referring to a new relationship or not.

Another potentially relevant dimension of heterogeneity can be the loan maturity. Even though in aggregate terms we show that banks were able to readily substitute their wholesale market funding with ECB funding, one important aspect is that the maturity of this new funding source is incomparably shorter. The 3 year long term refinancing operations were implemented only at the end of 2011. We can thus expect that the substantial decrease in the maturity of banks' liabilities would be mirrored by a decrease in banks' liabilities. According to the results reported in column 6, that does not seem to be the case. When we interact the exposure to the shock with a variable that captures the share of long-term loans of each firm (defined as those with maturities above one year), we find that there is no significant impact on loan maturity. This further supports the credibility of the lender of last resort compromise of the ECB, which was made very clear at least since the announcement of the fixed rate full allotment.

The final step in our empirical strategy to uncover the role of the ECB as lender of last resort in a sudden stop scenario is to estimate equation 3. In this specification, we specifically look into the role of the change in ECB funding to explain banks' lending decisions. The results presented thus far show that despite the magnitude of the shock and the heterogeneity in the exposure to the loss of access to market funding, banks' aggregate lending was not affected. The

descriptive analysis presented earlier in the paper shows that this was possible because banks were able to fully replace their market funding with ECB loans.

In Table 6 we report the results from this estimation, where we confirm whether banks that obtained more funds from the ECB were able to lend more. The table follows the same structure of Table 2. In column 1 we present the results without bank fixed effects. In column 2 we add these fixed effects. In columns 3 and 4 we repeat the two exercises, but now adding time-varying bank characteristics. Finally, in column 5 we exclude unused credit lines from the dependent variable. In all instances, the change in ECB funding does not bear any statistically significant relationship with loan supply. Our results are consistent with those of Abbassi *et al.* (2016), who find that German banks who borrowed more from the ECB did not grant significantly more nor less credit to firms than other banks. Note that this result holds in a situation that is quite different from that analyzed in our paper, in which the increase in ECB funding was due to a sudden stop scenario for Portuguese banks in wholesale debt markets.

In sum, the loan-level analysis shows that the ECB played a key role in avoiding a credit crunch in the Portuguese economy when the perfect storm hit Portuguese banks, suddenly excluding them from participation in international debt markets. Given that this was a very important financing source for these banks, loan supply remained virtually unchanged due the willingness of the ECB to lend freely against good collateral, as prescribed by Bagehot.

Dependent variable: $loan\_growth_{ij}$					
	(1)	(2)	(3)	(4)	(5)
Magnitude of the shock:					
$\Delta Securities/Assets_{jT}$	0.386*	0.402*	-0.051	-0.106	-0.075
	(0.203)	(0.216)	(0.213)	(0.203)	(0.231)
Other bank characteristics:					
$Ln(assets)_{jT-9}$			-1.136	-1.646	-1.901
			(1.634)	(1.579)	(1.795)
$Loan-to-deposit_{jT-9}$			-0.049	-0.078*	-0.095**
			(0.041)	(0.039)	(0.045)
$Liquidity\ ratio_{jT-9}$			0.312	0.333*	0.343
			(0.191)	(0.185)	(0.215)
$Solvency\ ratio_{jT-9}$			0.503***	0.607***	0.610***
			(0.153)	(0.156)	(0.180)
Constant	-8.943***	-8.861***	14.332	29.814	38.491
	(2.058)	(2.148)	(41.016)	(38.398)	(43.318)
Firm FE	N	Y	N	Y	Y
Unused credit lines	Y	Y	Y	Y	N
Observations	180,727	180,727	180,727	180,727	161,455
R-squared	0.002	0.407	0.006	0.410	0.454

TABLE 2. Loan growth and the magnitude to the shock

Notes: Dependent variable: Log change in loans at the firm-bank level between March and December 2010. In the first column we report the results without firm fixed effects and without controlling for bank characteristics. In the second column we introduce firm fixed effects. In the third column we introduce bank characteristics, without firm fixed effects, which are added in the fourth column. This is our baseline regression. In the fifth column we consider a modified version of the dependent variable, excluding the unused amounts of credit lines from the definition of loan growth. All variables defined in table 1. Second line values in parentheses are the robust standard errors clustered at the bank level. * significance at 10 per cent; ** significance at 5 per cent; *** significance at 1 per cent.

Dependent variable: *loan growth*$_{ijT}$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Exposure to the shock:															
Debt securities/Assets$_{jT-9}$	-18.660	-21.152	-0.625	-1.235	-4.660										
	(17.567)	(17.293)	(18.898)	(17.502)	(19.702)										
Liabilities with residual maturity $< 6M/Assets_{jT-9}$						-0.217***	-0.232***	0.077	0.124	0.181					
						(0.049)	(0.060)	(0.139)	(0.176)	(0.201)					
Securities with residual maturity $< 6M/Assets_{jT-9}$											-0.466***	-0.503***	-0.070	0.026	0.076
											(0.082)	(0.084)	(0.269)	(0.283)	(0.317)
Other bank characteristics:															
$Ln(assets)_{jT-9}$			-0.936	-1.229	-1.264			-3.533**	-4.355**	-5.263***			-2.828	-3.907*	-4.768**
			(2.266)	(2.115)	(2.358)			(1.598)	(1.547)	(1.824)			(1.964)	(1.941)	(2.155)
$Loan-to-deposit_{jT-9}$			-0.051	-0.083**	-0.101**			-0.105***	-0.142***	-0.165***			-0.103***	-0.141***	-0.164***
			(0.042)	(0.040)	(0.045)			(0.029)	(0.022)	(0.027)			(0.030)	(0.022)	(0.028)
Liquidity ratio$_{jT-9}$			0.311	0.331*	0.333			0.410***	0.445***	0.465***			0.407***	0.450***	0.475**
			(0.184)	(0.178)	(0.207)			(0.136)	(0.135)	(0.162)			(0.135)	(0.150)	(0.181)
Solvency ratio$_{jT-9}$			0.466***	0.530***	0.528***			0.743***	0.910***	1.051***			0.550**	0.726**	0.816**
			(0.152)	(0.149)	(0.169)			(0.240)	(0.303)	(0.345)			(0.259)	(0.272)	(0.304)
Constant	-7.651**	-7.203**	10.632	22.115	26.306	13.888*	15.620*	70.281*	88.870***	106.338***	-6.915***	-6.599***	63.924	93.406**	116.227**
	(2.914)	(2.709)	(51.724)	(47.763)	(53.166)	(6.729)	(7.959)	(36.958)	(27.546)	(34.564)	(2.122)	(2.169)	(46.749)	(42.657)	(47.890)
Firm FE	N	Y	N	Y	Y	N	Y	N	Y	Y	N	Y	N	Y	Y
Unused credit lines	Y	Y	Y	Y	N	Y	Y	Y	Y	N	Y	Y	Y	Y	N
Observations	180,727	180,727	180,727	180,727	161,455	172,765	172,765	172,765	172,765	154,405	172,765	172,765	172,765	172,765	154,405
R-squared	0.001	0.406	0.006	0.410	0.454	0.004	0.424	0.007	0.428	0.471	0.005	0.425	0.007	0.428	0.471

TABLE 3. Loan growth and the exposure to the shock

Notes: Dependent variable: Log change in loans at the firm-bank level between March and December 2010. We consider the effect of different explanatory variables, with 5 specifications for each, following the same order as in table 2, i.e. (1) without firm fixed effects and without controlling for bank characteristics, (2) with firm fixed effects, (3) with bank characteristics but without firm fixed effects, (4) with bank characteristics and with firm fixed effects (baseline specification), (5) excluding the unused amounts of credit lines from the definition of loan growth. Columns (1) to (5) use as explanatory variable the share of the bank debt securities over total assets in March 2010. Columns (6) to (10) use as explanatory variable the share of the bank liabilities with residual maturity up to 6 months over total assets in March 2010. Columns (11) to (15) use as explanatory variable the share of the bank debt securities with residual maturity up to 6 months over total assets in March 2010. All variables defined in table 1. Second line values in parentheses are the robust standard errors clustered at the bank level. * significance at 10 per cent; ** significance at 5 per cent; *** significance at 1 per cent.

Dependent variable: $loan\ growth_{ijT}$	(1)	(2)	(3)	(4)	(5)
Exposure to the shock:					
Securities with residual maturity $< 6M/Assets_{jT-9}$	-1.404	-0.406	0.027	0.016	-0.548
	(1.380)	(0.758)	(0.320)	(0.339)	(8.347)
Interaction between exposure and bank characteristics:					
$Exposure * Loan-to-deposit_{jT-9}$	0.008				
	(0.007)				
$Exposure * Liquidity\ gap\ 1M\text{-}3M_{jT-9}$		-0.049			
		(0.084)			
$Exposure * Collateral_{jT-9}$			-0.000		
			(0.021)		
$Exposure * Solvency\ ratio_{jT-9}$				0.002	
				(0.018)	
$Exposure * Ln(assets)_{jT-9}$					0.023
					(0.337)
Other bank characteristics:					
$Ln(assets)_{jT-9}$	-3.480*	-3.817*	-3.905*	-3.865*	-3.889*
	(1.903)	(2.007)	(1.907)	(2.113)	(1.899)
$Loan-to-deposit_{jT-9}$	-0.192***	-0.132***	-0.141***	-0.142***	-0.141***
	(0.054)	(0.029)	(0.027)	(0.026)	(0.022)
$Liquidity\ ratio_{jT-9}$	0.460***	0.473***	0.450***	0.443**	0.443**
	(0.147)	(0.153)	(0.147)	(0.196)	(0.170)
$Solvency\ ratio_{jT-9}$	0.386	1.146	0.726**	0.661	0.683
	(0.441)	(0.802)	(0.289)	(0.880)	(0.665)
Constant	96.013**	85.539*	93.326**	93.462**	93.643**
	(39.932)	(46.217)	(42.012)	(42.189)	(43.255)
Firm FE	Y	Y	Y	Y	Y
Unused credit lines	Y	Y	Y	Y	Y
Observations	172,765	172,765	172,765	172,765	172,765
R-squared	0.428	0.428	0.428	0.428	0.428

TABLE 4. Exposure to the shock and bank characteristics

Notes: Dependent variable: Log change in loans at the firm-bank level between March and December 2010. The main explanatory variable is the share of the bank debt securities with residual maturity up to 6 months over total assets in March 2010. This exposure measure is then interacted with each bank characteristic measured at March 2010. All variables defined in table 1. Second line values in parentheses are the robust standard errors clustered at the bank level. * significance at 10 per cent; ** significance at 5 per cent; *** significance at 1 per cent.

Dependent variable: $loan\ growth_{ijT}$						
	(1)	(2)	(3)	(4)	(5)	(6)
Exposure to the shock:						
Securities with residual maturity < 6M/Assets$_{jT-9}$	0.003	0.196	-0.013	0.084	0.032	0.163
	(0.316)	(0.276)	(0.287)	(0.283)	(0.282)	(0.600)
Interaction between exposure and firm characteristics:						
$Micro\ firm_{iT} * Exposure_{jT-9}$	-0.109					
	(0.114)					
$Small\ firm_{iT} * Exposure_{jT-9}$	-0.194**					
	(0.089)					
$Large\ firm_{iT} * Exposure_{jT-9}$	0.190					
	(0.169)					
$Firm\ in\ default_{iT} * Exposure_{jT-9}$		-0.843**				
		(0.391)				
$Firm\ with\ future\ default_{iT} * Exposure_{jT-9}$			0.320*			
			(0.156)			
$Relationship\ loan_{iT} * Exposure_{jT-9}$				-0.085		
				(0.060)		
$New\ relationship_{iT} * Exposure_{jT-9}$					-0.040	
					(0.150)	
$Long-term\ lending_{iT} * Exposure_{jT-9}$						0.002
						(0.003)
Bank characteristics:						
$Ln(assets)_{jT-9}$	-3.637	-3.741*	-3.892*	-3.920*	-3.905*	-5.728*
	(2.150)	(1.907)	(1.942)	(1.942)	(1.943)	(3.274)
$Loan-to-deposit_{jT-9}$	-0.152***	-0.137***	-0.141***	-0.143***	-0.141***	-0.161***
	(0.022)	(0.022)	(0.022)	(0.022)	(0.022)	(0.031)
$Liquidity\ ratio_{jT-9}$	0.454***	0.454***	0.451***	0.456***	0.450***	0.494**
	(0.155)	(0.148)	(0.150)	(0.151)	(0.150)	(0.226)
$Solvency\ ratio_{jT-9}$	0.511	0.711**	0.724**	0.730**	0.725**	0.905
	(0.307)	(0.268)	(0.272)	(0.274)	(0.272)	(0.565)
Constant	93.724*	88.814**	93.051**	94.002**	93.357**	140.893*
	(46.090)	(41.927)	(42.662)	(42.634)	(42.702)	(68.275)
Firm FE	Y	Y	Y	Y	Y	Y
Unused credit lines	Y	Y	Y	Y	Y	Y
Observations	145,414	172,765	172,765	169,806	172,765	114,538
R-squared	0.420	0.430	0.428	0.426	0.428	0.529

TABLE 5. Exposure to the shock and firm and loan characteristics

Notes: Dependent variable: Log change in loans at the firm-bank level between March and December 2010. The main explanatory variable is the share of the bank debt securities with residual maturity up to 6 months over total assets in March 2010. This exposure measure is then interacted with firm characteristics measured at March 2010. Firm size categories are defined according to the EU Recommendation 2003/361. Firm in default is a dummy for firms with a loan in default with any bank for two consecutive quarters. Relationship loan is a dummy for bank-firm relationships where the bank is responsible for the larger share of lending of the firm. New relationship is a dummy for newly established relationships between firms and banks. Long-term lending is the share of long-term loans (i.e., with maturities above one year) in total loans. All remaining variables defined in table 1. Second line values in parentheses are the robust standard errors clustered at the bank level. * significance at 10 per cent; ** significance at 5 per cent; *** significance at 1 per cent.

Dependent variable: $loan\ growth_{ijT}$					
	(1)	(2)	(3)	(4)	(5)
Access to ECB funding:					
$\Delta ECB\ funding/Assets_{jT}$	-0.072	-0.069	-0.168	-0.087	-0.114
	(0.269)	(0.283)	(0.250)	(0.279)	(0.344)
Other bank characteristics:					
$Ln(assets)_{jT-9}$			-1.023	-1.555	-1.643
			(1.486)	(1.516)	(1.809)
$Loan-to-deposit_{jT-9}$			-0.033	-0.069	-0.088*
			(0.046)	(0.045)	(0.050)
$Liquidity\ ratio_{jT-9}$			0.293	0.318	0.331
			(0.184)	(0.188)	(0.225)
$Solvency\ ratio_{jT-9}$			0.479***	0.548***	0.570***
			(0.085)	(0.082)	(0.096)
Constant	-10.555***	-10.567***	10.733	28.002	32.742
	(2.688)	(2.713)	(39.083)	(38.876)	(45.782)
Firm FE	N	Y	N	Y	Y
Unused credit lines	Y	Y	Y	Y	N
Observations	179,995	179,995	179,995	179,995	160,822
R-squared	0.000	0.408	0.006	0.413	0.456

TABLE 6. Loan growth and access to ECB funding

Notes: Dependent variable: Log change in loans at the firm-bank level between March and December 2010. Same order of columns as in table 2. All variables defined in table 1. Second line values in parentheses are the robust standard errors clustered at the bank level. * significance at 10 per cent; ** significance at 5 per cent; *** significance at 1 per cent.

6. What if? A counterfactual approach

To grasp the consequences of what could have been the situation if there had not been a lender of last resort available to provide support to an entire banking system hit by a large and unexpected shock, we design a simple counterfactual scenario. The main idea is to understand what could have happened if there had not been any alternative source of funding when access to wholesale debt markets suddenly evaporated in the Spring of 2010.

To do that, we estimate the following panel regression with bank level data[14]:

$$Y_{jt} = c + \alpha_j + \beta_1 securities_{jt-3} + \beta_2 X_{jt} + \beta_3 trend_t + \varepsilon_{jt} \quad (4)$$

where Y_{jt} refers to total loans or total assets of bank j in period t and α_j are bank fixed effects. The coefficient β_1 represents the impact on these bank variables from funding via wholesale markets ($securities_{jt-3}$ refers to the amount outstanding of debt issued by banks in the previous 3 months). X_{jt} is a vector of bank characteristics (including liquidity and capital ratios). The goal of this regression is to explore the structural relationship between funding through wholesale markets and lending to gauge the magnitude of the shock and, in a second step, to understand to what extent ECB funding was successful in substituting market funding.[15] To do that, we first estimate this regression in the pre-shock period (2005-2009). The coefficient β_1 gives us the elasticity of lending or total assets to funding in wholesale markets. Second, we estimate a modified version where we consider the sum of funding through securities and through the ECB, in order to confirm whether central bank funding was relevant in the pre-shock period (given that this value was negligible in this period, we expect the results to be very similar):

$$Y_{jt} = c + \alpha_j + \beta_1 (securities_{jt-3} + ECB_{jt-3}) + \beta_2 X_{jt} + \beta_3 trend_t + \varepsilon_{jt} \quad (5)$$

The next step is to estimate these two equations in the post-shock period (2010-2011). Given the sudden loss of access to markets, we expect that the pre-shock relationship between funding in wholesale markets and lending or total assets breaks down (reflected in a significant change in β_1 in equation 4). Adding ECB funding to market funding (by estimating equation 5 for the post shock period) will finally allow us to confirm if the lender of last resort role of the ECB played a part in avoiding a collapse in banks' assets.

14. In the appendix we report summary statistics for the variables used in these regressions.

15. The link between banks' exposure to rollover risk coming from wholesale market funding and bank's lending decisions has been illustrated, for instance, by Paligorova and Santos (2017).

As we run the regression in levels, we first confirm that there is a cointegration relationship between the variables with a time trend. This trend can be related to common factors for Portuguese banks explaining their evolution prior to the crisis. In these regressions we consider only the 24 banks that issued securities at least once prior to 2010 and that were eligible to participate in Eurosystem operations.

Tables 7 and 8 present our results. Table 7 reports the impact on loans to firms (including credit lines) and Table 8 the impact on banks' total assets. In the first two columns of each table we show the results of these estimations using data until 2009. We see that before the shock there was a positive and statistically significant relationship between market funding and banks' loans and assets (column 1). Portuguese banks strongly relied on access to international debt markets to finance their activity. For the average bank, half of the amount financed in the wholesale market would be directed to loans to firms. Moreover, it contributed to leverage banks' balance sheets, as the relationship between securities and total assets is larger than one. In column 2, we estimate the same regressions in the same period, but instead of considering the relationship between securities issued and banks' assets, we consider the sum of securities issues and ECB financing, which was very small at the time (equation 5). Given this, the results are virtually unchanged.

Dependent variable: Total loans (including credit lines)$_j$

	2005-2009		2010-2011	
	(1)	(2)	(3)	(4)
securities$_{jt-3}$	0.555***		-0.112**	
	(0.0422)		(0.0413)	
(securities + ECB)$_{jt-3}$		0.480***		-0.110*
		(0.0954)		(0.0620)
Liq ratio$_{jt-12}$	-8.811***	-8.250*	4.204	8.631
	(3.046)	(4.089)	(6.120)	(8.436)
Solv ratio$_{jt-12}$	8.179	13.84	48.39	66.11*
	(15.42)	(21.55)	(35.18)	(33.98)
trend	19.73**	26.80**	-18.46	-7.218
	(7.621)	(12.12)	(15.47)	(16.33)
Constant	4,214***	4,795***	9,344***	8,599***
	(349)	(511)	(1,319)	(1,315)
Banks	24	18	19	18
Nº obs	1,032	864	436	427
Prob>F	0.0000	0.0000	0.0315	0.1186

TABLE 7. Results for the panel regression at the bank level for the evolution of loans (including credit lines) to non-financial firms

Notes: All variables are defined in Table 1. The dependent variable is total loans granted by banks, including unused credit lines. In columns 1 and 3 we report the results for the estimation of equation (4) in the periods before (2005-2009) and after (2010-2011) the shock, respectively. In columns 2 and 4 we report the results for the estimation of equation (5) for the same two periods. All regressions include bank fixed effects. Second line values in parentheses are the robust standard errors. * significance at 10 per cent; ** significance at 5 per cent; *** significance at 1 per cent.

Dependent variable: Total assets$_j$

	2005-2009		2010-2011	
	(1)	(2)	(3)	(4)
securities$_{jt-3}$	1.597***		0.0539	
	(0.143)		(0.132)	
(securities + ECB)$_{jt-3}$		1.444***		0.352***
		(0.227)		(0.0792)
Liq ratio$_{jt-12}$	-27.54**	-27.26	17.67	43.76
	(12.94)	(18.62)	(21.40)	(38.06)
Solv ratio$_{jt-12}$	68.38	85.43	115.1	80.41
	(52.21)	(70.41)	(68.11)	(61.62)
trend	88.16**	108.9**	23.61	13.27
	(32.83)	(44.25)	(48.83)	(42.54)
Constant	9,992***	11,052***	21,615***	20,829***
	(1,148)	(1,503)	(4,443)	(3,903)
Banks	23	18	19	18
N^o obs	1,031	864	436	427
Prob>F	0.0000	0.0000	0.2278	0.0017

TABLE 8. Results for the panel regression at the bank level for the evolution of total assets

Notes: All variables are defined in Table 1. The dependent variable is banks' total assets. In columns 1 and 3 we report the results for the estimation of equation (4) in the periods before (2005-2009) and after (2010-2011) the shock, respectively. In columns 2 and 4 we report the results for the estimation of equation (5) for the same two periods. All regressions include bank fixed effects. Second line values in parentheses are the robust standard errors. * significance at 10 per cent; ** significance at 5 per cent; *** significance at 1 per cent.

In columns 3 and 4 we show the same regressions as in columns 1 and 2, but for the 2010-2011 period[16]. If our hypothesis is correct, we would expect the positive relationship between loans or assets and securities to break. However, this relationship should hold when we include ECB funding if this is a quasi-perfect substitute for the lost wholesale market funding. The results are indeed strikingly different from those of the first period, confirming our hypothesis: the positive correlation between outstanding debt securities and banks' assets entirely disappears. The coefficient is not statistically significant for total assets (Table 8) and is actually negative for loans (Table 7). The more market debt outstanding banks had, the lower their stock of loans to firms during this period. This result is consistent with Dagher and Kazimov (2015), who find that there is a negative relation between wholesale funding and the supply of credit, but only during the global financial crisis.

In the last column we consider the joint effect of securities issued and access to ECB funding in the crisis period, in order to test if access to the central bank allowed to restore the previous relationship between securities and loans to firms. For loans we still obtain a negative coefficient. Given that in these regressions we are not controlling for demand effects, unlike what we

16. If the estimation is done only for 2010, the results described below are generally consistent.

did when using loan level data, it is possible that this result is being affected by a contraction of loan demand in a period of strong adjustment of expectations.

In contrast, when we look at the effect on total assets, we find a positive coefficient, showing that access to the lender of last resort was indeed critical to avoid a collapse in the banking system. This coefficient is smaller than those of columns 1 and 2, suggesting that ECB funding did not perfectly substitute securities issuance. The results on loans and on total assets suggest that the replacement of securities funding by ECB funding was likely used for other purposes than granting loans to firms.

7. Where did the money go?

This last result, together with the aggregate analysis in Section 4, hints at the hypothesis that banks used ECB funding to invest in assets other than loans to firms. These results are consistent with the hypothesis of financial repression or moral suasion presented by Becker and Ivashina (2018) and Ongena *et al.* (2018). These authors argue that during this period sovereigns in distress encouraged banks to buy their debt. To test this hypothesis in our setting, we estimate the following equation:

$$Sov_{jt} = c + \alpha_j + \beta_1(ECB_{jt-3}) + \beta_2 X_{jt} + \beta_3 trend_t + \varepsilon_{jt} \tag{6}$$

where Sov_{jt} are the holdings of Portuguese sovereign bonds by banks. The results are shown in Table 9.

The first column shows the results for the period 2005-2009 and no correlation is found between the two variables. However, for the period 2010-2011 we observe a positive correlation between ECB funding and holdings of sovereign debt, thus providing support to the financial repression hypothesis. These results are consistent with those of Drechler *et al.* (2016) and Carpinelli and Crosignani (2018). Using weekly data on bank-level ECB borrowing, these authors find that euro area banks used central bank funding to invest in distressed sovereign debt instead of channeling funds to the real economy.

To make sure that our results are consistent with those presented in Section 5, we estimate equation 3, but now using the log change in domestic sovereign bond holdings between March and December 2010 as the dependent variable, such that:

$$Ln(\Delta bonds)jT = c + \alpha_i + \beta \Delta ECBfunding_{jT} + \delta X_{jT-9} + \varepsilon_{ijT} \tag{7}$$

The previous results are confirmed (Table 10). Banks that obtained proportionally more funding more the ECB were those that accumulated more sovereign bond holdings, in all the specifications considered.

Dependent variable: Holdings of domestic sovereign bonds$_j$		
	2005-2009	**2010-2011**
ECB funding$_{jt-3}$	0.0271	0.204***
	(0.0372)	(0.0480)
Liq ratio$_{jt-12}$	-3.403	-6.956
	(2.571)	(17.09)
Solv ratio$_{jt-12}$	14.49	-5.547
	(15.52)	(16.90)
trend	5.651*	0.328
	(2.724)	(10.44)
Constant	-97.42	651.8
	(290.2)	(887.4)
Banks	16	15
N^{o} obs	705	331
Prob>F	0.1522	0.0002

TABLE 9. Results for the panel regression at the bank level for the evolution of Portuguese sovereign bond holdings

Notes: All variables are defined in Table 1. The dependent variable is total Portuguese government bond holdings. The table reports the results for the estimation of equation (4) in the periods before (2005-2009) and after (2010-2011) the shock, in columns 1 and 2, respectively. All regressions include bank fixed effects. Second line values in parentheses are the robust standard errors. * significance at 10 per cent; ** significance at 5 per cent; *** significance at 1 per cent.

There are several alternative explanations that jointly explain why the banks used the ECB funding to buy more sovereign bonds. For sure this was a profitable strategy, most notably in a context of scarce investment opportunities with the same level of risk and return (and considering the uncertainty regarding the prospects for an overly indebted corporate sector), thus supporting a carry trade argument. It could certainly be related with pure risk-shifting incentives, as discussed in Acharya *et al.* (2018) and Drechler *et al.* (2016). It was also a way for banks to boost their capital ratios, given the zero risk-weights attached to sovereign bond holdings and to increase the collateral available for further financing (Crosignani *et al.* 2016). More importantly, there is also a moral suasion (or financial repression) dimension. All Portuguese issuers were shunned by the markets, not only the banks, but first and foremost the sovereign. Encouraging the banks to buy sovereign debt that no one else would purchase was thus a strategy adopted in many countries at the time, as shown by Becker and Ivashina (2018) and Ongena *et al.* (2018). Banks also gained from tying themselves to the sovereign, thus further exacerbating the sovereign bank links.

In sum, we find that the positive relationship between securities issued and banks' loans and total assets observed before 2010 broke after banks lost access to markets. Unlimited access to the ECB successfully helped banks to substitute market funding, leaving banks' assets virtually unchanged. However, this new funding is not directed only to loans to non-financial firms. Banks also used these funds to buy sovereign bonds, in a period in which the sovereign also

Dependent variable: *Log change in bond holdings*$_{jT}$				
	(1)	(2)	(3)	(4)
Access to ECB funding:				
$\Delta ECB\ funding/Assets_{jT}$	9.400**	9.928**	13.824***	14.264***
	(4.258)	(3.822)	(4.683)	(4.198)
Other bank characteristics:				
$Ln(assets)_{jT-9}$			-0.530	-0.637
			(19.464)	(17.414)
$Loan-to-deposit_{jT-9}$			-2.616*	-2.630**
			(1.386)	(1.223)
$Liquidity\ ratio_{jT-9}$			0.353	0.347
			(4.084)	(3.586)
$Solvency\ ratio_{jT-9}$			1.921*	1.875*
			(1.076)	(0.940)
Constant	-0.856	-3.463	396.190	399.485
	(35.361)	(30.999)	(539.516)	(476.437)
Firm FE	N	Y	N	Y
Unused credit lines	Y	Y	Y	Y
Observations	190,441	190,441	190,441	190,441
R-squared	0.153	0.419	0.401	0.588

TABLE 10. Access to ECB funding, exposure to the shock and sovereign bond holdings

Notes: Dependent variable: Log change in Portuguese government bond holdings at the firm-bank level between March and December 2010. Both regressions include firm fixed effects. All variables defined in table 1. Second line values in parentheses are the robust standard errors clustered at the bank level. * significance at 10 per cent; ** significance at 5 per cent; *** significance at 1 per cent.

faced difficulties in access to markets. Our results thus suggest that the ECB played a dual role as lender of last resort during this period: on one hand it allowed banks to maintain loan flows to the private sector, avoiding a collapse in credit markets, while on the other hand it allowed the distressed sovereign to refinance some of its maturing debt. Without this support, the consequences for the financial system and for the economy as a whole could have been dramatic.

8. Concluding remarks

What happens when an entire banking system highly reliant on foreign financing suddenly loses access to debt markets? At the very least, a credit crunch might follow. More likely, the entire economy will be disrupted.

In the recent past, Portuguese banks went through an episode that could easily fit this description. In the early days of the euro sovereign debt crisis, when distress in Greece started to assume large-scale proportions, international investors suddenly became unwilling to provide funding to Portuguese banks, due to concerns about the sustainability of sovereign debt levels. Despite the magnitude of this shock, credit flows during this period were virtually unchanged. This is even more surprising when we consider that Portuguese banks were highly dependent on market funding, as their loan-to-deposit ratios were around 160%.

The answer to this puzzle has one very obvious solution: the ECB monetary policy framework allowed banks to obtain all the liquidity they needed almost immediately and without major implications on funding costs.

In this paper we argue that this "perfect storm" scenario is also the perfect setting to study empirically something that has been absent from the empirical literature: the role of the lender of last resort. By exploring very detailed bank data, we are able to document the critical role of the central bank in avoiding the collapse of the financial system and, consequently, of the economy. We show that funding with the central bank increased dramatically over the course of a few months, supporting credit supply to firms. At the same time, banks were able to play an important role in the financing of the sovereign, who also lost access to markets in this period. Without the supporting role of the lender of last resort, a collapse of the banking system would possibly have been unavoidable.

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Appendix

Variable	Unit	Obs	Mean	Std. Dev.	P25	Median	P75
Loans + lines	Million euro	3,629	4,211	8 136	113	723	3,653
Loans	Million euro	3,629	3,269	6,128	93	557	3,186
Assets	Million euro	3,591	12,505	23,509	758	2,347	7,706
Securities	Million euro	3,629	1,685	4,191	0	0	495
ECB funding	Million euro	2,891	821	2,278	0	0	310
PT bonds	Million euro	2,085	609	1,228	6	82	543
Liq ratio	ratio	3,615	25.6	23.8	9	17	37
Solv ratio	ratio	3,622	12.1	13.6	9	11	14

TABLE A.1. Descriptive statistics of the variables used in the analysis at the bank level