Banco de Portugal Economic Studies

Volume III

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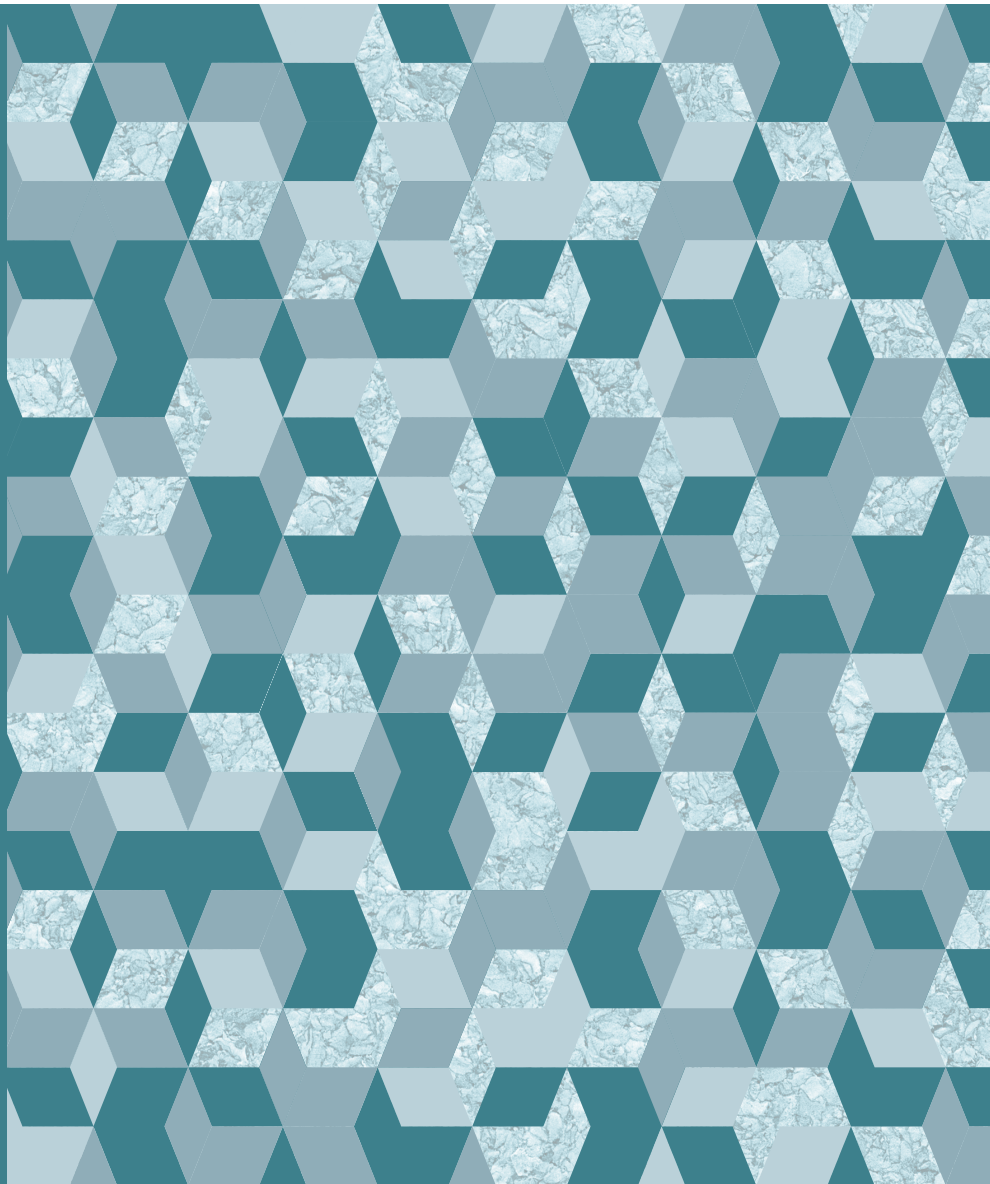

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Content

Editorial

July 2017

The third issue of Banco de Portugal Economic Studies for 2017 contains three essays that cover the cross-border consequences of prudential policy, the determinants of corporate credit risk, and a macroeconomic model of the Portuguese economy with an emphasis on the role of the banking system.

In the first paper, by Diana Bonfim and Sónia Costa and entitled "Spillovers of prudential policy across borders: evidence for Portugal", the authors produce an empirical analysis of the effects in Portugal of changes in policies regulating banking in other countries. The paper summarizes the results for Portugal of a remarkable joint international research project involving central banks worldwide, meant to study cross-border effects of bank regulation using micro data.

The empirical work used quarterly bank level data from the beginning of 2006 up until the end of 2014. The prudential tools considered were general capital requirements, sector-specific capital buffers (for instance, for real estate and consumption) and loan-to-value ratio limits. An international database provided quarterly information on the timing of tightening or loosening of prudential tools in 64 countries over the period under study. For each prudential tool, the database included one index for its change, where a negative value (-1) corresponded to a loosening, a positive value (+1) to a tightening and zero signaled that no change had occurred in the quarter.

Data for banks operating in Portugal came from quarterly supervisory reports which were merged with bank level data underlying the International Banking Statistics and the Monetary Financial Statistics from Banco de Portugal. The final dataset included 57 banks (25 domestic and 32 foreign), which account, on average, for 96% of the credit granted by banks in Portugal.

The analysis looked at two channels by which foreign policies affect domestic credit markets. In the first, foreign regulation affects the evolution of credit granted by Portuguese banks taking into account the exposures that these banks have abroad. This channel is studied by using regressions explaining quarterly growth rates in the domestic credit granted by each Portuguese bank. These are explained by time and bank fixed effects, a vector of bank balance sheet characteristics for each bank (such as total assets, capital ratio, core deposits ratio, etc.), and current and lagged indices of policy changes. For each Portuguese bank, each country's policy changes contribution to the overall index is weighted by the international exposure of that bank to that country. The regressions also use the interactions between the indices and bank characteristics. The results of the regressions show that the effects of foreign policy changes are statistically significant for sector specific capital requirements and for the loan-to-value ratio limits, but not for

the general capital requirements. More specifically, a tightening in the sector specific capital requirements yields an increase in the growth of loans granted by domestic banks in Portugal, a diversion of resources effect. On the other hand, a tightening of the loan-to-value ratios abroad decreases credit growth domestically, a change that may be due to reductions in profitability.

The second channel is that foreign regulation affects the growth of credit granted in Portugal by branches and subsidiaries of foreign banks. In this case the regressions are similar to those used to explain the first channel (i.e. explanatory variables include fixed effects and bank characteristics) but the indices are based only on the policy changes in the home country of each bank. The significant results come from the capital requirements and the loan-to-value limits. While for the loan-to-value ratio a tightening abroad is associated with more credit in Portugal, for the general capital requirements it is the opposite. These results are consistent with the interpretations that capital requirements tend to be imposed at the consolidated level and thus they restrain credit growth in all the markets a bank operates on, whereas loan-to-value limits are usually local policies, inducing substitutive effects across markets.

A final set of results relate to the legal form of a foreign bank. A branch is not legally autonomous and belongs directly to the parent bank. A subsidiary is a legally independent institution in the host country. Branches and subsidiaries can be affected differently by policy and regulatory changes in the home countries and that is what the results show. Tighter capital requirements decrease the credit extended by branches but have no significant effect on credit from subsidiaries. On the other hand, more stringent limits at home on the loan-to-value ratios tend to increase credit growth in Portugal for both branches and subsidiaries.

The second paper, by Luciana Barbosa and Paulo Soares de Pinho, is entitled "Operational cycle and tax liabilities as determinants of corporate credit risk" and constitutes a contribution to a large literature studying credit risk. This is an extremely relevant topic, as non-performing loans and the health of the banking systems in Southern European countries continue to be topics of concern for analysts and policy makers alike. In fact, Banco de Portugal Economic Studies has recently published yet another contribution to this area of study by Antunes, Prego, and Gonçalves (2016)[1]. The novelty in the present paper is an assessment of the role that more detailed accounting ratios can play, most notably measures of cash reserves, trade credit, inventories and tax liabilities.

Barbosa and Pinho conduct a careful and detailed literature review, highlighting the different branches of literature. The paper defines the

1. Antunes A., Gonçalves H., Prego P. (2016), Firm default probabilities revisited, Banco de Portugal Economic Studies, Volume II - n. 2, pp. 21.

issues most relevant for understanding credit risk in economies such as the Portuguese, where few firms use broad financial markets in order to issue bonds and even fewer are listed publicly. For the vast majority of Portuguese firms, outside financing mostly means bank credit and so examining defaults by non-financial firms is the most direct way to analyze and quantify credit risk.

In their empirical analysis Barbosa and Pinho use micro data from the Central Balance Sheet Database and from the Central Credit Register. They connect the two databases to obtain a panel of firm characteristics and their respective bank-credit annual variables for the period 2006-2009, years where data suitable for their analysis are available. A default is defined as having three months or more of delays in payments to a bank. Excluding firms with less than 5 workers, financial firms and firms with problematic data, the sample they work with has 230,730 annual observations. The authors start by comparing the descriptive statistics of the defaulting firms with the non-defaulting firms and find that the latter have statistically significantly higher levels of working capital, turnover (sales/assets), sales growth, investment turnover (sales/investment), higher coverage of liabilities and interest by EBITDA, are older and have higher concentration of total debt in fewer banks. Non-defaulting firms also have lower levels of leverage and of cash flow volatility.

The analysis continues with estimates of several panel logit regressions explaining new episodes of default. The results from the descriptive analysis survive. In the regressions' more detailed analysis we see that the levels of accounts payable increase the probability of default, as do larger levels for inventories. We can interpret these findings as suggesting that firms that take longer to repay their suppliers, or firms that build up inventories for longer periods present higher probabilities of default. Tax liabilities also have a significant positive association with defaults. A later refinement of the analysis shows that social security liabilities in particular are related to higher probability of default. The results are robust when examined by firm size except for large firms, where fewer variables have statistically significant relationships to default. All in all, Barbosa and Pinho's work provides insights into what drives a firm to default and offers clues for building better credit scoring models.

The last paper in this issue, by Sandra Gomes, is titled "A model with financial frictions and a banking system for the Portuguese economy". The paper describes a dynamic general equilibrium large scale model that has been developed for European economies and its adaptation to the case of Portugal. The model has four blocs (Portugal, rest of Euro area, USA, rest of the World) and is characterized by New-Keynesian features such as imperfectly competitive labor markets, monopolistic competition in the markets for goods and financial frictions. The model has imbedded some nominal rigidities with staggered adjustments for both wages and prices of goods.

The agents in the model include patient households (savers), impatient households and entrepreneurs (borrowers) and bankers. Banking is country specific as banks intermediate funds between domestic agents. Borrowers need to use real estate or capital (in the case of entrepreneurs) as collateral. Banks face regulatory capital requirements and limits on loan-to-value ratios. Firms produce either intermediate goods or final non-tradable goods that are used for consumption or investment. Monetary authorities follow a Taylor-type rule, with the nominal interest rate being a function of inflation and output growth while trying to smooth interest rates. Portugal and the rest of the euro area are in a monetary union and consequently share a single monetary authority. In each bloc there is also a fiscal authority that purchases a final good, makes transfers to households, issues bonds to refinance its debt, and levies taxes.

After calibration, the model is then used to study two types of policy shocks, where one can see that the financial markets play a prominent role. The first is an expansionary shock that leads to a reduction of the monetary policy rate of 25 basis points. The second is a more targeted contractionary policy shock leading to a one percent reduction in the loan-to-value ratio for loans collateralized with the housing stock in Portugal, followed by its gradual return to the steady-state level.

The expansionary shock increases GDP, consumption and investment, imports and exports (thanks to a depreciation of the euro exchange rate). The drop in interest rates leads to an increase in the demand for loans, and indirectly for housing (given its use as collateral) which in turn increases housing prices. In a second scenario, the same expansionary shock is simulated but setting a higher loan-to-value ratio (to 90% from 70% in the benchmark), benefiting impatient households. In this case the expansionary effects of the shock are higher.

The contractionary policy reducing the loan-to-value ratio in Portugal leads to a decrease in the domestic demand for loans and a lower interest rate and thus a lower demand for deposits. The consequences include a decrease in the demand for real estate driving down prices. The overall drop in demand leads to a decrease in GDP, coming mostly from the effects of a reduced borrowing capacity on the consumption of borrowers.

Overall, these analyses shed light not only on shocks stemming from financial variables but also on the way that frictions in financial markets matter for the transmission of the shocks to the overall economy, a point that will not be lost on policy makers.

Spillovers of prudential policy across borders: evidence for Portugal

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July 2017

Abstract
When a (macro-)prudential authority implements tools available within its toolkit, its primary concern is with the domestic financial stability, independently of the domestic or foreign origin of the risks. However, an important aspect that is often neglected is that these decisions may have (positive or negative) cross-border spillovers. In this article we summarize the results for Portugal of a joint international research project involving central banks worldwide, to study cross-border effects of bank regulation using bank-level data. We confirm that credit developments in Portugal are affected by foreign bank regulation. This effect depends on the type of regulation and on the channel of transmission. We also show that the cross-border effects of capital requirements work differently through branches and subsidiaries of foreign banks operating in Portugal. (JEL: F42, G21, G28)

Introduction

The regulation of the financial system shapes its activity. For instance, tightening capital requirements will possibly constrain credit supply in the short run, even if the overall impact on financial stability and economic growth is positive (Cerutti and Laeven (2017), Dagher *et al.* (2016), Gersbach and Rochet (2017)). When a micro or macro-prudential authority decides to implement such a measure, it usually has at the core of its concerns the domestic financial system. However, it is not unlikely that prudential measures may have impacts that go beyond domestic borders, affecting credit growth elsewhere (Ayar *et al.* 2014).

This article summarizes the main findings for Portugal of a joint research project involving central banks worldwide, with the goal of documenting cross-border spillovers of prudential regulation.[1] The International Banking

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1. This article summarizes some of the main findings of Bonfim and Costa (2017).

Research Network (IBRN) involves researchers from central banks around the world, engaged in using proprietary confidential data available at each central bank to address a common research question in international banking, using a common methodological framework.[2] The most recent project evaluates how prudential policies generate cross-border spillovers.

To undertake this challenge, two approaches could be considered. On the one hand, it is possible to evaluate the impact of changes in domestic bank regulation on lending in other countries. On the other hand, we can examine the impact of changes in foreign regulation on lending in Portugal. In this article, we focus on the latter for two main reasons. First, there were not many changes in prudential regulation in Portugal during the last decades that could have had significant effects abroad. Second, from a practical view point, it is much harder to collect granular data to examine the outward influence of domestic prudential regulation than the opposite.

The Portuguese banking system provides an interesting setting to analyze the cross-border spillovers of prudential regulation. Domestic banks have important international activities, thus being exposed to foreign regulation through their branches and subsidiaries abroad. Furthermore, foreign banks have a meaningful (and increasing) presence in the Portuguese banking system. It is thus important to understand how foreign bank regulation can affect bank lending in Portugal. This is an increasingly relevant issue for policymakers, most notably when considering the large number of macroprudential policy measures being adopted worldwide.

Foreign banking regulation may have two opposing effects in domestic credit. On the one hand, we could expect that there are cross-border complementary effects arising from regulation: a tightening in foreign regulation targeted at constraining lending in the home country may also lead to less lending in other countries. On the other hand, there may be cross-border substitution effects: when facing a tightening in foreign regulation, banks may actually increase lending in other countries to diversify their exposures and to maximize profitability.

To analyze the effects of foreign regulation on domestic credit we consider two possible channels. First we analyze the effect of foreign regulation on the credit granted in Portugal by Portuguese banks with activity abroad. Second we analyze the influence of foreign regulation on the growth of credit granted in Portugal by the foreign banks operating in the country.

In this last case we zoom in on the cross-border transmission of regulation and ask whether the regulation implemented in the home countries of foreign banks operating in Portugal has different effects on the credit granted in Portugal through foreign branches and subsidiaries. This distinction is relevant if we consider the differences in the legal form of these two types

2. For further details, please visit https://www.newyorkfed.org/ibrn.

of institutions: whereas branches are legally part of the parent foreign bank, subsidiaries are legally independent entities and might be allowed to fail on their own. This distinction has important regulatory consequences. For instance, deposits held at subsidiaries are guaranteed by the host country, while those of branches are guaranteed by the home country. Furthermore, and perhaps more relevant for the purposes of our study, branches of European Union banks are exempt from capital requirements in the host country.

This paper is organized as follows. First, we describe the international linkages of the banks located in Portugal. Next, we discuss our empirical approach. We also describe the data used. We then present the main results. We then explore in more detail possible distinctions between branches and subsidiaries in the cross-border spillovers of prudential policy. Finally, we present a few concluding remarks.

An overview of the international linkages of the Portuguese banking system

In the period under analysis credit granted in Portugal witnessed strong movements. While in the mid-2000s credit was expanding quickly, it started to decelerate in 2008-09 during the global financial crisis and has been declining since the beginning of the euro area sovereign debt crisis and the Economic and Financial Assistance Programme to Portugal. In this period, the behavior of domestic and foreign banks operating in Portugal has not always been alike (Figure 1). While in the years 2010-11 domestic institutions started to reduce credit, foreign banks continued to expand credit granted in Portugal (Costa and Farinha 2011). This heterogeneity was essentially explained by the increase in funding difficulties and the need to deleverage of domestic banks. However, in the most recent years, foreign banks have also cut their activity in Portugal. Nevertheless, their market share in the credit market remained around 25 per cent, which is slightly higher than what was observed before the crisis. The recent decline in activity by foreign banks was mostly determined by branches (Figure 2). The weight of credit granted by foreign subsidiaries has been increasing since 2010. On average, between 2006 and 2014, credit granted by subsidiaries represents around 15 per cent of total credit and almost 70 per cent of credit granted by foreign banks.

The Portuguese banking system is highly concentrated. The five largest banking groups accounted for around 75 per cent of bank credit to non-financial residents in Portugal in the last quarter of 2014. One of these five groups is part of a large foreign banking group. The rest of the Portuguese banking system comprises many small and medium-sized banks. Most of these banks are small scale universal banks, competing directly with the five largest banking groups. A few of them have specialized business models,

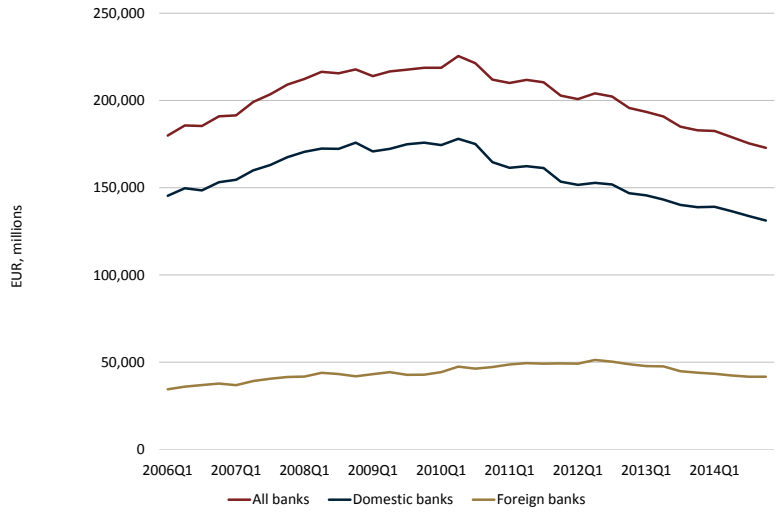

FIGURE 1: Credit granted by domestic and foreign banks in Portugal
Source: Banco de Portugal.

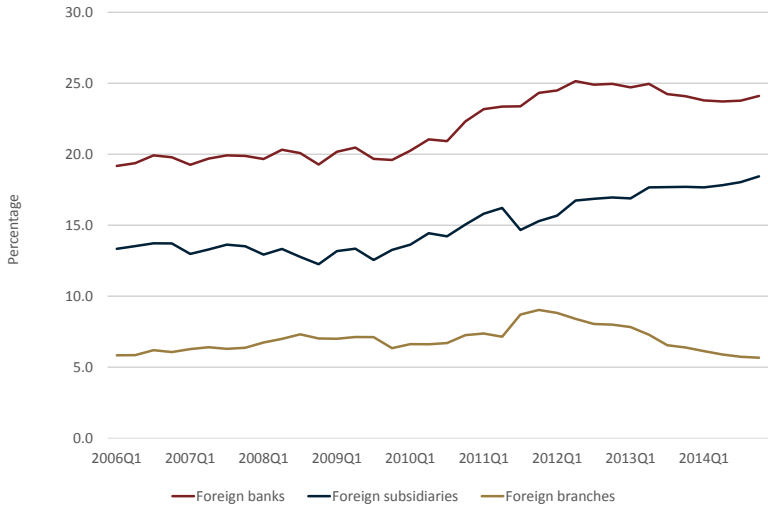

FIGURE 2: Credit granted by foreign banks in Portugal as a percentage of total credit
Source: Banco de Portugal.

offering only specific products such as consumer loans or asset management services.

By ownership nationality, Spanish banks dominate the market with a weight on the total credit granted by foreign banks of more than 65 per cent over the period under analysis. The other countries with a non-negligible presence in the Portuguese credit market are the United Kingdom, Germany and France (Figure 3).

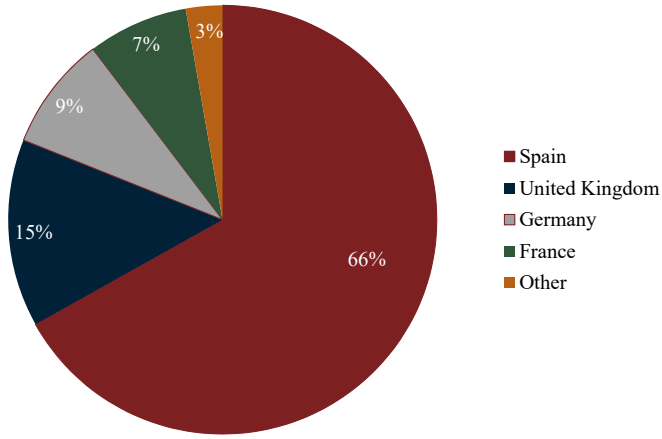

FIGURE 3: Distribution of the credit granted in Portugal by foreign banks, by country of the parent bank, over the period 2006-14

Source: Banco de Portugal.

Spain also has a dominant weight in the international activity of Portuguese banks, accounting for around 30 per cent of the total foreign exposure through affiliates over the period 2006-14 (Figure 4). Additionally, domestic banks were, during our sample period, significantly exposed to Poland and to a lesser extent to Greece, France, United States and some emerging market economies, such as Brazil, Angola and Mozambique. The activity of the Portuguese banks in non-European countries has increased during the crisis, being responsible for the increase in total exposures, while the activity in Europe remained broadly stable (Figure 5).

All this evidence shows that the Portuguese banking system has important international linkages, both through the exposures that Portuguese banks have abroad and through the operations of foreign banks in Portugal.

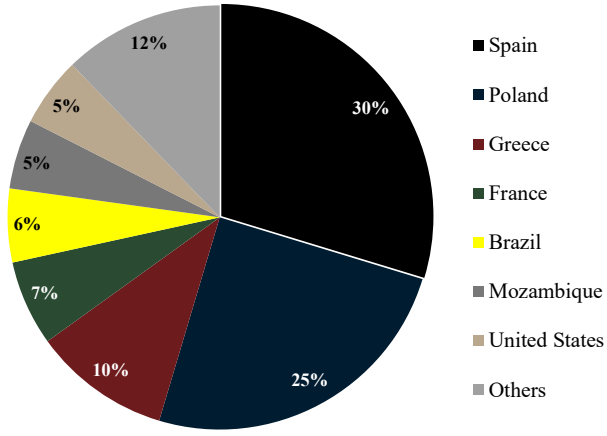

FIGURE 4: Distribution of the foreign exposures of the Portuguese banks over the period 2006-2014

Source: Banco de Portugal.

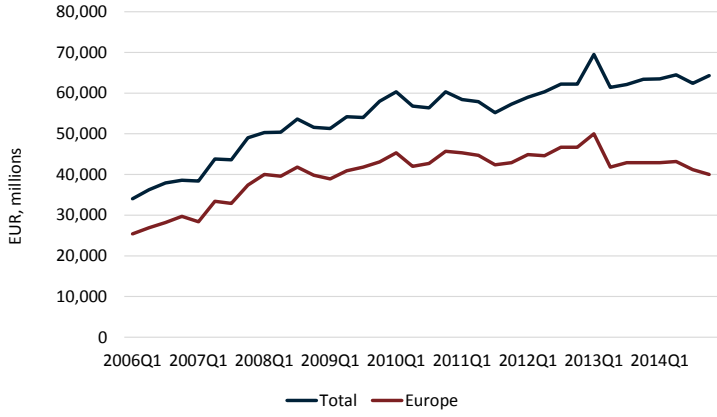

FIGURE 5: Exposures of the Portuguese banks abroad

Note: Claims plus liabilities of the branches and subsidiaries of the Portuguese banks abroad and on an immediate borrower basis.
Source: Banco de Portugal.

Empirical approach

The empirical approach we use to analyze the inward transmission of foreign regulation on loans granted by banks in Portugal is described in detail in Buch and Goldberg (2017) and includes two different specifications. In

the first specification (specification A), the objective is to understand how foreign regulation affects the evolution of credit granted by domestic banks in Portugal. The channel in focus in this specification comes from the exposures that domestic banks have abroad. In the second specification (specification B), the goal is to understand how foreign regulation affects the growth of credit granted in Portugal by branches and subsidiaries of foreign banks.

In specification A we want to evaluate the impact of the prudential regulation implemented in the countries where the Portuguese banks have branches and subsidiaries. Thus, we construct for each Portuguese bank and prudential instrument, an index ($ExpP_{b,t}$) for the change of the host countries' regulation ($HostP_{i,t}$), weighted by the bank's foreign exposures to the host countries ($\theta_{b,i,t-1}$). In the calculation of weights we use data on the previous 4 quarters.

$$ExpP_{b,t} = \sum_{i} HostP_{i,t}\theta_{b,i,t-1} \tag{1}$$

$$\theta_{b,i,t-1} = \frac{\sum_{t=t-4}^{t-1} exposure_{b,i,t}}{\sum_{i}\sum_{t=t-4}^{t-1} exposure_{b,i,t}} \tag{2}$$

The exposure of the domestic bank b to country i is measured by the claims plus liabilities of the branches and subsidiaries of that bank on country i, denominated in local currency (i.e in the currency of country i) and on an immediate borrower basis.

In the construction of these exposure-weighted prudential policy indexes only exposures to countries with data available in the prudential database could be considered. In our sample, this means we are taking into account 87% of the total foreign exposures of the Portuguese banks, through their affiliates abroad.

With specification B we are interested in evaluating the impact of the regulation adopted in the home country of each foreign bank with branches and subsidiaries in Portugal. Thus, in this case the regulation variables used in the regressions correspond to the indexes of the prudential database for the change in the prudential instruments in the countries of the parent banks ($HomeP_{j,t}$), without any weighting.

The following regressions are estimated:

Specification A: Exposure-weighted inward transmission of regulation

$$\begin{aligned} \triangle Y_{b,t} = &\sum_{k=o}^{2} \alpha_{k+1} ExpP_{b,t-k} + \alpha_4 X_{b,t-1} + \\ &\sum_{k=o}^{2} \beta_{k+1} ExpP_{b,t-k} X_{b,t-k} + f_b + f_t + \varepsilon_{b,t} \end{aligned} \tag{3}$$

Specification B: Inward transmission of home prudential policy via affiliates

$$\begin{aligned}\triangle Y_{b,j,t} = \alpha_o + \sum_{k=o}^{2} \alpha_{k+1} HomeP_{j,t-k} + \alpha_4 X_{b,j,t-1} + \alpha_5 Z_{j,t} \\ + \sum_{k=o}^{2} \beta_{k+1} HomeP_{j,t-k} X_{b,j,t-k} + f_b + f_t + \varepsilon_{b,j,t}\end{aligned} \tag{4}$$

In both specifications A and B, our dependent variable is $\triangle Y$, which is defined as the quarterly change in credit granted by bank b to non-financial residents in Portugal in quarter t, measured in log percentage points. However, there are important differences in the way the two specifications are estimated. While in specification A the regressions are estimated only for domestic banks, in specification B the regressions are estimated for the full sample, including foreign and domestic banks (thus adding the subscript j to refer to the country of origin of the bank).

$X_{b,t-1}$ is the vector of bank control variables. Its interaction with the regulation variables ($ExpP_{b,t-k}$ and $HomeP_{j,t-k}$) captures the degree to which a bank is exposed to changes in regulation through *ex-ante* balance sheet composition and market access.

In both specifications the following bank balance sheet characteristics ($X_{b,t-1}$) are considered: the percentage of a bank's portfolio of assets that is illiquid ($IlliquidAssetsRatio_{b,t-1}$), the percentage of the bank's balance sheet financed with core deposits ($CoreDepositsRatio_{b,t-1}$), bank's capital to asset ratio ($CapitalRatio_{b,t-1}$), the percentage of the bank's net external intragroup funding relative to its total liabilities ($NetIntragroupFunding_{b,t-1}$), and the log of total assets ($LogTotalAssets_{b,t-1}$). In order to take into account the degree of the foreign exposure, specification A includes also as control variable the percentage of the assets plus liabilities of bank's affiliates abroad relative to total assets plus total liabilities ($InternationalActivity_{b,t-1}$). These variables are defined in detail in Appendix A. Both specifications include bank and time fixed effects. Additionally, in specification B, standard errors are clustered by country. In this specification, we also control for macroeconomic and financial conditions in the home country of foreign banks: $Z_(j,t)$ represents the economic and credit cycle variables for country j. In specification B, the regulation variables and the financial and business cycle variables are set to zero for domestic banks. This allows all the identification on the regulation and cycle variables to come from foreign banks. Domestic banks enter the regressions to provide more strength on the conclusions regarding the effect of bank characteristics on credit growth.

Data

We collect data on bank balance-sheet characteristics at solo basis from quarterly supervisory reports. Our analysis period begins in 2006Q1 and ends in 2014Q4. Before 2005 banks used a different accounting system and using a longer period would imply important breaks in some series, which are hard to address without compromising the quality of the data. Furthermore, the quality of analysis could also be compromised if many more years were included, as the beginning of that decade was dominated by a merger wave that substantially changed the landscape in the Portuguese financial system (for details, please see Barros *et al.* (2014)). During the analysis period, the structure of the Portuguese banking system was relatively stable. Furthermore, most of the changes in foreign regulation affecting Portuguese banks were implemented during the sample period.

All financial institutions are classified as domestic or foreign, depending on their ownership status. Foreign institutions are classified as branches or subsidiaries and there is information on the country of origin. Our dataset only includes monetary financial institutions (i.e., banks in their classic definition, as these are the only institutions authorized to receive deposits from the public). We exclude non-monetary financial institutions from the analysis because there is no information on their exposures to foreign countries. Furthermore, there are important differences in their funding models and in their regulation that would hamper the interpretation of the results.

All bank control variables are defined in detail in Appendix A. Table 1 summarizes these indicators for the full sample of banks operating in Portugal, as well as for domestic and foreign banks separately. Domestic banks are larger, better capitalized, less illiquid, rely more on core deposits and less on net external intragroup funding than foreign banks.

In order to have data on the international activity of the Portuguese banks, we merge the supervisory bank database with the bank level data underlying the International Banking Statistics reported to the BIS. This data was used on a consolidated basis (i.e. excluding intragroup positions) and on immediate borrower basis, and it refers to the local claims and liabilities of the branches and subsidiaries of the Portuguese banks. Additionally, we use bank-level data collected for the construction of the Euro Area Monetary Financial Statistics to obtain information on assets and liabilities against the banks of the same banking group located abroad. The use of these two data sources implied the exclusion of the Mutual Agricultural Credit Banks from the sample, as in these sources the data for this type of institutions is aggregated at a consolidated level. In any case, given that these institutions are devoted mainly to local activities and have a small weight on the total credit (around 3.75 per cent over the sample period), we believe that their inclusion in the sample would not be relevant for the purpose of this study.

Variable	All banks (n=57) Mean	Median	SD	Portuguese banks (n=25) Mean	Median	SD	Foreign banks (n=32) Mean	Median	SD
Dependent variable									
Domestic credit (ln change) (in %)	0.318	-0.169	15.34	0.380	-0.293	14.13	0.266	-0.0720	16.30
Independent variables									
Log Assets	7.278	7.088	1.952	7.805	7.538	2.090	6.831	6.881	1.705
Capital Ratio (in %)	6.459	5.116	12.77	8.580	6.517	15.30	4.660	3.436	9.799
Illiquid Assets Ratio (in %)	79.95	89.88	24.13	78.61	88.16	24.04	81.09	92.57	24.17
International Activity (in %)	-	-	-	2.429	0	4.075	-	-	-
Net intragroup funding (in %)	25.36	4.763	42.48	1.297	0	9.798	45.77	56.42	48.45
Core Deposits Ratio (in %)	16.22	10.34	18.30	25.29	22.59	20.72	8.522	2.386	11.22

TABLE 1. Summary Statistics on Bank Credit and Characteristics

Notes: This Table provides summary statistics for bank balance sheet and credit data. Data are observed quarterly from 2006Q1-2014Q4. Banking data are reported at the solo level. All variables defined in Appendix A.

We merge the bank database with the IBRN Prudential Instruments Database (described in Cerutti *et al.* (2017)) and with economic and financial cycle data (obtained, respectively, from BIS (2014) and Drehmann *et al.* (2011)). The IBRN Prudential Instruments Database includes quarterly information on the timing of tightening or loosening of a number of prudential tools in 64 countries over the period 2000-14. For each prudential tool, the database includes one index for its change, where a negative value (-1) corresponds to a loosening, a positive value (+1) to a tightening and zero signals that no change has occurred in the quarter. In this paper, the prudential tools considered are capital requirements, sectoral specific capital buffers (for instance, for real estate and consumption) and loan-to-value ratio limits.[3]

In the construction of the exposure-weighted prudential policy indexes, used in specification A, only exposures to countries with data available in the prudential database could be considered. In our sample, this means we are taking into account 85 per cent of the total foreign exposures of the Portuguese banks, through their affiliates abroad. We also had to delete from our sample all banks belonging to Angolan banking groups (which have a weight on the domestic credit lower than 0.05 per cent), given that for this country we do not have data on the prudential measures. The final dataset includes 57 banks (25 domestic and 32 foreign), which account on average over the sample period for 96 per cent of the credit granted by banks in Portugal.

Table 2 and Figure 6 report some descriptive statistics on the prudential policy variables. As shown in the last column of Table 2, around 4-5 per

3. In Bonfim and Costa (2017) the analysis also includes reserve requirements and concentration ratios. These instruments changed less often in the countries where banks in Portugal have stronger linkages, so they are excluded from this article.

cent of all the observations in the sample of Portuguese banks (used in specification A) and around 2-5 per cent in the sample of foreign banks (used in specification B) are associated with changes in the prudential measures analyzed.[4] In the case of capital requirements and sectoral specific capital buffers, the changes in our sample refer mostly to tightening movements (for capital requirements, as explained in Cerutti *et al.* (2017), all changes refer to the implementation of Basel). By contrast, in the loan-to-value ratio, the most relevant changes refer to loosening decisions (Figure 6).

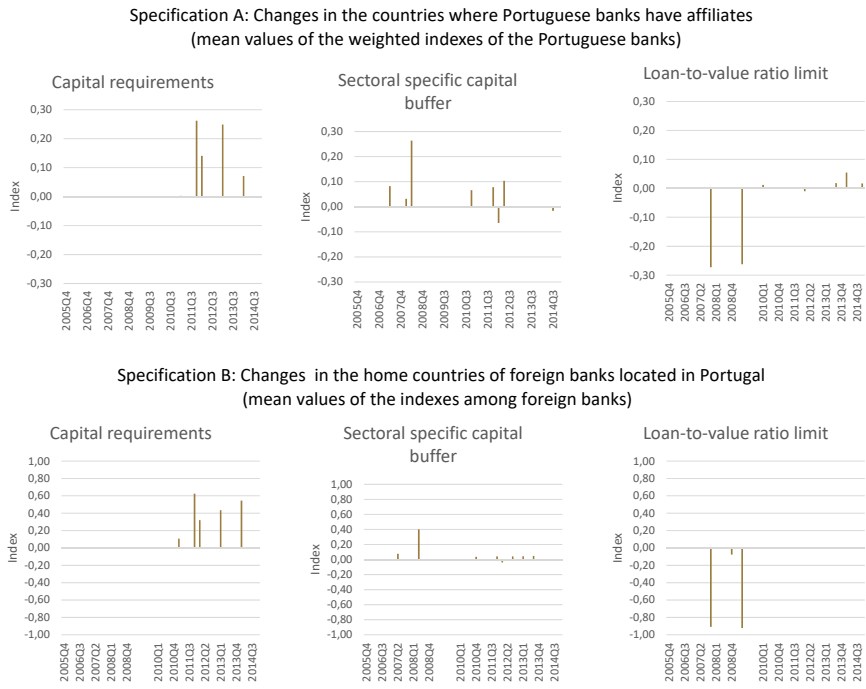

FIGURE 6: Changes in prudential tools

Source: IBRN and Banco de Portugal.

4. The sample used in specification B includes both domestic and foreign banks, but the statistics for the incidence of regulation were calculated using only foreign banks. In fact, since we are interested in estimating the impact of foreign regulation, the regulation variable was set to zero for Portuguese banks in the regressions of specification B. This means regulation in Portugal is not explicitly included in the regressions, although its effects are embedded in the time fixed effects.

Specification A

	Base Data (Before Aggregating to Exposure-Weighted Measures)					Exposure-Weighted Observations
Instrument	# of Country-Time Changes	# of Country-Time Changes (Tightening)	# of Country-Time Changes (Loosening)	# of Bank-Time Changes	Proportion Base-MPP Nonzero on total observations	Proportion ExpP_t Nonzero on total observations
General capital requirements	30	30	0	55	0.003	0.035
Sector specific capital buffer	17	15	2	36	0.002	0.052
Loan-to-value ratio limits	18	11	7	36	0.002	0.049

Specification B

Instrument	# of Country-Time Changes	# of Country-Time Changes (Tightening)	# of Country-Time Changes (Loosening)	# of Bank-Time Changes	Proportion HomeP_t Nonzero on total observations
General capital requirements	15	15	0	48	0.050
Sector specific capital buffer	10	8	2	21	0.022
Loan-to-value ratio limits	3	0	3	23	0.024

TABLE 2. Summary Statistics on Changes in Prudential Instruments

Notes: These tables show summary statistics on the changes on general capital requirements, sector specific capital buffers and loan to value ratio limits. In the table for specification A, the data refers to changes in regulation in the countries where the branches and subsidiaries of the Portuguese banks are located over the period 2005q4-2014q4. In the table for specification B, the data refers to changes in regulation in the home countries of the foreign banks operating in Portugal over the period 2005q4-2014q4. Data on the prudential instruments come from the "Prudential Instruments Database" by Cerutti et al. (2015) and are on the quarter level. The number of changes in prudential instruments is reported on several dimensions, i.e. on the country-time level and on the bank-time level. The table also shows the share of prudential changes to total observations (i.e. the share of nonzero observations). In the first table, the column "Exposure weighted observations" is based on the underlying data on prudential changes in foreign countries (columns "base data"). The reported data is based on the regression sample.

Main results

In this section we discuss the results of our empirical estimations, trying to understand how foreign regulation affected the evolution of credit granted in Portugal. Table 3 presents the results of the estimation of equation (3). We consider contemporaneous effects and two lags for the regulation variable. In the first lines of the table we report the results for these three terms and in the bottom of the table the results for the sum of the three coefficients. Given space constraints, for the interactions of regulation with the bank control variables we report only the joint effect of these three coefficients, i.e., the results for sum of the interactions with the contemporaneous and lagged regulation. In order to have an idea of the impact of regulation when both the direct effect and the interactions effects are taken into account, at the bottom of the table

we also include the average marginal effects of changes in regulation. The magnitude of the marginal effects reflects the average impact (in percentage points) on the growth rate of credit of a simultaneous tightening in regulation in all countries where Portuguese banks have affiliates.

The columns report the results for each prudential tool individually, i.e., for the capital requirements, sector-specific capital buffer and for the loan-to-value ratio limits. By examining the lines of the table with the marginal effects, we can conclude that foreign regulation affects the evolution of loans granted domestically through the international exposures of domestic banks. The effect is statistically significant for the sector specific capital requirements and the loan-to-value ratio limits, but not for the general capital requirements.

Analyzing the statistical significance of the marginal effects allows us to establish that there are cross-border spillovers of regulation. However, it is also very important to understand in which direction do these spillovers go. Does a tightening in regulation abroad lead to more or less credit at home? We find that a tightening in the sector specific capital requirements yields an increase in the growth of loans granted by domestic banks in Portugal. This result suggests that Portuguese banks operating internationally divert their resources to internal markets when they face tougher sector specific capital requirements abroad. For the loan-to-value ratio the effect is the opposite: a tightening of this instrument abroad decreases credit growth domestically. For this instrument a tightening might imply a decline in the profitability of the affiliates (given that more risky borrowers for whom higher spreads are applied might be left out of the market), which can lead to a reduction in the domestic activity. It is also possible to argue that despite tighter loan-to-value limits banks still find it profitable to lend abroad, given that this instrument is usually tightened when credit and real estate markets are booming and hence (short-term) profitability might be very high. Assuming that resources are limited, this might imply a constraint in domestic credit. Cerutti *et al.* (2017) find that there is a positive correlation between credit growth and the decline of loan-to-value limits, thus supporting this hypothesis.

Though the signal of the effects of foreign regulation on the evolution of domestic credit is of primary interest, it is also relevant to understand exactly through which mechanisms these effects are transmitted across borders. Our specification allows us to do that through the analysis of the interaction terms. The substitution effects of foreign regulation leading to an increase in domestic credit growth, which work though sectoral capital buffers, are stronger for banks with more liquid assets and with lower core deposits ratio. In turn, the complementary effects arising from a tightening in the loan-to-value ratio are reinforced for smaller banks and for banks with more net external intragroup funding and a higher core deposits ratio. Banks' with a higher weight of their retail domestic activity, measured by core deposits ratio, thus seem to be more prone to contract domestic credit when facing tighter regulation on their foreign activity.

	(1)	(2)	(3)
	ExpP= Capital Requirements	ExpP= Sector-Specific Capital Buffer	ExpP= Loan To Value Ratio
ExpP_t	-58.08***	13.91	29.59
	(19.08)	(22.83)	(25.49)
ExpP_t-1	41.58	37.61	-156.3*
	(39.24)	(40.59)	(79.69)
ExpP_t-2	1.331	58.39**	-112.5**
	(21.62)	(27.30)	(47.77)
Log Total Assets_t-1	1.895	1.062	3.002
	(2.653)	(2.513)	(2.960)
Capital Ratio_t-1	0.0539	0.0768	0.0676
	(0.0534)	(0.0585)	(0.0625)
Illiquid Assets Ratio_t-1	0.0419	0.0543	0.0256
	(0.109)	(0.107)	(0.118)
International Activity_t-1	0.828**	0.347	0.763**
	(0.310)	(0.282)	(0.326)
Net intragroup funding_t-1	0.0955	0.0576	0.137**
	(0.0648)	(0.0683)	(0.0663)
Core Deposits Ratio_t-1	0.0768	0.108	0.0680
	(0.125)	(0.130)	(0.136)
Log Total Assets * ExpP	4.45***	-2.41	40.13***
	(11.2928)	(0.6192)	(5.0245)
Capital Ratio * ExpP	2.35***	-0.02	2.20
	(10.7245)	(0.0961)	(1.9921)
Illiquid Assets Ratio * ExpP	-0.48	-0.95**	-0.75
	(1.782)	(3.4517)	(1.1776)
International Activity* ExpP	1.41**	0.72	-0.92
	(3.9663)	(1.9943)	(1.1751)
Net intragroup funding * ExpP	0.48**	0.82	-3.44**
	(4.414)	(1.9257)	(3.1076)
Core Deposits Ratio * ExpP	-0.68***	-0.27***	-4.12**
	(7.725)	(9.2166)	(3.3567)
ExpP (ExpP_t+ExpP_t-1+ExpP_t-2)	-15.17	109.9069***	-239.2609*
F-Statistics	(0.0839)	(8.8012)	(4.2453)
P-Values	0.77	0.01	0.05
Average marginal effects of ExpP	-12.32	11.97*	-71.63**
Observations	703	703	703
Adjusted R-squared	0.04	0.02	0.03
Number of banks	25	25	25

TABLE 3. Inward Transmission of Policy through International Exposures of Domestic Banks

Notes: This table reports the effects of changes in regulation and firm characteristics and their interactions on log changes in domestic loans. The data are quarterly from 2006Q1 to 2014Q4 for a panel of domestic banks. Foreign exposure weighted regulation ExpP is calculated as the weighted average of changes in foreign regulation where the weights are assets and liabilities of the bank affiliates in the respective foreign country. For ExpP interaction effects, the reported coefficient is the sum of the contemporaneous term and two lags, with the corresponding F-statistics for joint significance in parentheses. For more details on the variables see Appendix A. Each column gives the result for the regulatory measure specified in the column headline. All specifications include time and bank fixed effects. Standard errors are not clustered. ***, **, and * indicate significance at the 1 per cent, 5 per cent, and 10 per cent level, respectively.

Table 4 presents the results of the estimation of equation (4), i.e. specification B. In this case, the goal is to understand how foreign regulation

affects credit granted in Portugal by branches and subsidiaries of foreign banks. As shown in equation (4), we consider contemporaneous effects and two lags for the foreign regulation variable. As in the previous table, the reported coefficients for interaction effects are the sum of the contemporaneous term and two lags. For the direct effects we report both the coefficients of the three HomeP terms (in the first lines of the table) and their sum (at the bottom of the table). The table also includes the average marginal effects of changes in regulation and their significance, calculated for all the foreign banks.

These results also suggest that changes in regulation abroad have an impact on the growth of credit granted in Portugal. In this case the marginal effects reported at the bottom of the table show that the effect comes from the capital requirements and the loan to value limits. While for the loan-to-value ratio a tightening abroad is associated with more credit growth in Portugal, for the general capital requirements we find the opposite.

To better understand these results, it is important to discuss our expectations about this transmission channel. When regulation is tightened in the home country of a given bank, this might affect the whole activity of the banking group, including its affiliates abroad, if the regulation is applied at the consolidated level. So, while in the previous specification domestic banks could to some extent substitute between foreign and domestic credit when regulation was tightened or loosened abroad, in this specification this substitution might be more likely to occur in the case of regulations that are not applied at the consolidated level. The results we obtain are in line with this reasoning. In fact, capital requirements are usually applied at the consolidated level, while limits to the loan-to-value ratio are most often applied at the local level, when specific risks are building up in the home country of the bank, where most of its activity is usually concentrated. To be more effective, these instruments are typically targeted to the vulnerabilities they want to address and thus do not cover the international activity of banks.

As before, our empirical strategy allows us to understand through which channels these mechanisms are working by exploring the interaction terms in the regressions. The negative effect of tighter capital requirements on credit growth in Portugal by foreign banks is mitigated when banks have less intra-group external net debt. Other indicators of banks' financial strength and business models are not statistically significant. Looking at the positive effect of a tightening in the loan-to-value ratio, we find that this effect is stronger when the affiliate becomes better capitalized and more liquid. This suggests that foreign banks with better financial standing substitute some of the credit granted abroad by domestic loans when lending requirements become tighter at home. Additionally, the substitution effect is stronger for the affiliates that rely more on intra-group funding and less on deposits from residents in the host country.

	(1)	(2)	(3)
	HomeP= Capital Requirements	HomeP= Sector-Specific Capital Buffer	HomeP= Loan To Value Ratio
HomeP_t	-10.19	13.78	82.47***
	(12.15)	(10.62)	(22.66)
HomeP_t-1	24.61*	34.93**	18.43***
	(11.28)	(13.15)	(3.501)
HomeP_t-2	-12.66**	31.46*	18.15**
	(5.555)	(15.82)	(6.553)
Log Total Assets_t-1	-1.300	-1.709	-1.514
	(1.557)	(1.581)	(1.558)
Capital Ratio_t-1	0.0835*	0.0798*	0.0753**
	(0.0374)	(0.0396)	(0.0329)
Illiquid Assets Ratio_t-1	-0.0577	-0.0436	-0.0739
	(0.0774)	(0.0744)	(0.0775)
Net intragroup funding_t-1	-0.0408	-0.0578	-0.0376
	(0.0448)	(0.0484)	(0.0410)
Core Deposits Ratio_t-1	0.0842	0.0922	0.0973*
	(0.0651)	(0.0643)	(0.0492)
Financial cycle (Home country)	-0.0405*	-0.0438	-0.0350
	(0.0209)	(0.0256)	(0.0209)
Business cycle (Home country)	1.375**	1.489**	1.246**
	(0.470)	(0.506)	(0.495)
Log Total Assets * HomeP	0.23	1.51	1.10
	(0.0124)	(0.7981)	(2.1151)
Capital Ratio * HomeP	-0.54	-0.91**	2.44***
	(1.2924)	(7.3717)	(28.9896)
Illiquid Assets Ratio * HomeP	0.16	-1.09***	-1.51***
	(0.7227)	(24.3021)	(17.74)
Net intragroup funding * HomeP	-0.37*	0.24*	0.31***
	(3.9579)	(4.8046)	(14.68)
Core Deposits Ratio * HomeP	-0.41	-0.43	-0.54***
	(1.6546)	(0.6513)	(87.823)
HomeP (HomeP_t+HomeP_t-1+HomeP_t-2)	1.75	80.17***	119.05***
F-Statistics	(0.0171)	(43.432)	(20.3492)
P-Values	0.90	0.00	0.00
Average marginal effects of HomeP	-7.1*	4.87	24.91***
Observations	1,619	1,619	1,619
Adjusted R-squared	0.046	0.046	0.052
Number of banks	57	57	57

TABLE 4. Inward Transmission of Policy via Affiliates of Foreign-Owned Banks

Notes: This table reports the effects of changes in regulation and firm characteristics and their interactions on log changes in domestic loans. The data are quarterly from 2006Q1 to 2013Q4. HomeP refers to the changes in regulation in the home (i.e. parent bank) country of foreign affiliates. For HomeP interaction effects the reported coefficient is the sum of the contemporaneous term and two lags with the corresponding F-statistics for joint significance in parentheses. For the Portuguese banks the regulation variables and the financial and business cycle variables are zero. For more details on the variables see Appendix A. Each column gives the result for the regulatory measure specified in the column headline. All specifications include time and bank fixed effects. Standard errors are clustered by country. ***, **, and * indicate significance at the 1 per cent, 5 per cent, and 10 per cent level, respectively.

The international results

As mentioned before, this article summarizes the results for Portugal obtained under an international collaborative project, hosted by the International Banking Research Network (IBRN). This network was launched in 2012 and involves researchers from central banks around the world, working on issues related to the role of international banks. The goal of the network is to overcome important data and research gaps identified during the global financial crisis. The use of micro-level data has proven to be of critical importance, in particular to look at cross-border linkages of individual banks. However, much of this data is confidential and cannot be publicly assessed or merged for a joint analysis of different countries, thereby undermining the possibility of having a broad picture of international financial linkages. To overcome this, the IBRN sets up country teams that work in parallel on the same topics. The network jointly defines a common research question, a common methodological approach and a similar data and research design. Each country team uses their own bank-level data to arrive at comparable cross-country evidence, which is then used to derive joint conclusions using a meta-data approach. This allows to overcome the limitations of data confidentiality, by arriving at comparable cross-country results that can be of high relevance to inform policy-making. The first IBRN project focused on the transmission of liquidity shocks through global banks and the joint results of the project are summarized in Buch and Goldberg (2015).

This article summarizes the results obtained for Portugal in the second IBRN project. The joint results are described in Buch and Goldberg (2017). The main conclusion that emerges from the analysis of all the country-specific results is that sometimes prudential instruments have cross-border effects. Still, the direction and magnitude of these spillovers varies significantly across instruments and across banks. Bank-specific financial ratios and business models have an influence on the way these cross-border spillovers affect bank lending. Across the board, the cross-border spillovers do not seem to be very large in magnitude, though the results refer to a period when the changes in prudential instruments were more subdued than what is foreseen in the future, given the ample macro-prudential toolkit that authorities can now use.

Cross-border spillovers through branches and subsidiaries

A bank might be present in a foreign country through two different legal forms: a branch or a subsidiary. A branch is not a legally autonomous entity and belongs directly to the parent bank. In turn, a subsidiary is a legally independent institution in the host country. In legal terms, it works in a very similar way to the domestic banks operating in that country, with the main difference being that its capital is held by a foreign bank. For an uninformed

customer the differences between a branch and a subsidiary would not be perceptible as the management of their operations and their relationships with customers have no reason to differ. However, important differences apply in regulatory terms due to legal nature of each institution. For instance, deposits held by customers in a branch are guaranteed by the deposit guarantee scheme of the home country, while for the subsidiary the responsibility lies entirely with the host country. More importantly for the purposes of our study, some prudential instruments are applied differently for branches and subsidiaries. Cerutti *et al.* (2007), Dell'Ariccia and Marquez (2010), Focarelli and Pozzolo (2005) and Goldberg and Saunders (1981) discuss in more detail some of the differences between branches and subsidiaries and the way banks choose to expand internationally, while Peek and Rosengren (1997, 2000) analyze the implications on the transmission of shocks.

The most relevant example in the European Union is perhaps the case of capital requirements: branches of EU banks are exempt from fulfilling capital requirements in the host country, but are directly subject to capital requirements in the home country. In this setting, the cross-border implications of regulations may be differentiated. While both branches and subsidiaries are affected by the capital requirements implemented in the home country, only subsidiaries are affected by changes in capital requirements in the host country. In contrast, loan-to-value ratios limits are usually applied directly to exposures in markets in which there are concerns regarding the buildup of risks in real estate markets. Thus, if the regulator applies this measure in the home country, the loans granted by home country affiliates abroad should not be directly affected.

Given these important differences, in this section we extend our previous analysis to understand how the cross-border transmission of prudential policy works through different types of foreign banks. More specifically, we look separately at the transmission through foreign branches and subsidiaries located in Portugal, as their legal form has implications for the way regulation is applied. In this analysis we will focus on the prudential tools for which we find evidence of transmission through foreign banks to the domestic economy: capital requirements and loan-to-value limits.

To analyze this, we adapt equation (4) and estimate the following regression:

Specification B1: Inward transmission of home prudential policy via branches and subsidiaries

$$\begin{aligned}\triangle Y_{b,j,t} = \alpha_0 + \sum_{k=o}^{2} \alpha_{k+1} HomeP_{j,t-k} Branch_{b,t} \\ + \sum_{k=o}^{2} \alpha_{k+4} HomeP_{j,t-k} Subsidiary_{b,t} + \alpha_7 X_{b,j,t-1} + \alpha_8 Z_{j,t} \\ + \sum_{k=o}^{2} \beta_{k+1} HomeP_{j,t-k} X_{b,j,t-k} Branch_{b,t} \\ + \sum_{k=o}^{2} \beta_{k+4} HomeP_{j,t-k} X_{b,j,t-k} Subsidiary_{b,t} + f_b + f_t + \varepsilon_{b,j,t}\end{aligned} \tag{5}$$

All the variables and estimation restrictions are the same as in equation (4). The only difference is that the prudential variable is interacted with a categorical variable for branches and subsidiaries. The omitted category is the one referring to domestic banks. These regressions include bank and time fixed effects. Standard errors are clustered by country.

The results are presented in Table 5.[5] The results in the previous section (Table 4) show that tighter capital requirements in the home country of a foreign bank are associated with less credit growth in the host country. By looking at the marginal effects in Table 5 we are able to find that this cross-border spillover of regulation works only through branches. As discussed above, the impact of foreign regulation should in theory affect both types of foreign banks. One possible explanation for this difference might be the different way branches and subsidiaries are affected by capital regulation. Branches are only affected by their home country regulation and so it makes sense to find this statistically significant spillover. In turn, subsidiaries are simultaneously affected by home and host regulation. Capital requirements were higher in Portugal than in most other European countries during a large part of the sample period. These measures were taken to strengthen the resilience of the Portuguese banking system amidst an environment of erosion of trust. Given this backdrop, when capital requirements were tightened in the home countries, their effect on subsidiaries was possibly not felt as they were already subject to more demanding capital requirements due to host regulation.

Regarding the loan-to-value ratio, in Table 4 we reported that a tightening in the home country implies more credit growth in the host country through foreign banks. In Table 5, we report positive marginal effects both for branches

5. Given space constraints, we do not report the coefficients of the direct effects of bank control variables.

	(1) HomeP= Capital Requirements	(2) HomeP= Loan To Value Ratio
HomeP_t*Subsidiaries	-54.73	-43.82***
	(39.71)	(4.802)
HomeP_t*Branches	11.66	25.66***
	(26.87)	(7.122)
HomeP_t-1*Subsidiaries	-81.43*	26.55***
	(44.36)	(4.560)
HomeP_t-1*Branches	28.41	34.83***
	(16.16)	(8.106)
HomeP_t-2*Subsidiaries	-81.46***	-14.57
	(22.70)	(10.21)
HomeP_t-2*Branches	-8.625	46.35***
	(7.357)	(8.019)
Financial cycle (Home country)	-0.0348	-0.0286
	(0.0232)	(0.0234)
Business cycle (Home country)	1.398**	1.235**
	(0.492)	(0.508)
Log Total Assets * HomeP*Subsidiaries	24.7664***	2.768
	(39.8632)	(1.4382)
Log Total Assets * HomeP*Branches	-2.801	13.9214***
	(1.5096)	(61.3848)
Capital Ratio* HomeP*Subsidiaries	4.4552***	6.6972***
	(10.9829)	(28.8127)
Capital Ratio* HomeP*Branches	-0.787	-0.7752**
	(0.9531)	(7.3751)
Illiquid Assets Ratio* HomeP*Subsidiaries	-0.125	-0.120
	(0.0443)	(0.0799)
Illiquid Assets Ratio* HomeP*Branches	0.125	-2.2814***
	(0.2071)	(89.1302)
Net intragroup funding * HomeP*Subsidiaries	-0.045	0.111
	(0.8222)	(0.2571)
Net intragroup funding* HomeP*Branches	-0.4185*	0.2852*
	(4.6719)	(4.9366)
Core Deposits Ratio * HomeP*Subsidiaries	-0.6817*	-0.6982***
	(3.3879)	(20.8261)
Core Deposits Ratio * HomeP*Branches	-1.226	0.364
	(3.2624)	(2.0952)
HomeP (HomeP_t+HomeP_t-1+HomeP_t-2)*Subsidiaries	-217.6286***	-31.847
F-Statistics	(15.244)	(3.088)
P-Values	0.004	0.113
HomeP (HomeP_t+HomeP_t-1+HomeP_t-2)*Branches	31.448	106.8409***
F-Statistics	(1.2814)	(34.985)
P-Values	0.287	0.000
Average marginal effects of HomeP for foreign banks		
For subsidiaries	1.038	44.2201***
For branches	-12.222***	27.8768***
Observations	1,619	1,619
Adjusted R-squared	0.047	0.055
Number of banks	57	57

TABLE 5. Inward Transmission of Policy via Affiliates of Foreign-Owned Banks – branches versus subsidiaries

Notes: This table reports the effects of changes in regulation and firm characteristics and their interactions on log changes in domestic loans. The data are quarterly from 2006Q1 to 2014Q4. HomeP refers to the changes in regulation in the home (i.e. parent bank) country of foreign affiliates. For HomeP interaction effects with bank characteristics the reported coefficient is the sum of the contemporaneous term and two lags with the corresponding F-statistics for joint significance in parentheses. For the Portuguese banks the regulation variables and the financial and business cycle variables are zero. For more details on the variables see Appendix A. Each column gives the result for the regulatory measure specified in the column headline. All specifications include time and bank fixed effects. Standard errors are clustered by country. ***, **, and * indicate significance at the 1 per cent, 5 per cent, and 10 per cent level, respectively.

and subsidiaries, which supports our hypothesis that this instrument should affect in the same way the two types of institutions.

Concluding Remarks

In this paper we offer a contribution to understand the cross-border impacts of prudential regulation. Our results suggest that the cross-border effects of regulation depend on the prudential tool considered as well as of the channel of transmission. When the channel of transmission are the domestic banks with international activity, we find that a tightening abroad of sector specific capital buffers leads to an increase in credit growth in Portugal which suggests the presence of substitution effects. For the loan to value ratio, we obtain the opposite sign, thus suggesting the existence of complementary effects. Indeed, a tightening of the loan-to-value ratio limit is associated with a decrease in the growth of domestic loans granted by Portuguese banks. This result might stem from the reduction in profits for the banking group as a whole. Alternately it might reflect the conditions under which this instrument is usually applied, i.e. periods of booms in real estate markets. Having limited resources, banks may prefer to limit domestic lending to continue to lend abroad if this market still yields high profitability despite the tighter regulation.

When we analyze the influence of foreign regulation on the growth of credit granted in Portugal by the foreign banks operating in the country, it is interesting to note that the cross-border spillovers for the loan-to-value limits work in a different way – after a tightening in this instrument in the country of the parent bank, foreign banks increase credit growth in Portugal. One possible explanation for positive effect in the case of foreign banks (as opposed to domestic banks) is that foreign banks might be more worried with the building up of risks in the home country (where most of their activity is concentrated) and thus increase credit growth abroad. For the capital requirements, we find that foreign banks decrease credit in Portugal, after a tightening in the home country. The opposite effects obtained for capital requirements and loan to value ratio are in line with what could be expected given that when regulation is tightened in the home country of a given bank, substitution effects are more likely to occur if regulation is applied at the local level, than if it is applied at the consolidated level.

We also try to understand whether the transmission of foreign prudential policy through foreign banks operating in a given country works differently through branches or subsidiaries. We find as expected that in the case of the loan-to-values ratio the positive effect works both through branches and subsidiaries. By contrast, the negative effect of tighter capital requirements, in the home country of a foreign bank, on credit in the host country work only through branches. One possible explanation for this difference might be the fact when capital requirements were tightened in the home countries, their

effect on subsidiaries was possibly not felt as these banks were already subject to more demanding capital requirements due to Portuguese regulation. These results show that the legal form of credit institutions plays an important role of the cross-border transmission of prudential regulation, most notably due to differences in the scope and perimeter of application of the instruments.

With increasingly harmonized regulation across the world, this project contributes to understand how changes in prudential tools in one country might affect the evolution of credit granted in another country. This is relevant to think about intended and unintended international spillovers when designing regulation. With increased pressure for international reciprocity between regulators (as set out for instance in the countercyclical capital buffer framework), having at hand empirical evidence on the way regulation affects lending in other countries will certainly be highly valuable for policymakers.

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Appendix

Variable Name	Description	Data Source
Illiquid Assets Ratio	(1-(Cash and claims on central banks and credit institutions/Total assets)) (in %)	Supervisory data (Banco de Portugal)
Log Assets	Ln (Total assets/GDP deflator 2012)	Supervisory data (Banco de Portugal) and National accounts (Statistics Portugal)
Core Deposits Ratio	(Time deposits from residents + deposits redeemable at notice from residents + savings deposits from residents)/Total assets (in %)	Supervisory data (Banco de Portugal)
Capital Ratio	Equity capital/Total assets (in %)	Supervisory data (Banco de Portugal)
Net intragroup funding	(Deposits of banks of the same banking group located abroad - credit, debt securities shares and other equity to banks of the same banking group located abroad)/Total liabilities (in %)	Montlhy balance sheet statistics and supervisory data (Banco de Portugal)
International Activity	Local claims plus liabilities (denominated in local currency) of the branches and subsidiaries (of the Portuguese banks) located outside Portugal/(Total assets and total liabilities of the parent bank + Local claims and liabilities of the branches and subsidiaries located outside Portugal) (in %)	Bank level data on a consolidated basis underlying the report to the International Banking Statistics of the BIS and Supervisory data (Banco de Portugal)

TABLE A.1. Construction of Balance Sheet Variables

Operational cycle and tax liabilities as determinants of corporate credit risk

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Abstract
Liquidity and turnover indicators are usually mentioned as important dimensions in the corporate credit risk literature. However, these variables may reflect different firms' operational activity management and efficiency. In this article, we investigate if information on these firms' allow us to improve the assessment of firm's financial positions and in determining its probability of a bank credit default event. For this, we explore the breakdown of working capital and turnover into variables related to cash, activity indicators, investment, and tax liabilities. According to the results obtained, we observe that firms that take longer to repay their suppliers, or firms whose purchase stay longer as inventories, have higher probabilities of a credit default event. Moreover, there is evidence of a positive relationship between firms' credit risk and the share of tax liabilities in total assets. These indicators seem to be signals about a firm's financial fragilities. (JEL: G21, G33, C25)

Introduction

Corporate credit risk has received great interest in the financial and banking literature. In the banking perspective, the asymmetric information in the credit market between entrepreneurs and lenders is critical. For credit risk management, it is crucial to assess a firm's financial position and identify its vulnerabilities in order to determine the price of a loan, or to decide even about its approval (Stiglitz and Weiss (1981)). Afterwards, a careful monitoring of the firm's financial developments is also required, given the impact of default events on banks' provision and impairment policies, as well as on regulatory capital requirements. Over the

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last decade, there has been a renewed interest about credit risk management and measurement supported by financial innovations, competition policies, and computational improvements. Additionally, under the Basel II Capital framework, banks were allowed to use internal credit risk models in order to determine their capital requirements. Thus, banks had developed several techniques to analyze firms' financial positions, probability of default, and other credit risk parameters. More recently, the economic and financial crises, and the significant increase in the materialization of credit risk, reinforced the importance of a close monitoring of firm's financial position and credit risk standards.

This study explores corporate credit default, investigating if some variables underlying liquidity indicators, such as working capital, and turnover contain additional information regarding a firm's financial health and its creditworthiness. Apart from the standard financial variables applied in the empirical literature, related to profitability, leverage, or firm size, we include variables directly related to firms' activity, such as production cycle, cash holdings, and efficiency in determining the probability of a bank loan default. We also explore the role of firms' tax liabilities. This analysis has in mind that working capital and turnover may have significant underlying differences related to firms' operational cycle, efficiency, or even the management of inflows and outflows, and consequently potentially different assessments of firms' financial soundness.

In this analysis we combine micro data for Portuguese firms from the Central Balance Sheet Database with information about credit status and banking relationships from the Central Credit Register, both databases available at Banco de Portugal. As these databases are quite exhaustive, the data set allows a high coverage of banks' exposure to the corporate sector. It also allows exploring corporate heterogeneity, analyzing different firms' segments. In the econometric analysis we apply a logit model for panel data to assess the relevance of firm's characteristics in its probability of default.

According to the results obtained, the breakdown of firms' working capital and turnover improves the analysis of the probability of default. In particular, the indicators related to firm's activity, such as management of inflows and outflows contain additional information regarding firms' financial positions. The results also highlight the relevance of tax liabilities as an indicator of firms' financial fragilities. These results suggest the value of a close analysis of a firm's activity as a signal of that firm's financial soundness. Moreover, the results suggest a relationship between tax liabilities and a firm's financial fragility.

The remainder of this article is organized as follows: the next section briefly reviews related literature. Next, a description of the data sources and variables under analysis is provided, as well as some descriptive statistics. The main econometric results are then presented, including the analysis of

different corporate segments. The next section presents some robustness tests. The last section summarises the main conclusions.

Review of the literature

Credit risk is related to the possibility of losses due to changes in the credit quality of the counterparts. Much of the literature on corporate credit risk is related to modeling default events, *i.e.* the failure of a firm to meet the terms agreed in credit contracts. Several quantitative models have emerged in this field.

For firms with publicly traded equity or debt, there are the structural and reduced-form approaches (see Bielecki and Rutkowski (2002)), depending on the information available. Structural models focus on modeling and pricing credit risk of a firm, in which the firm's asset value plays a crucial role. These models intend to link the credit events, mainly default, to the firm's fundamentals. One of the most popular structural models was developed by Merton (1974). According to Merton's model, a firm's equity value is similar to a call option on the value of its assets, where the strike price is the value of the liabilities. In this framework, default occurs when the firm's asset value falls below the value of the liabilities at the maturity date.[1] In line with this model, the credit risk of a firm is essentially driven by the dynamics of the asset value and the respective volatility, taking the value of liabilities as given: the greater the value of the firm, and the less its volatility, the lower the probability of a default event.[2] Several studies have explored this model in determining the probability of default. Moody's - KMV model (Moody's (2004)) is one of the most well known. In turn, under reduced form models (in line with Jarrow and Turnbull (1992)), firm's assets value is not modeled and default events are specified exploring some exogenous process.

Despite the attractiveness of these approaches, and the forward looking perspective that market data incorporates, their implementation is limited by the availability of data. This is an important drawback given that the fraction of listed firms or firms with access to debt markets is quite limited for several

1. Note that default event is different from bankruptcy. The latter occurs when the firm is liquidated, *i.e.* it is not able to pay own debts. Bankruptcy is based on a legal definition, and so it is a country-specific concept. Default corresponds to a delay in payments according to the pre-defined terms of credit contracts.

2. The number of standard deviations that a firm's asset value is away from the default point is defined as distance-to-default. Generally, distance-to-default (DD) is the distance between the firm's asset value in one year $E(V_1)$ and the default point (DPT), based on liabilities' structure maturity, expressed in standard deviations of assets' value (assets' volatility):

$$DD = (E(V_1) - DTP)/\sigma_{V_1}$$

European countries. This fraction is even lower for firms that are traded on a regular basis.

Therefore, much of the empirical literature relies on more traditional approaches in order to explore the firm's idiosyncratic risk factors and its creditworthiness. In particular, these studies intend to identify the contribution of firms' financial indicators, mainly based on accounting data, and other characteristics in determining the probability of a default event. Even though the limitations of accounting data (lack of theoretical support, and the backward perspective), some studies, such as Demirovic and Thomas (2007) and Agarwal and Taffler (2008), found evidence that accounting-ratio approaches are also meaningful in credit risk analysis. Demirovic and Thomas (2007) found evidence that accounting variables contain incremental information when added to an approach with market measures. Agarwal and Taffler (2008) found that traditional models are robust and not inferior to market-based models.[3]

The empirical researches explore corporate credit risk in different perspectives, using different data and alternative methodologies. The seminal empirical papers analyzing the relevance of financial variables in identifying firms' default go back to the 1960s with Beaver (1966) and Altman (1968). Beaver (1966) found that several ratios present significant differences between failed and viable firms. He also observed that those differences increased as the time to a failure decreased. Using a set of some financial variables, Altman developed a weighted linear indicator to identify distress and non-distress firms. The Altman's indicator, known as *Z-score*, has persisted as a benchmark until the present day in corporate credit risk literature.[4]

Despite a lack of consensus in the literature regarding which firms' characteristics should be considered as more important in modeling default events, a pattern among the variable selection suggests the importance of some categories of indicators. Looking at financial data, measures related to profitability, leverage, and liquidity are within those typically found as relevant in determining firms' default. Other firms' characteristics, such as size, age, and business sector were also highlighted in empirical analyses (see, for instance, Bunn and Redwood (2003), Benito *et al.* (2004), Carling *et al.* (2007), Lacerda and Moro (2008), and Bonfim (2009)).

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3. Actually, Agarwal and Taffler (2008) argued that despite some limitations, there are also some facts that justify that the account ratios should also be assessed in credit risk perspective. The authors argued that corporate failure events are not a sudden episode. In general, failures occur after some years with adverse performances, with impact on firms' accounting financial statements. They also highlighted that several loan covenants (in credit contracts) are defined based on accounting indicators.

4. The variables included in Altman's *Z-score* index were: working capital/total assets, retained earnings/total assets, *ebitda*/total assets, market-value-equity/book value total liabilities, and sales/total assets.

As a complement to firm-specific information, the macroeconomic and financial environment has also been included in the credit risk empirical literature. This was motivated by the fact that average default frequency and firm default probabilities present some co-movements with macroeconomic and financial variables. This suggests that aggregate shocks can be a driver of corporate default.[5] Duffie *et al.* (2007), Pesaran *et al.* (2006), Jacobson *et al.* (2013), and Bonfim (2009), among others, show that (in addition to the firm's idiosyncratic characteristics) general macroeconomic variables improve the prediction of the probability of default models.

Some avenues of credit risk literature also explored the relevance of trade credit in corporate default, as well as bank lending relationships. Actually, trade credit plays an important role as external funding source for firms in several countries. One of the main questions is related to firm's choice between bank and trade credit, as trade credit is perceived as more expensive (based on implicit interest rate). The literature presents several reasons for their coexistence. Some arguments are related to financial factors, while others are related to the non-financial role of trade credit, such as transaction costs, price discrimination, warranty of product quality, or customer relationships, (*e.g.* Petersen and Rajan (1997)). On the financial perspective, many studies emphasize that firms use trade credit because there are bank credit constraints (*e.g.* Petersen and Rajan (1994), Nilsen (2002), and Cuñat (2007)).[6] These studies support the hypothesis that firms use other available forms of credit before trade credit as a funding source. In this context, non-bank private markets complement banks and public funding sources (financial markets) mainly for lower credit quality firms. Nevertheless, according to Biais and Gollier (1997) and Burkart and Ellingsen (2004), trade and bank credits can be either complements or substitutes. This argument is based on the fact that suppliers may have a comparative advantage over banks in collecting information on firms, in assessing their creditworthiness, and in monitoring their actions. Giannetti *et al.* (2011) also supports the complementarity between trade and bank credit.

According to the bank lending relationship literature, the firm-bank relationship is crucial in mitigating asymmetric information. This is especially important for smaller and younger firms, for which information is scarcer. A lending relationship may help to overcome this, given that banks obtain firms' private information through repeated interactions (Diamond (1984)). Thus, the literature suggests that firms that borrow from a small number

5. See, for instance, the initial analysis presented in Bonfim (2009), or the Financial Stability Reviews of European Central Bank and Banco de Portugal.

6. For instance, Cuñat (2007), for a panel of UK firms, found that trade credit is used at the margin, when other forms of credit have already been exhausted. The results also suggest that the evolution of trade credit is related to the length of the commercial relationships, and that trade credit seems to be more usual when firms have lower levels of liquidity.

of banks, or even concentrate a substantial part of their funding in a single relationship, tend to record lower financing constraints and obtain more favorable credit conditions.[7,8] However, a non-negligible fraction of firms has more than a single relationship. The stability and efficiency of lending relationships depend on several factors, both in banks and firms' perspectives. For instance, there are hold-up issues (information rents), market competition pressure, and banks' portfolio diversification incentives (e.g. Sharpe (1990), Rajan (1992), Detragiache *et al.* (2000), Von Thadden (2004), and Carletti *et al.* (2007)).

The link between the number of banking relationships and firm's credit quality has also been explored, but the arguments are mixed. Some authors argue that a single relationship may be driven by potential refusal of credit from other banks. Hence, it may be a negative signal to the market, making exclusive bank relationships undesirable. Other authors report evidence that firms with lower credit quality tend to establish multiple lending relationships (*e.g.* Detragiache *et al.* (2000), Degryse and Ongena (2001), Farinha and Santos (2002), and Fok *et al.* (2004)).

Looking at the Portuguese corporate sector, there are also some studies exploring credit risk. Antunes *et al.* (2005) estimated the probability of default of non-financial corporations using bank loan data, firms' business sector, and macroeconomic variables. In turn, Soares (2006) and Bonfim (2009) based their analyses on micro data. Soares (2006) estimated a synthetic indicator to identify potential distress events. In this study, based on discriminant analysis, the financial ratios selected were related to leverage, funding structure, liquidity and profitability. According to Bonfim (2009), profitability, solvency, liquidity, investment path, and sales were relevant in determining the probability of default. Moreover, as mentioned above, the inclusion of macroeconomic developments improved the econometric results. Lacerda and Moro (2008) analyzed Portuguese firms' default exploring three alternative techniques, namely logistic regressions, discriminant analysis and support vector machine (SVM). They found that SVM was very good in capturing non-monotonic dependence of the probability of default from some firms' characteristics. However, they also found that the three methods identified several important common variables. Indicators related to funding costs,

7. For instance, an increase in the number of lending relationships decreases the amount of credit (Petersen and Rajan (1994), Cole (1998), and Harhoff and Korting (1998)), while longer relationships increase the availability of credit (Petersen and Rajan (1994), Harhoff and Korting (1998)), and contribute to a decrease in collateral requirements (Harhoff and Korting (1998), and Berger and Udell (1995)). Looking at interest rates, the empirical evidence is mixed (*e.g.* Berger and Udell (1995), Petersen and Rajan (1994), and Bonfim *et al.* (2008)).

8. Boot (2000) and Ongena and Smith (1998) review the first wave of the literature on banking relationships, while Berger and Udell (2006) discuss the role of banking relationships in a more recent financial framework, given the transformation observed in the financial industry since the early 2000s.

liquidity, activity, leverage, as well as interest over debt ratio, credit lines, accounts payable, and size played a role as predictors of a firm's default event. Variables related to the number of banking relationships and the length of time of employees in the firm also revealed to be important in the analysis. Bhimani *et al.* (2010) also found the importance for some of the above-mentioned indicators, and highlighted the relevance of non-financial variables in determining a firm's default. Finally, Antunes and Martinho (2012) developed a scoring model for Portuguese firms (updated recently in Antunes *et al.* (2016)). They emphasized the heterogeneity across firms' business sectors regarding credit risk and bank credit default events.

Data and variables

Data sources

The empirical analysis performed in this study explores the Central Balance Sheet Database (CB) and the Central Credit Register (CRC), both databases available at Banco de Portugal.[9]

The CB contains financial information, based on balance sheet and profit and losses account, as well as other firm characteristics, such as the economic activity sector, and the date of set up. Since 2006, instead of a voluntary survey, the annual CB is based on Simplified Corporate Information (*Informação Empresarial Simplificada* - IES). IES also contains financial and non-financial data, as previously reported in the survey approach, but it covers virtually the entire Portuguese corporate sector.[10]

The CRC contains information regarding the credit granted by financial institutions operating in Portugal. This database, which is mandatory and reported on a monthly basis to Banco de Portugal, contains the total outstanding amount of loans, potential credit, and information for credit overdue, among other components. Due to the low threshold required for this report (loans above 50 euros), CRC contains nearly all the credit exposures of the banking system to Portuguese firms.[11]

9. Occasionally, *Quadros de Pessoal* database (QP) was also used to complement some information regarding firm's employees.

10. IES is an electronic submission of information of accounting, fiscal and statistical nature that firms have usually to submit to several Portuguese authorities, namely Ministry of Justice, Ministry of Finance, Statistics of Portugal, and Banco de Portugal. Thus, instead of firms submitting nearly the same information to the different entities, at different moments of time, and in different reports, as occurred before 2006, with the IES system they do it once. As all firms are expected to submit the report, IES allows a high coverage of the Portuguese corporate sector by the Central Balance Sheet Database of Banco de Portugal.

11. For further details on the CRC and IES databases, see Booklet Nr.5 of Banco de Portugal (Banco de Portugal (2011)), and Supplement of Statistical Bulletin (Banco de Portugal (2008)), respectively.

In order to explore IES, which has broad coverage of the Portuguese corporate sector and simultaneously avoids the possible sample bias that voluntary surveys may induce (especially toward firms with better financial position),

the period under analysis is limited to 2006 - 2009. The sample period ends in 2009, given that some variables explored in the current analysis (discussed in following sections) were discontinued from 2010 on.[12]

Moreover, some selection criteria were imposed. The financial sector and public administrations were excluded, as well as observations with misreported data for total assets, business volume, number of employees, and age. Furthermore, firms with fewer than five employees were also ruled out. Then, observations with extreme values for some variables included in the analysis were excluded (1 per cent of the tails of the respective distributions), which allows controlling for extreme outliers.

After these steps, and given the purposes of this study, we restricted the sample to firms that are simultaneously on the two databases. In other words, we restricted the sample to firms with relationships with the financial system. Combining all the criteria, the data set comprises around 230,700 observations.

Determinants of firm default

This study analyzes if some components underlying working capital and turnover contain relevant information for determining the probability of default of a firm. Simultaneously, firm's business risk is included in the analysis, in line with the structural models, in which volatility is one of the key elements. Other firm characteristics and macroeconomic developments were also controlled for, given their relevance in determining a default event, as discussed in the literature section. Moreover, following the banking relationship literature, the firm's relationships with the banking system were also included in the analysis. In general, we have:

$$\begin{aligned}\text{Prob}(Default_{i,t}) = f(&working\ capital\ and\ turnover\ components_{i,t};\\ &other\ characteristics_{i,t};\ banking\ relationships_{i,t};\\ &business\ risk_i;\ macroeconomic\ environment_t)\end{aligned} \tag{1}$$

where the left-hand side is the probability of default of firm i at the period t. The right-hand side includes a set of several variables that may be related to a firm's default.

12. As mentioned above, IES started in 2006, but for the main element in financial statements, information for the previous year was also required. Given this fact, data for 2005 were also collected to compute some indicators for 2006. In turn, in 2010 there were changes in IES data. In parallel with the introduction of new accounting rules, there were also some changes in the IES templates, creating a discontinuity in some variables.

In this study, a default event is defined when a firm has bank credit overdue for a period longer than three consecutive months (flagged in the CRC), evaluated at the end of the year, and greater than 500 euros.[13]

Looking at firm characteristics, working capital (WORKING CAPITAL), defined as the ratio of current assets net of current liabilities over total assets, is a relevant indicator in the financial analysis of a firm, given that it represents operating liquidity and liabilities commitments in the short-run. Debt holders are usually concerned with firm's liquidity, since they are concerned about the payment of the initial loan, but also with the ongoing payments. Earlier studies identified liquidity as a relevant firm's dimension in determining default events, with a negative relationship (*e.g.* Altman (1968) and Bhimani *et al.* (2010)). However, working capital requires a careful analysis. For instance, an increase in this indicator may reflect firms' decisions to promote business, such as decisions that might minimize stock-out events or even stimulate sales. However, an increase in this ratio by the assets' component may also reflect a build up of inventories (and money is tied up in inventories) or credit to customers. In these cases, the firm cannot use those assets to pay off any of its commitments. Therefore, an increase in working capital may have underlying negative developments in the firm's financial health and increase its vulnerabilities. The turnover variable (TURNOVER), defined as sales over total assets, is related to the firm's efficiency, as it indicates how a firm uses assets in its business. A high volume of sales into total assets means that the firm takes advantage of its investments.

In this study, working capital and turnover indicators are decomposed into some underlying components related to cash holdings, investment turnover, and activity indicators, namely accounts receivable, accounts payable, and inventories, in order to identify firm's operational fragilities that may induce default. Additionally, we also include in the analysis the share of tax liabilities.[14]

Looking at the other variables included in the analysis (equation 1), the component "other firm characteristics' includes accounting and non-accounting indicators, in line with the empirical findings discussed above. Concerning accounting data, the analysis includes measures related to leverage (LEVERAGE), sales growth (SALES GROWTH), interest coverage by

13. Note that a default event corresponds to a delay in the payment of the installment and/or the reimbursement of the principal at the debt maturity. It does not necessarily imply a bankruptcy event. Moreover, it should be noted that the imposition of three consecutive months may be a conservative criterion, as financial institutions should report overdue events after the 90 days. This conservative rule implies that the default events may be underestimated in the data set, but it avoids some potential misreporting records. The 500 euros threshold is also intended to exclude misleading events.

14. Bernhardsen and Larsen (2007) explored trade accounts payable and unpaid taxes in the extended version of the model used to analyze banks' credit risk exposures to the corporate sector (Norges Bank), in addition to other financial ratios, age, size, and industry.

earning before interest, depreciation, and amortization, *i.e. ebitda* (INTEREST COVERAGE), as well as the coverage of total liabilities by *ebitda* (DEBT COVERAGE). These coverage indicators allow analyzing firms' ability to repay capital and interest through the ongoing operational income.[15,16]

The set of variables also includes firm size, based on the natural logarithm of real total assets (SIZE). Concerning non-accounting data, age (AGE) and changes in the number of total employees (CHANGE EMPLOYEES) were also included. Furthermore, business sectors were controlled for, given that financial ratios should be assessed in conjunction with the market in which the firm operates.

In turn, for business risk the proxy was the volatility of cashflow over total assets (SD CASHFLOW). Banking relationships comprise the number of total relationships, defined at the banking group level and taking into account the weight of each banking group in the firm's total bank debt (BANKING RELATIONSHIPS). The analysis also includes the absolute change in the number of those relationships over the year (CHANGE BANK RELATIONSHIP), as well as the availability of unused credit lines (CREDIT LINE).[17]

Finally, in order to control for the economic and financial environment, time dummies were included in the specification, or alternatively the GDP year-on-year growth rate (GDP) and the average interest rate applied on loans to non-financial corporations (INT RATE). Table A.1 in the Appendix Section summarizes the definition of each variable. Table A.2 presents the correlation matrix between the variables.

Descriptive statistics

This sub-section presents some summary statistics of the data set used in this study, including a breakdown by default and non-default firms and by firms' size (based on the recommendation of the European Commission).[18]

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15. In order to avoid potential collinearity in the regressors, a direct measure of profitability was not included in the specifications. Indeed, in the correlation matrix included in the Appendix Section of this article, we can observe that DEBT COVERAGE and INTEREST COVERAGE are highly correlated with the profitability indicator (PROFITABILITY), measured by operational returns over total assets.

16. Note that according to the *ebitda* multiple approach, a standard procedure adopted in the valuation of firms, the coverage of firms' liabilities by ebitda can be seen as a proxy for the coverage of debt by the firm's market value, for firms belonging to the same business sector.

17. The BANKING RELATIONSHIPS variable corresponds to the Hirschman-Herfindahl concentration index.

18. According to the European Commission Recommendation of 6 May 2003 (2003/361/EC), micro firms are defined as those with fewer than 10 employees and less than 2 million euro of business volume or total assets; small firms are those with fewer than 50 employees and less than 10 million euro of business volume or total assets; medium firms are those with fewer than 250 employees and a business volume below 50 million euros or whose total assets are lower than 43 million euros. All remaining firms are defined as large firms.

In Table 1 we see that micro and small firms represent most of the sample (around 90 per cent). In turn, in the period under analysis, the fraction of default events is small in the total sample, as well as in each firm's dimension class. Nonetheless, in general, there is a gradual increase of this fraction over the horizon period, which is in line with macroeconomic and financial developments, and supports the cyclicality of default events.

	Total		Micro		Small		Medium		Large	
Year	# Obs.	% default	# Obs.	% default	# Obs.	% default	# Obs.	% default	# Obs.	% default
2006	58,540	1.9	27,700	1.9	25,782	1.8	4,357	2.2	701	2.0
2007	59,627	2.1	27,923	2.0	26,472	2.1	4,489	2.3	743	3.9
2008	58,209	2.5	27,382	2.6	25,793	2.5	4,327	2.1	707	1.4
2009	54,354	3.0	25,629	2.9	24,068	3.0	4,014	3.1	643	3.0
Average	57,683	2.4	27,159	2.3	25,529	2.4	4,297	2.4	699	2.6
Total	230,730		108,634		102,115		17,187		2,794	

TABLE 1. Sample summary statistics

Notes: # Obs. stands for the number of observations in each year, while % default corresponds to the share of firms with credit overdue (in line with the definition adopted in this article). Firm size is defined according to the European Commission Recommendation of May 2003 (2003/361/EC).

The differences between default and non-default firms are illustrated in Table 2, which displays some descriptive statistics of firms' characteristics for both groups. It is noteworthy that the sample mean of firm characteristics for the two groups are statistically different according to the Welch test.[19] Thus, firms that do not fulfill their credit commitments seem to present some particular features.

Default firms show lower levels of working capital and turnover in comparison to non-default firms. They also present lower coverage of liabilities and interest by *ebitda*, sales growth and employees changes. Moreover, these firms show lower levels of cashflows and higher volatility. In turn, default firms have significantly higher leverage ratios. Note that the leverage ratio of the percentile 25 of default firms is close to the percentile 50 of non-default firms. Looking at bank lending relationships variables, default firms show a lower concentration of bank debt, which means that these firms tend to establish more banking relationships than non-default firms (or at least, tend to have greater dispersion of credit among their lenders).

19. The Welch test compares the mean figures between two groups, taking into account possible differences in the variance of these groups.

Looking at some components underlying working capital and turnover indicators, default firms have higher levels for the activity indicators, *i.e.* for accounts payable, accounts receivable, and inventories. Default firms reveal lower cash reserves, and investment turnover. These firms also present a significantly higher proportion of tax liabilities over total assets.

Table 3 has the mean and median figures of some variables by firm size, given the potential difference of some of these characteristics by firm dimension, in line with information opaqueness of firms and diversified activity. for this purpose, we split the sample in four segments: micro, small, medium and large firms. A positive relationship is broadly observed for working capital, while there is no significant variation for assets turnover. Concerning activity indicators, there is a negative relationship for inventories and accounts payable, while for accounts receivable the relationship is not monotonic. Investment turnover seems to present a U-shape relationship. The same path applies, in general, for the coverage of interest by *ebitda*. In turn, a negative relationship is observed between firm size and leverage, tax liabilities, cashflow volatility (even though small), as well as weighted bank relationships. Debt coverage and sales growth show a positive relationship with firm size.

Econometric Results

Do activity indicators and tax liabilities contain relevant information?

The analysis carried out above shows a significant difference between default and non-default firms. In particular, we observe differences regarding operational management. In this Section we intend to corroborate some of these findings through econometric analysis. For this purpose we focus on new episodes of default, *i.e.* we exclude from the data set observations that recorded default events in two consecutive years.[20] The rationale for this option is to identity the main characteristics of firms that may justify transaction events, *e.g.* transaction from a regular position to a default event.

The econometric approach adopted relies on a logit model for panel data. Moreover, the model estimated was based on unbalanced panel data, with random effects.[21]

20. This demanded the exclusion of around of 1,500 observations.

21. Note that it would not be possible to adopt a firm fixed-effect specification, as some variables under analysis are constant at the firm level. Moreover, this approach would collapse the data set to firms that changed their position in the sample period, excluding from the analysis firms that did not record default events. It is important to include these firms in the analysis in order to observe their characteristics, and so the main patterns of firms that default and those that do not.

Panel A - Non-default firms

	mean	sd	p10	p25	p50	p75	p90
WORKING CAPITAL	0.19	0.42	-0.32	-0.04	0.19	0.45	0.71
TURNOVER	1.42	0.99	0.50	0.78	1.18	1.77	2.59
ACCOUNTS PAYABLE	0.29	0.27	0.03	0.10	0.22	0.38	0.60
ACCOUNTS RECEIVABLE	0.23	0.23	0.00	0.03	0.18	0.34	0.51
INVENTORIES	0.36	0.65	0.00	0.03	0.14	0.38	0.88
CASH & EQUIVALENTS	0.28	0.60	0.01	0.02	0.08	0.26	0.69
INVESTMENT TURNOVER	16.46	42.28	1.19	2.44	5.46	13.31	32.99
TAX LIABILITIES	0.05	0.07	0.01	0.01	0.03	0.06	0.11
SOCIAL SEC. LIABILITIES	0.00	0.02	0.00	0.00	0.00	0.00	0.00
DEBT COVERAGE	0.20	0.32	-0.03	0.06	0.13	0.26	0.50
INTEREST COVERAGE	105.9	827	-1.1	2.2	5.7	17.2	60.8
LEVERAGE	0.74	0.27	0.40	0.58	0.75	0.88	0.98
SALES GROWTH	0.01	0.27	-0.28	-0.12	0.00	0.12	0.30
CASHFLOW RATIO	0.07	0.12	-0.03	0.02	0.06	0.12	0.19
SD. CASHFLOW	0.06	0.07	0.01	0.02	0.04	0.08	0.14
CHANGE-EMPLOYEES	0.03	0.19	-0.17	-0.08	0.00	0.10	0.23
BANKING RELATIONSHIPS	0.71	0.27	0.34	0.49	0.72	1.00	1.00
CHANGE_BANK_RELATIONSHIP	0.21	0.84	-1.00	0.00	0.00	1.00	1.00
CREDIT LINE	0.67	0.47	0.00	0.00	1.00	1.00	1.00
SIZE	13.32	1.42	11.64	12.34	13.19	14.14	15.17
AGE	2.48	0.84	1.39	1.95	2.56	3.09	3.47

Panel B - Default firms

	mean	sd	p10	p25	p50	p75	p90
WORKING CAPITAL	0.03	0.45	-0.55	-0.23	0.04	0.30	0.61
TURNOVER	0.86	0.71	0.28	0.44	0.68	1.05	1.59
ACCOUNTS PAYABLE	0.58	0.45	0.08	0.25	0.49	0.80	1.22
ACCOUNTS RECEIVABLE	0.33	0.31	0.00	0.06	0.26	0.49	0.78
INVENTORIES	0.51	0.91	0.00	0.02	0.17	0.56	1.41
CASH & EQUIVALENTS	0.12	0.29	0.00	0.01	0.02	0.09	0.33
INVESTMENT TURNOVER	11.93	37.94	0.63	1.25	2.86	7.64	21.50
TAX LIABILITIES	0.13	0.14	0.01	0.03	0.07	0.18	0.33
SOCIAL SEC. LIABILITIES	0.03	0.06	0.00	0.00	0.00	0.03	0.12
DEBT COVERAGE	0.07	0.20	-0.12	-0.02	0.06	0.13	0.23
INTEREST COVERAGE	25.41	447	-5.78	-0.58	1.91	5.04	14.39
LEVERAGE	0.92	0.28	0.62	0.76	0.88	1.00	1.25
SALES GROWTH	-0.13	0.35	-0.57	-0.33	-0.12	0.05	0.26
CASHFLOW RATIO	0.00	0.14	-0.16	-0.05	0.02	0.06	0.13
SD. CASHFLOW	0.08	0.09	0.01	0.03	0.05	0.10	0.18
CHANGE-EMPLOYEES	-0.05	0.21	-0.29	-0.17	-0.06	0.00	0.20
BANKING RELATIONSHIPS	0.58	0.25	0.28	0.38	0.52	0.80	1.00
CHANGE_BANK_RELATIONSHIP	0.02	0.99	-1.00	0.00	0.00	0.00	1.00
CREDIT LINE	0.60	0.49	0.00	0.00	1.00	1.00	1.00
SIZE	13.60	1.37	12.05	12.68	13.42	14.37	15.43
AGE	2.45	0.78	1.39	1.95	2.48	3.00	3.43

TABLE 2. Descriptive statistics: Non-default *versus* default firms

Notes: sd stands for standard deviation. p10, p25, p50, p75, and p90 stand for, respectively, the percentiles 10, 25, 50, 75, and 90 of the distribution of each variable.

We begin by presenting the results for a baseline specification that includes working capital and turnover indicators in the set of explanatory variables.

	Micro		Small		Medium		Large	
	Mean	Median	Mean	Median	Mean	Median	Mean	Median
WORKING CAPITAL	0.16	0.17	0.21	0.20	0.22	0.20	0.20	0.18
TURNOVER	1.42	1.16	1.41	1.18	1.39	1.17	1.38	1.19
ACCOUNTS PAYABLE	0.30	0.21	0.30	0.24	0.27	0.23	0.23	0.20
ACCOUNTS RECEIVABLE	0.21	0.15	0.25	0.21	0.24	0.22	0.21	0.19
INVENTORIES	0.42	0.16	0.32	0.13	0.25	0.14	0.21	0.12
CASH & EQUIVALENTS	0.30	0.09	0.26	0.08	0.21	0.05	0.23	0.04
INVESTMENT TURNOVER	18.51	5.68	14.49	5.27	13.48	4.64	18.22	5.03
TAX LIABILITIES	0.06	0.03	0.05	0.03	0.04	0.02	0.03	0.02
LEVERAGE	0.77	0.78	0.72	0.74	0.69	0.71	0.67	0.69
DEBT COVERAGE	0.19	0.12	0.21	0.13	0.23	0.14	0.28	0.16
INTEREST COVERAGE	106.4	5.7	94.9	5.6	122.9	5.2	223.3	6.2
SALES GROWTH	-0.01	-0.01	0.01	0.00	0.02	0.01	0.03	0.02
CASHFLOW RATIO	0.06	0.06	0.07	0.06	0.07	0.06	0.08	0.07
SD CASHFLOW	0.07	0.04	0.06	0.04	0.05	0.03	0.04	0.03
CHANGE-EMPLOYEES	0.00	0.00	0.05	0.00	0.04	0.00	0.04	0.01
BANKING RELATIONSHIPS	0.78	0.89	0.67	0.63	0.52	0.46	0.50	0.42

TABLE 3. General statistics description by firm dimension

Notes: Firm size is defined according to the European Commission Recommendation of May 2003 (2003/361/EC). Mean and Median figures are based on the distribution of each variable.

The results are presented in Models 1 and 2 of Table 4. For each model, the first column presents the estimated coefficient, while the second column shows the average marginal effects.

We observe that WORKING CAPITAL is statistically significant with a negative coefficient, meaning that firms with higher liquidity tend to present lower probabilities of default. TURNOVER also presents a negative and statistically significant coefficient. Thus, firms with higher efficiency have lower default probabilities.

Looking at the other firm characteristics included in the analysis, LEVERAGE shows a positive coefficient. Thus, firms whose assets are highly financed by external funding sources have a higher probability of default, which is in line with the results reported in the literature (*e.g.* Bonfim (2009), Bhimani *et al.* (2010), Bunn and Redwood (2003), and Benito *et al.* (2004)). DEBT COVERAGE shows a negative and statistically significant relationship with default probability, while INTEREST COVERAGE is not statistically significant.[22]

22. Lacerda and Moro (2008) found some evidence supporting a non-monotonic effect for the interest coverage variable. However, the results of the specifications with dummy variables based on the quartiles of the interest coverage's distribution do not support this fact. We found a monotonic impact, *i.e.* the probability of default decreases as interest coverage ratio increases. Additionally, due to the low coefficients obtained, and the sample distribution, namely the tails'

These results suggest that firms with higher indebted ratios or firms with lower profits (or even losses) are more vulnerable, *i.e.* they have lower ability to overcome a negative shocks, and *ceteris paribus*, present higher probability of default.

A negative coefficient was found for SALES GROWTH, that seeks to capture corporate potential growth.[23] CHANGE EMPLOYEES, which may be more deeply related with a firm's growth, shows a similar relationship. These findings suggest that firms with higher growth opportunities have lower probability of default.[24] AGE shows a negative and statistically significant coefficient: younger firms have higher probability of default. Corporate size, measured by real total assets, shows a positive and statistically significant coefficient. As larger firms are typically perceived with lower risk, this result is somewhat counterintuitive. However, some studies also found a positive relationship between default and firm size (*e.g.* Bonfim (2009), Bhimani *et al.* (2010), and Benito *et al.* (2004)).[25]

As far as bank lending relationships variables are concerned, BANKING RELATIONSHIPS have a negative coefficient. This suggests that firms with a higher concentration of bank debt also present lower default probability. These results are in line with empirical studies that argue that firms with higher credit quality tend to establish fewer lending relationships or, at least, preserve a main relationship, as discussed in Farinha and Santos (2002). It's worthy mentioning, however, regarding the dynamics of the total number of lending relationships in each year (CHANGE BANK REL), the estimated coefficient is negative: firms that increase the number of relationships tend to show lower probability of default. Note that the two results are not contradictory. A firm may increase the number of banking relationships without major changes in the importance of its main lenders (and then without sizable effect on the concentration index). Firms with unused credit lines (CREDIT LINES) tend to present lower default probabilities. This result suggests that firms have available funds to overcome unfavorable events (that

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levels, we redefined the interest coverage variable, winsorizing the observations below/above the percentile 10/90 at these figures. The magnitude of the coefficient obtained for this variable increased, as expected. However, the conclusions of the analysis continued to hold. Given these findings, we preserved the initial definition of the interest coverage variable in the empirical analysis presented inthis article.

23. As mentioned, sales growth is related with a firm's growth opportunities. However, high growth rates may reflect excessive risk taking. This argument suggests that strong sales growth rates can be positively related with firms distress. However, the analysis of the impact of different percentiles of the sales growth distribution does not suggest this situation, *i.e.* we find a monotonic impact of sales growth on default probability.

24. It should be noted that even though sales growth and employees changes may both be related to firm's growth opportunities, the correlation between these variables is not high, as can be seen in the correlation matrix presented in the Appendix Section of this article.

25. AGE may also be capturing part of the firm's credit quality, and its estimates are in line with *a priori* expectations, *i.e.* it shows a negative relationship with a firm's probability of default.

could lead to default). However, according to robustness tests (presented in Section 5), the inclusion of these variables in the specification does not affect the conclusions of the analysis.

The business risk proxy, the volatility of cashflow over total assets, shows a positive and statistically significant coefficient. Firms whose cash flows are more volatile, as expected, have higher probabilities of default. Following the literature that highlights the relevance of global developments, time dummies were also included (Model 1). These variables are all statistically significant and jointly relevant, supporting the contribution of global factors in determining default events. According to these variables, the progressive deterioration in the macroeconomic and financial environment observed in the sample period had a negative impact on default probability. Therefore, common factors related to the global conditions affect the probability of default in addition to the firm's idiosyncratic components. If we try to disentangle the time dimension in some economic drivers, despite the very short period under analysis, we find that the probability of default decreases with the GDP growth but increases with the average interest rate applied on bank credit granted to non-financial corporations (Model 2).[26]

Finally, as mentioned above, all the specifications include business sector dummies, given the structural differences between economic activity sectors. For simplicity, the coefficients of these variables are not reported. Even though they were not all individually statistically significant, the relevance of their inclusion in the specifications was confirmed by the statistical tests. This result is in line with the findings highlighted in Antunes and Martinho (2012), namely the heterogeneity across business sectors regarding credit quality.

Since the two specifications are similar regarding the estimated coefficients and the regressions' statistics properties, in the remaining econometric analysis presented in this article we prenset only the results estimated for the specifications that include the time dummies.[27]

Table 5 presents the main results of the specifications in which working capital and turnover are replaced by the variables related with cash reserves, accounts receivable, accounts payable, inventories, investment turnover, and the share of tax liabilities.

The activity indicators, namely accounts payable, accounts receivable, and inventories, have positive and statistically significant coefficients. These results suggest that firms that take longer to repay their suppliers, firms

26. The hypothesis of equality of GDP growth and average interest rate coefficients was rejected by statistical tests.

27. Indeed, the coefficients of the variables under analysis were very similar to those obtained in specifications with the macroeconomic variables (GDP growth and interest rate). Moreover, due to the short-time dimension of the data set, the overall performance of the two models did not present sizeable differences.

that wait longer to be paid by their customers, and firms that build up inventories for longer periods present higher probabilities of default. In turn, firms with more cash reserves present lower probability of default, in line with the empirical literature on credit default (such as Benito *et al.* (2004), and Lacerda and Moro (2008)).[28] Investment turnover also presents a negative and statistically significant coefficient. Finally, the share of tax liabilities has a positive and statistically significant coefficient. Therefore, firms with higher shares of those liabilities tend to show higher probabilities of default.

Looking at the average marginal effects, accounts payable and tax liabilities are worthy of mention, with greater impacts on the firm's probability of default (based on a one standard-deviation increase). The results suggest that these variables are closely related to a firm's financial fragility, and consequently firm's creditworthiness.

The remaining variables included as regressors preserve the results discussed above. Table A.3 in the Appendix Section presents the estimated coefficients for the remaining variables.

Finally, note that the inclusion of the breakdown of working capital and turnover improves the general performance of the econometric regressions in comparison to the baseline ones.

28. Nevertheless, it should be noted that Acharya *et al.* (2012) argue that an increase in cash holdings may induce higher risk in medium/long run. The authors claim that riskier firms may choose to hold higher cash reserves as a buffer against possible cashflow shortfalls in the future.

	Model 1		Model 2	
	Coef.	Marg. Eff.	Coef.	Marg. Eff.
WORKING CAPITAL	-0.3298***	-0.0030***	-0.2999***	-0.0028***
	(-5.68)	(-5.43)	(-5.21)	(-5.00)
TURNOVER	-1.2003***	-0.0111***	-1.1995***	-0.0113***
	(-26.62)	(-15.14)	(-26.70)	(-15.29)
LEVERAGE	1.6575***	0.0153***	1.6717***	0.0157***
	(18.13)	(14.48)	(18.39)	(14.75)
DEBT COVERAGE	-0.5434***	-0.0050***	-0.5478***	-0.0051***
	(-4.04)	(-3.90)	(-4.08)	(-3.94)
INTEREST COVERAGE	0.0000	0.0000	0.0000	0.0000
	(0.38)	(0.38)	(0.39)	(0.39)
SD CASHFLOW	2.1177***	0.0195***	2.1026***	0.0198***
	(8.55)	(7.93)	(8.54)	(7.94)
SALES GROWTH	-0.8297***	-0.0076***	-0.8203***	-0.0077***
	(-12.35)	(-10.43)	(-12.25)	(-10.40)
SIZE	0.0744***	0.0007***	0.0730***	0.0007***
	(4.17)	(4.14)	(4.11)	(4.09)
AGE	-0.3929***	-0.0036***	-0.3961***	-0.0037***
	(-12.67)	(-10.32)	(-12.81)	(-10.46)
CHANGE EMPLOYEES	-1.2849***	-0.0118***	-1.2848***	-0.0121***
	(-11.63)	(-9.75)	(-11.65)	(-9.81)
CREDIT LINES	-0.6156***	-0.0057***	-0.6092***	-0.0057***
	(-13.23)	(-12.69)	(-13.16)	(-12.69)
BANKING RELATIONSHIPS	-2.6191***	-0.0241***	-2.6129***	-0.0245***
	(-28.46)	(-16.39)	(-28.57)	(-16.55)
CHANGE BANK REL	-0.2494***	-0.0023***	-0.2477***	-0.0023***
	(-11.89)	(-9.93)	(-11.81)	(-9.92)
Time dummies	yes		no	
Macroeconomic controls	no		yes	
Nr. of Observations	195,329		195,329	
Nr. of Firms	72,649		72,649	
Log likelihood	-14,043.2		-14,054.6	
Pseudo-R^2	0.158		0.158	
Wald Chi2	2,960.2		3,004.9	
Prob > Chi2	0.00		0.00	
Rho	0.24		0.23	
BIC	28,452		28,463	
AIC	28,146		28,167	

TABLE 4. Logit regression, dependent variable: Default

Notes: ***, **, and * denote statistical significance levels at 1, 5, and 10 per cent, respectively. All models estimated using a random-effects logit estimator, where the dependent variable, default, is a binary variable related to credit overdue. Z-scores are presented in parentheses. The first column of each Model presents the estimated coefficients, while the second column shows the marginal effects, namely the average marginal effects, assuming as baseline firms with credit lines. In all regressions a constant and business sector dummies were included. The Pseudo-R^2 is a measure of goodness of the fit, being computed as function of the model's log-likelihood and of the log-likelihood of the constant-only model, for the sub-sample used in each estimation. The Wald test evaluates the overall statistical significance of the estimated coefficients. Rho measures the proportion of the total variance resulting from the panel-level variance component. If Rho is zero, the panel-level variance is not relevant and the panel estimator is not different from the pooled estimator. BIC stands for the Schwarz's Bayesian Information Criterion, while AIC stands for the Akaike Information Criterion.

	Model 1		Model 3	
	Coef.	Marg. Eff.	Coef.	Marg. Eff.
WORKING CAPITAL	-0.3298***	-0.0030***		
	(-5.68)	(-5.43)		
TURNOVER	-1.2003***	-0.0111***		
	(-26.62)	(-15.14)		
ACCOUNTS PAYABLE			1.7279***	0.0141***
			(28.23)	(18.14)
ACCOUNTS RECEIVABLE			0.3068***	0.0025***
			(3.63)	(3.58)
INVENTORIES			0.0995***	0.0008***
			(4.00)	(3.94)
CASH & EQUIVALENTS			-0.3139***	-0.0026***
			(-3.08)	(-3.04)
INVESTMENT TURNOVER			-0.0034***	-0.0000***
			(-4.61)	(-4.48)
TAX LIABILITIES			6.5032***	0.0530***
			(32.61)	(19.80)
Other firm controls	yes		yes	
Sectoral dummies	yes		yes	
Other firm controls	yes		yes	
Time dummies	yes		yes	
Nr. of Observations	195,329		195,329	
Nr. of Firms	72,649		72,649	
Log-likelihood	-14,043.2		-13,353.2	
Pseudo-R^2	0.158		0.200	
Wald Chi2	2,960.2		2,981.6	
Prob > Chi2	0.00		0.00	
Rho	0.24		0.31	
BIC	28,452		27,121	
AIC	28,146		26,774	

TABLE 5. Logit regression, dependent variable: Default - Activity indicators

Notes: ***, **, and * denote statistical significance levels at 1, 5, and 10 per cent, respectively. All models estimated using a random-effects logit estimator, where the dependent variable, default, is a binary variable related to credit overdue. Z-scores are presented in parentheses. The first column of each Model presents the estimated coefficients, while the second column shows the marginal effects, namely the average marginal effects, assuming as baseline firms with credit lines. In all regressions a constant and business sector dummies were included. The Pseudo-R^2 is a measure of goodness of the fit, being computed as function of the model's log-likelihood and of the log-likelihood of the constant-only model, for the sub-sample used in each estimation. The Wald test evaluates the overall statistical significance of the estimated coefficients. Rho measures the proportion of the total variance resulting from the panel-level variance component. If Rho is zero, the panel-level variance is not relevant and the panel estimator is not different from the pooled estimator. BIC stands for the Schwarz's Bayesian Information Criterion, while AIC stands for the Akaike Information Criterion.

Heterogeneity by firm size

Firm size has usually been associated with activity diversification, which may affect the firm's ability to react to idiosyncratic and external shocks. Moreover, it is also related to available information, and is therefore a proxy for firm's information opaqueness to general economic agents. The uniqueness of the data set used in this study allows a deeper analysis of corporate segments. Against this background, we ran the previous specifications partitioning the sample by firm dimension. Table 6 presents the main results under this set up (the estimates for all variables are presented in Table **??** in the Appendix Section).

In general, the results described for the full sample apply for micro and small firms, as illustrated in Panel A, even though with some exceptions. Looking at the specification that includes the breakdown of working capital and turnover (Model 2 for each size cohorts), the activity indicators and tax liabilities are relevant variables related to the probability of a default event. However, for micro firms accounts receivable and cash reserves are not statistically significant. Comparing the two models, the specifications with the breakdown improve the performance of the baseline specifications.

For firms classified in the medium and large classes, presented in Panel B, some variables lost statistical significance, notably in the case of larger firms. For medium firms, and as far as decomposition of working capital and turnover is concerned, accounts payable and tax liabilities are statistically significant, with positive coefficients. However, unlike the results in the other regressions, accounts receivable shows a negative and statistically significant coefficient. For large firms, fewer variables are statistically significant. Given the specificities of these firms, the results suggest that accounting data are less informative among large firms.

The results obtained by firm size confirm the heterogeneity between firms, since the relevance of some variables changes across size cohorts. The information underlying the working capital and turnover indicators, notably the accounts payable and the share of tax liabilities seem to be especially relevant for default probabilities in the segment of smaller firms.

Determinants *versus* predictors of default

The previous results highlight the relevance of activity indicators, investment turnover, cash reserves, and tax liabilities in estimating a firm's probability of default. In this sub-section we re-estimate the specifications presented above, but now including as regressors the firm-specific variables with a lag instead of the contemporaneous ones (with exception of AGE).

This approach allows us to check if these variables play a role as predictors of default events. In other words, in this specification we investigate if a

Panel A - Micro and small firms

	Micro				Small			
	Model 1		Model 2		Model 1		Model 2	
	Coef.	Mar.Eff	Coef.	Mar.Eff	Coef.	Mar.Eff	Coef.	Mar.Eff
WORKING CAPITAL	-0.2815***	-0.0026***			-0.4038***	-0.004***		
	(-3.38)	(-3.23)			(-4.64)	(-4.39)		
TURNOVER	-0.9336***	-0.0085***			-1.3256***	-0.0130***		
	(-13.64)	(-8.24)			(-18.33)	(-10.44)		
ACCOUNTS PAYABLE			1.2460***	0.0094***			1.9002***	0.0159***
			(14.17)	(9.89)			(20.24)	(12.94)
ACCOUNTS RECEIVABLE			0.0801	0.0006			0.2598**	0.0022**
			(0.65)	(0.65)			(2.08)	(2.05)
INVENTORIES			0.0671*	0.0005*			0.1102***	0.0009***
			(1.91)	(1.90)			(2.98)	(2.95)
CASH & EQUIVALENTS			-0.1281	-0.0010			-0.9161***	-0.0077***
			(-1.05)	(-1.05)			(-4.60)	(-4.38)
INVESTMENT TURNOVER			-0.0030***	-0.0000***			-0.0040***	-0.0000***
			(-3.08)	(-2.98)			(-3.28)	(-3.17)
TAX LIABILITIES			7.2637***	0.0550***			6.6968***	0.0562***
			(22.49)	(12.34)			(21.82)	(13.83)
Other firm controls	yes		yes		yes		yes	
Sectoral dummies	yes		yes		yes		yes	
Time dummies	yes		yes		yes		yes	
Nr. of Observations	83,562		83,562		92,953		92,953	
Nr. of Firms	38,969		38,969		35,995		35,995	
Log-likelihood	-6,063.7		-5,700.8		-6,624.8		-6,262.2	
Pseudo-R2	0.155		0.206		0.171		0.216	
Wald Chi2	1,248.6		1,161.7		1,374.7		1,330.0	
Prob > Chi2	0.00		0.00		0.00		0.00	
Rho	0.22		0.32		0.23		0.32	
BIC	12,467		11,787		13,593		12,913	
AIC	12,187		11,470		13,310		12,592	

TABLE 6. Logit regression, dependent variable: Default - By firm dimension (Continues)

(Continued)

Panel B - Medium and large firms

	Medium				Large			
	Model 1		Model 2		Model 1		Model 2	
	Coef.	Mar.Eff	Coef.	Mar.Eff	Coef.	Mar.Eff	Coef.	Mar.Eff
WORKING CAPITAL	-1.1330***	-0.0116***			0.7042	0.0072		
	(-4.41)	(-3.92)			(1.07)	(0.97)		
TURNOVER	-1.9127***	-0.0196***			-1.0691**	-0.0109*		
	(-8.78)	(-5.66)			(-2.53)	(-1.87)		
ACCOUNTS PAYABLE			3.2408***	0.0307***			2.3131***	0.0219***
			(10.06)	(7.07)			(2.69)	(2.67)
ACCOUNTS RECEIVABLE			-0.7111*	-0.0067*			2.4170**	0.0229
			(-1.82)	(-1.76)			(2.17)	(1.60)
INVENTORIES			-0.1671	-0.0016			0.2420	0.0023
			(-0.99)	(-0.99)			(0.48)	(0.48)
CASH & EQUIVALENTS			-0.7762	-0.0073			0.5171	0.0049
			(-0.99)	(-0.98)			(1.51)	(1.25)
INVESTMENT TURNOVER			-0.0034	-0.0000			-0.0032	-0.0000
			(-0.88)	(-0.86)			(-0.54)	(-0.53)
TAX LIABILITIES			6.5764***	0.0622***			1.7118	0.0162
			(8.16)	(6.23)			(0.35)	(0.35)
Other firm controls	yes		yes		yes		yes	
Sectoral dummies	yes		yes		yes		yes	
Time dummies	yes		yes		yes		yes	
Nr. of Observations	16,204		16,204		2,610		2,610	
Nr. of Firms	5,951		5,951		906		906	
Log-likelihood	-986.0		-946.4		-139.6		-132.5	
Pseudo-R^2	0.258		0.288		0.289		0.325	
Wald Chi2	287.1		270.3		67.4		67.3	
Prob > Chi2	0.00		0.00		0.00		0.00	
Rho	0.21		0.25		0.05		0.10	
BIC	2,263		2,222		515		533	
AIC	2,032		1,961		339		333	

TABLE 6. Logit regression, dependent variable: Default - By firm dimension

Notes: Firm size is defined according to the European Commission Recommendation of May 2003 (2003/361/EC). ***, **, and * denote statistical significance levels at 1, 5, and 10 per cent, respectively. All models estimated using a random-effects logit estimator, where the dependent variable, default, is a binary variable related to credit overdue. Z-scores are presented in parentheses. The first column of each Model presents the estimated coefficients, while the second column shows the marginal effects, namely the average marginal effects, assuming as baseline firms with credit lines. In all regressions a constant and business sector dummies were included. The Pseudo-R^2 is a measure of goodness of the fit, being computed as function of the model's log-likelihood and of the log-likelihood of the constant-only model, for the sub-sample used in each estimation. The Wald test evaluates the overall statistical significance of the estimated coefficients. Rho measures the proportion of the total variance resulting from the panel-level variance component. If Rho is zero, the panel-level variance is not relevant and the panel estimator is not different from the pooled estimator. BIC stands for the Schwarz's Bayesian Information Criterion, while AIC stands for the Akaike Information Criterion.

default event can be influenced by the characteristics of firm i at the end of the previous year, $t-1$. This specification may also be useful, give that accounting data are obtained with a significant delay. Even though a close banking relationship may minimize the lack of updated information about the firm's performance, some data are not disclosed in a timely way. Moreover, this approach allows us to minimize potential contemporaneous issues in the previous specifications related to a firm's creditworthiness and the respective financial position at the end of each year. The main results of this approach are presented in Table 7.

According to the results obtained, the general conclusions already discussed remain valid in terms of statistical significance and the relationship of each variable with the firm's default probability. Nevertheless, there are some exceptions. Looking at the specification with the decomposition of working capital and turnover (second specification in Table 7), the accounts receivable variable is not significant. Accounts payable and inventories, those activity indicators that can be deeply related to firm's decisions, show positive and significant coefficients. Therefore, firms with higher levels for these indicators tend to have higher probability of default in the following year. Cash reserves and investment turnover continue to present a negative relationship with the probability of default. In turn, the share of tax liabilities retains a positive and statistically significant coefficient. Thus, firms with higher shares of tax liabilities have a higher probability of default in the following year.

Looking at the impacts of each variable on a firm's probability of default (based on an increase of one standard-deviation), cash reserves and investment turnover reinforced their relevance, in comparison to the previous specifications. This analysis also confirms the importance of accounts payable and the share of tax liabilities on a firm's probability of default. Thus, these variables seem to be relevant indicators for firm's financial vulnerabilities, and its credit risk.

For the remaining explanatory variables, there are also some differences. In these specifications changes in the number of banking relationships show a positive and statistically significant coefficient. This result suggests that firms that changed the number of bank relationships have higher probabilities of default in the following year. This suggests that firms look for other lenders when they face some financial challenges. For simplicity, the estimates for these variables are presented in Table A.5 in the Appendix Section.

It is noteworthy that the variable related to the tax liabilities, as it is assessed at the end of each year, could reflect the firm's activity and the regular (and allowed) schedule of taxes payments. However, the results of this specification, which takes a lag for the explanatory variables, minimize this argument to some extent. Indeed, the coefficient is positive and statistically significant even with a lag. Moreover, it is worth noticing again that in the

econometric analysis we include only new default episodes. Therefore, we do not include in the analysis firms with high shares of tax liabilities and firms already had a bank credit default event (in period $t-1$).

Zoom in on tax liabilities

In the previous specifications, tax liabilities over total assets showed to be a relevant indicator in the credit risk analysis. Against this background we explore more deeply the role of this liabilities' component.

In particular, we decompose tax liabilities in tax related to Social Security (overdue) and the remaining taxes (TLSS, and TLOTHER, respectively), having in mind that the failure of commitments in Social Security taxes may be related to financial difficulties for a firm. The last specification in Table 7 displays the results under this conjecture.[29]

In this set up, the new variables are statistically significant and both show positive coefficients, especially the variable related with Social Security taxes. For the remanning explanatory variables the results described above continue to hold. Thus, firms with higher levels of Social Security (overdue) taxes over total assets have higher probabilities of default in the following year.

29. In this specification we used total liabilities instead of short-term, given that the breakdown by debt maturity was not available for the tax components under analysis. However, this procedure should not have any great impact on the analysis, given that a high share of total tax liabilities has short-term maturity.

	Model 1		Model 2		Model 3	
	Coef.	Marg. Eff.	Coef.	Marg. Eff.	Coef.	Marg. Eff.
WORKING CAPITAL$_{t-1}$	-0.3255***	-0.0046***				
	(-3.84)	(-3.69)				
TURNOVER$_{t-1}$	-1.0266***	-0.0144***				
	(-19.96)	(-11.01)				
ACCOUNTS PAYABLE$_{t-1}$			1.4550***	0.0177***	1.4223***	0.0174***
			(17.89)	(11.76)	(17.46)	(11.72)
ACCOUNTS RECEIVABLE$_{t-1}$			-0.1537	-0.0019	-0.1546	-0.0019
			(-1.32)	(-1.32)	(-1.33)	(-1.32)
INVENTORIES$_{t-1}$			0.1239***	0.0015***	0.1247***	0.0015***
			(3.69)	(3.61)	(3.71)	(3.63)
CASH & EQUIVALENTS$_{t-1}$			-0.5727***	-0.0070***	-0.5219***	-0.0064***
			(-3.91)	(-3.74)	(-3.60)	(-3.47)
INVESTMENT TURNOVER$_{t-1}$			-0.0045***	-0.0001***	-0.0045***	-0.0001***
			(-3.65)	(-3.50)	(-3.66)	(-3.52)
TAX LIABILITIES$_{t-1}$			5.5371***	0.0673***		
			(20.40)	(13.19)		
SOCIAL SEC. LIABILITIES$_{t-1}$					9.6421***	0.1178***
					(16.17)	(11.94)
OTHER TAXES$_{t-1}$					4.5341***	0.0554***
					(14.71)	(11.34)
Other firm controls	yes		yes		yes	
Sectoral dummies	yes		yes		yes	
Time dummies	yes		yes		yes	
Nr. of Observations	119,553		119,553		119,553	
Nr. of Firms	54,003		54,003		54,003	
Log-likelihood	-8,731.5		-8,615.9		-8,587	
Pseudo-R^2	0.129		0.141		0.143	
Wald Chi2	1,666.5		1,645.6		1,675.9	
Prob > Chi2	0.00		0.00		0.00	
Rho	0.05		0.14		0.14	
BIC	17,802		17,618		17,572	
AIC	17,521		17,298		17,243	

TABLE 7. Logit regression, dependent variable: Default - with lag regressors

Notes: ***, **, and * denote statistical significance levels at 1, 5, and 10 per cent, respectively. All models estimated using a random-effects logit estimator, where the dependent variable, default, is a binary variable related to credit overdue. Z-scores are presented in parentheses. The first column of each Model presents the estimated coefficients, while the second column shows the marginal effects, namely the average marginal effects, assuming as baseline firms with credit lines. In all regressions a constant and business sector dummies were included. The Pseudo-R^2 is a measure of goodness of the fit, being computed as function of the model's log-likelihood and of the log-likelihood of the constant-only model, for the sub-sample used in each estimation. The Wald test evaluates the overall statistical significance of the estimated coefficients. Rho measures the proportion of the total variance resulting from the panel-level variance component. If Rho is zero, the panel-level variance is not relevant and the panel estimator is not different from the pooled estimator. BIC stands for the Schwarz's Bayesian Information Criterion, while AIC stands for the Akaike Information Criterion.

Robustness

We performed some robustness tests in order to check how the previous results were influenced by some of the hypotheses adopted.[30]

30. For simplicity, the results of the robustness tests are not presented.

First, we test the impact of bank lending relationship variables on the results. As mentioned above, this test is related to the possible link between banks' decisions (reflected in the firm-banks variables) and firms' financial position. Therefore, we ran an alternative set of regressions in which the direct firm-bank variables(*i.e.* credit lines, number of banking relationships and its dynamics) were not included as explanatory variables. The results obtained for the core variables under analysis in this study remained valid in this framework. In another robustness exercise we re-estimate the specifications including the cash conversion cycle, defined as accounts receivable (in days) + inventories (in days) - accounts payable (in days), instead of the three activity indicators individually, *i.e.* accounts receivable, accounts payable, and inventories. According to the estimates, this variable was not statistically significant. We also ran some specifications that included the general government in net terms (defined as taxes liabilities net of assets position over total assets), *i.e.* taking into account assets and liabilities components simultaneously. The results remained unchanged overall, with a positive coefficient for this new variable.

Finally, and as far as the econometric method is concerned, all the regressions presented in previous sections were re-estimated, applying the logit model with standard errors adjusted for heteroscedasticity (robust errors) and clustered at the firm level instead of the panel data approach. The conclusions discussed before remained broadly valid. Namely, the effect of the core variables under analysis retained the sign and statistical significance regarding the probability of default. Moreover, the performance of the econometric regression also improved with the breakdown of the working capital and turnover indicators.

Final Remarks

In this study we analyzed the relationship of several firm characteristics and the respective credit risk. We sought to identify the potential impact of a firm's operational management and efficiency on its probability of default, controlling for other variables. We performed this analysis on a large data set for firm-banks registers, based on Central Balance Sheet Database and Central Credit Register, which allows for a high coverage of the exposures of the Portuguese banking system to the corporate sector. The sample period is from 2006 to 2009.

Liquidity indicators and turnover are usually identified as relevant variables in the credit risk literature. However, they can reflect different firms' production management and efficiency. According to the results obtained, the decomposition of these variables into variables related directly to cash reserves, activity indicators, investment turnover, and tax liabilities contains additional information regarding firms' financial fragilities. The

results obtained also broadly highlight the impact of other financial and non-financial variables on the probability of default, in line with earlier studies on corporate credit risk.

The analysis was based on *ex post* credit risk, *i.e.* situations in which we observe if firms had indeed defaulted or not. Thus we are able to characterize the financial position of firms that defaulted. Nevertheless, the specifications that include as explanatory variables firm's characteristics with a lag period confirmed the relevance of some firm's characteristics on its probability of default. Firms that take longer to repay their suppliers and firms whose purchases stay longer as inventories have higher probabilities of default. Tax liabilities should also be highlighted in the analysis. Furthermore, the breakdown of these liabilities allowed us to verify that Social Security taxes also seem to be a relevant indicator related with firms' financial fragility.

Broadly, the results suggest that the firm's operational cycle is an important component related to corporate financial health. Moreover, the results stress the relationship between tax liabilities measures and financial soundness/vulnerability of firms. Therefore, based on these findings, the analysis of corporate credit risk should also take into account these indicators. Moreover, the analysis and results presented in this article raise several questions in corporate finance and credit risk. For instance, how do firms decide on their default events? In which lenders do firms default more often or at first stage? Based on the "pecking *order*" theory, which establishes a hierarchy in a firm's funding sources (Myers (1984)), can we talk about a kind of "*pecking order*" in default? The relevance of these questions for credit risk assessment (and also for policy), suggests that these topics should be on the agenda for further work, even though the empirical research is quite data demanding, which may impose some constraints in the short-run.

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Appendix

Variable	Definition
Dependent variable	
DEFAULT	Dummy variable that takes the value 1 if the firm has payments in delay at least longer than 3 months in its bank credit
Firm's characteristics	
WORKING CAPITAL	Current assets net of short-term liabilities over total assets
TURNOVER	Sales over total assets
DEBT COVERAGE	Earning before depreciation and amortization, interest and income taxes over total debt
INTEREST COVERAGE	Earning before depreciation and amortization, interest and income taxes over interest paid
LEVERAGE	Total debt over total assets
SD CASHFLOW	Standard deviation of cashflow over total assets
SALES GROWTH	Sales growth defined as the difference of the natural logarithm of real sales
SIZE	Natural logarithm of real total assets
AGE	Natural logarithm of age in years (plus one)
CHANGE_EMPLOYEES	Change of the number of employees in the year
CASH & EQUIVALENTS	Cash and equivalents over total debt
ACCOUNTS PAYABLE	Trade credit over (purchases of goods for resale, raw materials, secondary and consumable + supplies & external services)
ACCOUNTS RECEIVABLE	Trade credit to customers over sales
INVENTORIES	Inventories over cost of goods sold
INVESTMENT TURNOVER	Sales over investment
TAX LIABILITIES	Short-term liabilities to the General Government over total assets
SOCIAL SECURITY TAXES	Social security liabilities (overdue) over total assets
OTHER TAXES	Other taxes rather than Social security liabilities (overdue) over total assets
BUSINESS SECTORS	Dummy variables for business sectors (13 sectors)
Banking relationships	
BANKING RELATIONSHIPS	Number of banking relationships defined at the banking group level, based on the weight of each group in firm's total banking debt
CHANGE_BANK_REL	Changes in the number of independent banking relationships in the year
CREDIT LINE	Dummy variable that takes the value 1 if the firm has unused credit lines
Macroeconomic variables	
GDP	Annual growth rate of Gross Domestic Product
INT_RATE	Average interest rate applied on loans granted to the non-financial corporations

TABLE A.1. Variables definition

	DEFAULT	WORKING CAP	TURNOV.	CASH & EQ	ACC PAYABLE	ACC RECEIV.	INVENT.	TAX LIAB.	SOCIAL SEC.	OTHER TAXES	INVEST. TUR.	DEBT COV.	LEVERAGE	INTEREST COV.	SD CASHF	SALE GROWTH	SIZE	AGE	VAR EMPL	CREDIT LINE	BANK REL.	PROFIT.	VAR BANK REL.
DEFAULT	1.000																						
WORKING CAPITAL	-0.057	1.000																					
TURNOVER	-0.085	0.000	1.000																				
CASH & EQUIVALENTS	-0.041	0.276	0.133	1.000																			
ACC. PAYABLE	0.157	-0.088	-0.366	-0.185	1.000																		
ACC. RECEIVABLE	0.067	0.263	-0.348	-0.146	0.393	1.000																	
INVENTORIES	0.036	0.020	-0.259	-0.110	0.209	0.023	1.000																
TAX LIABILITIES	0.151	-0.098	0.169	0.055	-0.006	-0.033	-0.046	1.000															
SOCIAL SECURITY	0.165	-0.075	-0.034	-0.034	0.092	0.032	0.012	0.412	1.000														
OTHER TAXES	0.117	-0.068	0.192	0.070	-0.043	-0.048	-0.053	0.920	0.111	1.000													
INVESTMENT TURNOVER	-0.016	0.186	0.184	0.067	-0.023	0.005	-0.018	0.054	0.004	0.058	1.000												
DEBT COVERAGE	-0.064	0.259	0.196	0.513	-0.243	-0.094	-0.149	0.052	-0.065	0.077	-0.009	1.000											
LEVERAGE	0.099	-0.555	0.004	-0.409	0.226	-0.037	0.065	0.169	0.136	0.140	-0.018	-0.501	1.000										
INTEREST COVERAGE	-0.015	0.056	0.048	0.143	-0.041	-0.028	-0.019	0.007	-0.019	0.014	0.025	0.162	-0.096	1.000									
SD CASHFLOW	0.032	-0.178	0.181	0.040	-0.058	-0.117	-0.046	0.253	0.088	0.245	0.010	-0.023	0.253	0.000	1.000								
SALE GROWTH	-0.078	-0.078	0.145	-0.008	-0.097	-0.105	-0.112	0.008	-0.035	0.019	0.020	0.133	0.030	0.019	-0.011	1.000							
SIZE	0.030	0.122	-0.289	-0.121	0.109	0.220	0.011	-0.297	-0.058	-0.301	-0.023	-0.037	-0.157	-0.009	-0.309	-0.002	1.000						
AGE	-0.006	0.225	-0.123	0.076	-0.005	0.118	0.054	-0.137	-0.032	-0.135	0.016	0.032	-0.297	0.003	-0.161	-0.167	0.361	1.000					
VAR EMPLOYEES	-0.058	-0.042	0.066	-0.010	-0.052	-0.038	-0.062	-0.008	-0.037	0.002	-0.021	0.057	0.014	0.004	0.004	0.302	0.006	-0.142	1.000				
CREDIT LINE	-0.024	0.099	-0.050	-0.063	0.012	0.100	-0.012	-0.138	-0.046	-0.134	-0.004	-0.021	-0.058	0.000	-0.113	-0.018	0.341	0.175	0.003	1.000			
BANK RELATIONSHIPS	-0.071	-0.049	0.106	0.161	-0.080	-0.161	-0.006	0.094	-0.006	0.105	0.069	0.087	-0.033	0.085	0.123	0.019	-0.379	-0.150	-0.015	-0.323	1.000		
PROFITABILITY	-0.069	0.180	0.219	0.181	-0.188	-0.069	-0.165	0.056	-0.066	0.083	-0.027	0.727	-0.373	0.091	-0.122	0.242	-0.026	-0.047	0.113	-0.005	-0.005	1.000	
VAR BANK RELATIONSHIPS	-0.035	0.045	-0.012	-0.028	-0.010	0.012	-0.007	-0.045	-0.030	-0.041	-0.022	-0.030	0.024	-0.008	-0.017	0.054	0.029	-0.051	0.074	0.084	-0.290	0.004	1.000

TABLE A.2. Correlation matrix

Notes: (DEFAULT)- Dummy variable that takes the value 1 if the firm has payments in delay at least longer than 3 months in its bank credit; (WORKING CAPITAL)- Current assets net of short-term liabilities over total assets; (DEBT COVERAGE)- Earning before depreciation and amortization, interest and income taxes over total debt; (LEVERAGE)- Total debt over total assets; (INTEREST COVERAGE)- Earning before depreciation and amortization, interest and income taxes over interest paid; (TURNOVER)- Sales over total assets; (SALE GROWTH)- Sales growth is defined as the difference of the natural logarithm of real sales; (SD CASHFLOW)- Standard deviation of cashflow over total assets; SIZE - Natural logarithm of real sales; (VAR EMPLOYEES)- Change of the number of employees in the year; (CASH & EQUIVALENTS)- Cash and equivalents over total debt; (ACC. PAYABLE)- Accounts payable - (Trade credit)/(Purchases of goods for resale, raw materials, secondary and consumable and supplies & external services); (ACC. RECEIVALE)- Accounts receivable - (Trade credits to customers/ sales); (INVENTORIES)- (Inventories/ Cost of goods sold); (INVESTIMENT TURNOVER)- Sales over investment; (TAX LIABILITIES)- Short-term liabilities to General Government over total assets; (AGE)- Natural logarithm of age in years (plus one); (BANK RELATIONSHIPS)- Number of banking relationships defined at the banking group level, based on the weight of each group in firm's total banking debt; (VAR BANK REL)- Changes in the number of independent banking relationships in the year; (CREDIT LINE)- Dummy variable that takes the value 1 if the firm has unused credit lines available; (PROFITABILITY)- Operational income over total assets.

	Model 1		Model 2		Model 3		Model 4	
	Coef.	Marg. Eff.	Coef.	Marg. Eff.	Coef.	Marg. Eff.	Coef.	Marg. Eff.
WORKING CAPITAL	-0.3298***	-0.0030***	-0.2999***	-0.0028***				
	(-5.68)	(-5.43)	(-5.21)	(-5.00)				
TURNOVER	-1.2003***	-0.0111***	-1.1995***	-0.0113***				
	(-26.62)	(-15.14)	(-26.70)	(-15.29)				
CASH & EQUIVALENTS					-0.3139***	-0.0026***	-0.3107***	-0.0026***
					(-3.08)	(-3.04)	(-3.06)	(-3.02)
ACCOUNTS PAYABLE					1.7279***	0.0141***	1.7189***	0.0143***
					(28.23)	(18.14)	(28.36)	(18.34)
ACCOUNTS RECEIVABLE					0.3068***	0.0025***	0.3023***	0.0025***
					(3.63)	(3.58)	(3.59)	(3.55)
INVENTORIES					0.0995***	0.0008***	0.0985***	0.0008***
					(4.00)	(3.94)	(3.99)	(3.93)
TAX LIABILITIES					6.5032***	0.0530***	6.4309***	0.0536***
					(32.61)	(19.80)	(32.75)	(20.00)
INVESTMENT TURNOVER					-0.0034***	-0.0000***	-0.0034***	-0.0000***
					(-4.61)	(-4.48)	(-4.59)	(-4.46)
LEVERAGE	1.6575***	0.0153***	1.6717***	0.0157***	0.8964***	0.0073***	0.8963***	0.0075***
	(18.13)	(14.48)	(18.39)	(14.75)	(9.68)	(9.09)	(9.75)	(9.16)
DEBT COVERAGE	-0.5434***	-0.0050***	-0.5478***	-0.0051***	-1.2083***	-0.0098***	-1.2077***	-0.0101***
	(-4.04)	(-3.90)	(-4.08)	(-3.94)	(-8.37)	(-7.62)	(-8.40)	(-7.65)
INTEREST COVERAGE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.38)	(0.38)	(0.39)	(0.39)	(0.18)	(0.18)	(0.21)	(0.21)
SD CASHFLOW	2.1177***	0.0195***	2.1026***	0.0198***	0.5320*	0.0043*	0.5186*	0.0043*
	(8.55)	(7.93)	(8.54)	(7.94)	(1.94)	(1.93)	(1.90)	(1.90)
SALES GROWTH	-0.8297***	-0.0076***	-0.8203***	-0.0077***	-0.8976***	-0.0073***	-0.8884***	-0.0074***
	(-12.35)	(-10.43)	(-12.25)	(-10.40)	(-12.26)	(-10.56)	(-12.18)	(-10.54)
SIZE	0.0744***	0.0007***	0.0730***	0.0007***	0.2998***	0.0024***	0.2968***	0.0025***
	(4.17)	(4.14)	(4.11)	(4.09)	(16.02)	(13.47)	(15.99)	(13.50)
AGE	-0.3929***	-0.0036***	-0.3961***	-0.0037***	-0.4034***	-0.0033***	-0.4052***	-0.0034***
	(-12.67)	(-10.32)	(-12.81)	(-10.46)	(-12.35)	(-10.44)	(-12.47)	(-10.55)
CHANGE-EMPLOYEES	-1.2849***	-0.0118***	-1.2848***	-0.0121***	-1.1728***	-0.0096***	-1.1725***	-0.0098***
	(-11.63)	(-9.75)	(-11.65)	(-9.81)	(-10.22)	(-9.06)	(-10.25)	(-9.10)
CREDIT LINES	-0.6156***	-0.0057***	-0.6092***	-0.0057***	-0.5330***	-0.0043***	-0.5272***	-0.0044***
	(-13.23)	(-12.69)	(-13.16)	(-12.69)	(-10.74)	(-10.88)	(-10.70)	(-10.86)
BANKING RELATIONSHIPS	-2.6191***	-0.0241***	-2.6129***	-0.0245***	-2.5193***	-0.0205***	-2.5119***	-0.0209***
	(-28.46)	(-16.39)	(-28.57)	(-16.55)	(-25.71)	(-16.96)	(-25.83)	(-17.12)
CHANGE_BANK_REL	-0.2494***	-0.0023***	-0.2477***	-0.0023***	-0.1934***	-0.0016***	-0.1913***	-0.0016***
	(-11.89)	(-9.93)	(-11.81)	(-9.92)	(-8.96)	(-8.16)	(-8.88)	(-8.11)
2007	0.2812***	0.0026***			0.3825***	0.0031***		
	(4.70)	(4.61)			(6.06)	(5.92)		
2008	0.5593***	0.0052***			0.7216***	0.0059***		
	(9.61)	(8.93)			(11.72)	(10.62)		
2009	0.6945***	0.0064***			0.7567***	0.0062***		
	(11.25)	(10.42)			(12.10)	(11.18)		
GDP			-0.1467***	-0.0014***			-0.1679***	-0.0014***
			(-11.60)	(-10.60)			(-12.86)	(-11.59)
INT_RATE			0.1799***	0.0017***			0.2590***	0.0022***
			(6.34)	(6.10)			(8.80)	(8.22)
Nr. Observations	195,329		195,329		195,329		195,329	
Nr. Firms	72,649		72,649		72,649		72,649	
Log-likelihood	-14,043.2		-14,054.6		-13,353.2		-13,367.7	
Log-likelihood constant	-16,682.8		-16,682.8		-16,682.8		-16,682.8	
Pseudo-R2	0.158		0.158		0.200		0.199	
Wald Chi2	2,960.2		3,004.9		2,981.6		3,053.8	
Prob > Chi2	0.00		0.00		0.00		0.00	
sigma_u	1.02		0.99		1.23		1.20	
rho	0.24		0.23		0.31		0.30	
Chi2_c	55.95		51.87		117.45		110.73	
BIC	28,452		28,463		27,121		27,137	
AIC	28,146		28,167		26,774		26,801	

TABLE A.3. Logit regression, dependent variable: Default - Activity indicators

Notes: ***, **, and * denote statistical significance levels at 1, 5, and 10 per cent, respectively. All models estimated using a random-effects logit estimator, where the dependent variable, default, is a binary variable related to credit overdue. Z-scores are presented in parentheses. The first column of each Model presents the estimated coefficients, while the second column shows the marginal effects. The marginal effects correspond to the average effects, assuming as baseline firms with credit lines and changes in the number of bank lending relationships. In all regressions a constant and business sector dummies were included. The Pseudo-R^2 is a measure of goodness of the fit, being computed as function of the model's log-likelihood and of the log-likelihood of the constant-only model, for the sub-sample used in each estimation. The Wald test evaluates the overall statistical significance of the estimated coefficients. Rho measures the proportion of the total variance resulting from the panel-level variance component. If rho is zero, the panel-level variance is not relevant and the panel estimator is not different from the pooled estimator.

(Continues)

Panel A - Micro and small firms

	Micro				Small			
	Model 1		Model 2		Model 1		Model 2	
	Coef.	Marg. Eff.	Coef.	Marg. Eff.	Coef.	Marg. Eff.	Coef.	Marg. Eff.
WORKING CAPITAL	-0.2815***	-0.0026***			-0.4038***	-0.0040***		
	(-3.38)	(-3.23)			(-4.64)	(-4.39)		
TURNOVER	-0.9336***	-0.0085***			-1.3256***	-0.0130***		
	(-13.64)	(-8.24)			(-18.33)	(-10.44)		
CASH & EQUIVALENTS			-0.1281	-0.0010			-0.9161***	-0.0077***
			(-1.05)	(-1.05)			(-4.60)	(-4.38)
ACCOUNTS PAYABLE			1.2460***	0.0094***			1.9002***	0.0159***
			(14.17)	(9.89)			(20.24)	(12.94)
ACCOUNTS RECEIVABLE			0.0801	0.0006			0.2598**	0.0022**
			(0.65)	(0.65)			(2.08)	(2.05)
INVENTORIES			0.0671*	0.0005*			0.1102***	0.0009***
			(1.91)	(1.90)			(2.98)	(2.95)
TAX LIABILITIES			7.2637***	0.0550***			6.6968***	0.0562***
			(22.49)	(12.34)			(21.82)	(13.83)
INVESTMENT TURNOVER			-0.0030***	-0.0000***			-0.0040***	-0.0000***
			(-3.08)	(-2.98)			(-3.28)	(-3.17)
LEVERAGE	1.3297***	0.0121***	0.8424***	0.0064***	2.1218***	0.0208***	1.1471***	0.0096***
	(10.29)	(8.14)	(6.36)	(5.85)	(14.41)	(11.02)	(7.59)	(7.06)
DEBT COVERAGE	-0.1038	-0.0009	-0.6175***	-0.0047***	-0.4764**	-0.0047**	-1.0620***	-0.0089***
	(-0.57)	(-0.57)	(-2.99)	(-2.87)	(-2.30)	(-2.24)	(-4.67)	(-4.37)
INTEREST COVERAGE	0.0001	0.0000	0.0001	0.0000	-0.0001	-0.0000	-0.0001	-0.0000
	(1.35)	(1.34)	(1.04)	(1.04)	(-0.92)	(-0.92)	(-0.93)	(-0.93)
SD CASHFLOW	2.5959***	0.0236***	1.4896***	0.0113***	1.7038***	0.0167***	0.5380	0.0045
	(7.40)	(6.29)	(3.79)	(3.65)	(4.54)	(4.33)	(1.29)	(1.29)
SALES GROWTH	-0.8992***	-0.0082***	-0.9243***	-0.0070***	-0.7293***	-0.0071***	-0.7909***	-0.0066***
	(-9.29)	(-7.20)	(-8.85)	(-7.32)	(-7.41)	(-6.51)	(-7.45)	(-6.63)
SIZE	0.2581***	0.0023***	0.7114***	0.0054***	0.0934***	0.0009***	0.5104***	0.0043***
	(5.84)	(5.36)	(15.23)	(10.23)	(2.66)	(2.64)	(13.61)	(10.52)
AGE	-0.3062***	-0.0028***	-0.3609***	-0.0027***	-0.4455***	-0.0044***	-0.4323***	-0.0036***
	(-6.55)	(-5.53)	(-7.13)	(-6.10)	(-9.80)	(-7.66)	(-8.90)	(-7.41)
CHANGE-EMPLOYEES	-1.2362***	-0.0112***	-0.9620***	-0.0073***	-1.3624***	-0.0133***	-1.0189***	-0.0085***
	(-7.35)	(-5.88)	(-5.54)	(-4.91)	(-8.76)	(-7.21)	(-6.27)	(-5.77)
CREDIT LINES	-0.6258***	-0.0057***	-0.5637***	-0.0043***	-0.6359***	-0.0062***	-0.5577***	-0.0047***
	(-9.75)	(-8.71)	(-8.18)	(-8.00)	(-9.14)	(-8.63)	(-7.41)	(-7.42)
BANKING RELATIONSHIPS	-3.0289***	-0.0275***	-3.0214***	-0.0229***	-2.3605***	-0.0231***	-2.2961***	-0.0193***
	(-21.88)	(-10.15)	(-19.91)	(-11.06)	(-17.58)	(-10.89)	(-15.90)	(-11.17)
CHANGE_BANK_REL	-0.3704***	-0.0034***	-0.3038***	-0.0023***	-0.1976***	-0.0019***	-0.1453***	-0.0012***
	(-10.26)	(-7.40)	(-8.05)	(-6.71)	(-6.66)	(-5.84)	(-4.73)	(-4.44)
2007	0.2451***	0.0022***	0.3230***	0.0024***	0.3269***	0.0032***	0.4357***	0.0037***
	(2.65)	(2.60)	(3.28)	(3.20)	(3.76)	(3.67)	(4.72)	(4.58)
2008	0.5812***	0.0053***	0.7614***	0.0058***	0.6173***	0.0060***	0.7926***	0.0066***
	(6.59)	(5.80)	(8.04)	(6.90)	(7.28)	(6.66)	(8.74)	(7.84)
2009	0.6071***	0.0055***	0.7232***	0.0055***	0.8148***	0.0080***	0.8867***	0.0074***
	(6.55)	(5.89)	(7.52)	(6.67)	(8.91)	(8.01)	(9.56)	(8.62)
Nr. Observations	83,562		83,562		92,953		92,953	
Nr. Firms	38,969		38,969		35,995		35,995	
Log-likelihood	-6,063.7		-5,700.8		-6,624.8		-6,262.2	
Log-likelihood constant	-7,179.5		-7,179.5		-7,987.2		-7,987.2	
Pseudo-R2	0.155		0.206		0.171		0.216	
Wald Chi2	1,248.6		1,161.7		1,374.7		1,330.0	
Prob > Chi2	0.00		0.00		0.00		0.00	
sigma_u	0.95		1.26		0.98		1.23	
rho	0.22		0.32		0.23		0.32	
Chi2_c	13.99		43.41		21.23		53.08	
BIC	12,467		11,787		13,593		12,913	
AIC	12,187		11,470		13,310		12,592	

TABLE A.4. Logit regression, dependent variable: Default - By firm dimension

(Continued)

Panel B - Medium and large firms

	Medium				Large			
	Model 1		Model 2		Model 1		Model 2	
	Coef.	Marg. Eff.	Coef.	Marg. Eff.	Coef.	Marg. Eff.	Coef.	Marg. Eff.
WORKING CAPITAL	-1.1330***	-0.0116***			0.7042	0.0072		
	(-4.41)	(-3.92)			(1.07)	(0.97)		
TURNOVER	-1.9127***	-0.0196***			-1.0691**	-0.0109*		
	(-8.78)	(-5.66)			(-2.53)	(-1.87)		
CASH & EQUIVALENTS			-0.7762	-0.0073			0.5171	0.0049
			(-0.99)	(-0.98)			(1.51)	(1.25)
ACCOUNTS PAYABLE			3.2408***	0.0307***			2.3131***	0.0219***
			(10.06)	(7.07)			(2.69)	(2.67)
ACCOUNTS RECEIVABLE			-0.7111*	-0.0067*			2.4170**	0.0229
			(-1.82)	(-1.76)			(2.17)	(1.60)
INVENTORIES			-0.1671	-0.0016			0.2420	0.0023
			(-0.99)	(-0.99)			(0.48)	(0.48)
TAX LIABILITIES			6.5764***	0.0622***			1.7118	0.0162
			(8.16)	(6.23)			(0.35)	(0.35)
INVESTMENT TURNOVER			-0.0034	-0.0000			-0.0032	-0.0000
			(-0.88)	(-0.86)			(-0.54)	(-0.53)
LEVERAGE	3.0376***	0.0312***	2.0214***	0.0191***	1.6623**	0.0169*	0.8887	0.0084
	(7.62)	(6.01)	(5.31)	(4.70)	(2.23)	(1.88)	(0.93)	(0.90)
DEBT COVERAGE	-2.1594***	-0.0222***	-3.4483***	-0.0326***	-2.8603**	-0.0291*	-3.0081**	-0.0285*
	(-3.42)	(-3.12)	(-5.30)	(-4.32)	(-2.32)	(-1.72)	(-2.29)	(-1.66)
INTEREST COVERAGE	-0.0016**	-0.0000**	-0.0009	-0.0000	0.0001	0.0000	0.0001	0.0000
	(-2.09)	(-2.03)	(-0.97)	(-0.96)	(0.81)	(0.77)	(0.35)	(0.34)
SD CASHFLOW	2.1967**	0.0226**	1.3678	0.0129	-1.0587	-0.0108	-1.6972	-0.0161
	(2.08)	(2.02)	(1.17)	(1.17)	(-0.24)	(-0.24)	(-0.36)	(-0.36)
SALES GROWTH	-0.5541*	-0.0057*	-0.8586***	-0.0081**	-1.5966*	-0.0162	-1.0226	-0.0097
	(-1.87)	(-1.82)	(-2.70)	(-2.52)	(-1.72)	(-1.42)	(-1.01)	(-0.96)
SIZE	-0.2011**	-0.0021**	0.3653***	0.0035***	0.0030	0.0000	0.0930	0.0009
	(-2.28)	(-2.17)	(4.07)	(3.68)	(0.01)	(0.01)	(0.42)	(0.42)
AGE	-0.1024	-0.0011	-0.0334	-0.0003	-0.2242	-0.0023	-0.1894	-0.0018
	(-0.88)	(-0.87)	(-0.28)	(-0.28)	(-0.86)	(-0.76)	(-0.68)	(-0.62)
CHANGE-EMPLOYEES	-1.6962***	-0.0174***	-1.2318**	-0.0117**	0.7051	0.0072	0.1911	0.0018
	(-3.35)	(-3.07)	(-2.40)	(-2.28)	(0.65)	(0.65)	(0.17)	(0.17)
CREDIT LINES	-0.4765*	-0.0049*	0.0411	0.0004	-1.5594**	-0.0159**	-0.8517	-0.0081
	(-1.69)	(-1.71)	(0.13)	(0.13)	(-2.01)	(-2.11)	(-1.01)	(-1.05)
BANKING RELATIONSHIPS	-2.0131***	-0.0207***	-2.2131***	-0.0209***	-0.2355	-0.0024	-0.4260	-0.0040
	(-5.47)	(-4.42)	(-5.54)	(-4.58)	(-0.30)	(-0.29)	(-0.51)	(-0.48)
CHANGE_BANK_REL	-0.1241**	-0.0013*	-0.0829	-0.0008	-0.1292	-0.0013	-0.1587	-0.0015
	(-1.99)	(-1.94)	(-1.29)	(-1.29)	(-0.92)	(-0.86)	(-1.07)	(-0.98)
2007	0.1697	0.0017	0.2648	0.0025	1.4191**	0.0144**	1.4988**	0.0142**
	(0.82)	(0.82)	(1.21)	(1.21)	(2.41)	(1.97)	(2.41)	(1.99)
2008	0.0935	0.0010	0.2194	0.0021	-0.4756	-0.0048	-0.2268	-0.0021
	(0.44)	(0.44)	(0.98)	(0.99)	(-0.65)	(-0.62)	(-0.29)	(-0.29)
2009	0.8110***	0.0083***	0.5588**	0.0053***	0.5690	0.0058	0.9925	0.0094
	(3.60)	(3.65)	(2.54)	(2.60)	(0.92)	(0.94)	(1.58)	(1.46)
Nr. Observations	16,204		16,204		2,610		2,610	
Nr. Firms	5,951		5,951		906		906	
Log-likelihood	-986.0		-946.4		-139.6		-132.5	
Log-likelihood constant	-1,328.7		-1,328.7		-196.3		-196.3	
Pseudo-R2	0.258		0.288		0.289		0.325	
Wald Chi2	287.1		270.3		67.4		67.3	
Prob > Chi2	0.00		0.00		0.00		0.00	
sigma_u	0.93		1.05		0.43		0.59	
rho	0.21		0.25		0.05		0.10	
Chi2_c	4.40		5.77		0.04		0.17	
BIC	2,263		2,222		515		533	
AIC	2,032		1,961		339		333	

TABLE A.4. Logit regression, dependent variable: Default - By firm dimension

Notes: Firm size is defined according to the European Commission Recommendation of May 2003 (2003/361/EC). ***, **, and * denote statistical significance levels at 1, 5, and 10 per cent, respectively. All models estimated using a random-effects logit estimator, where the dependent variable, default, is a binary variable related to credit overdue. Z-scores are presented in parentheses. The first column of each Model presents the estimated coefficients, while the second column shows the marginal effects. The marginal effects correspond to the average effects, assuming as baseline firms with credit lines and changes in the number of bank lending relationships. In all regressions a constant and business sector dummies were included. The Pseudo-R^2 is a measure of goodness of the fit, being computed as function of the model's log-likelihood and of the log-likelihood of the constant-only model, for the sub-sample used in each estimation. The Wald test evaluates the overall statistical significance of the estimated coefficients. Rho measures the proportion of the total variance resulting from the panel-level variance component. If rho is zero, the panel-level variance is not relevant and the panel estimator is not different from the pooled estimator.

	Model 1		Model 2		Model 3	
	Coef.	Marg. Eff.	Coef.	Marg. Eff.	Coef.	Marg. Eff.
WORKING CAPITAL$_{t-1}$	-0.3255***	-0.0046***				
	(-3.84)	(-3.69)				
TURNOVER$_{t-1}$	-1.0266***	-0.0144***				
	(-19.96)	(-11.01)				
CASH & EQUIVALENTS$_{t-1}$			-0.5727***	-0.0070***	-0.5219***	-0.0064***
			(-3.91)	(-3.74)	(-3.60)	(-3.47)
ACCOUNTS PAYABLE$_{t-1}$			1.4550***	0.0177***	1.4223***	0.0174***
			(17.89)	(11.76)	(17.46)	(11.72)
ACCOUNTS RECEIVABLE$_{t-1}$			-0.1537	-0.0019	-0.1546	-0.0019
			(-1.32)	(-1.32)	(-1.33)	(-1.32)
INVENTORIES$_{t-1}$			0.1239***	0.0015***	0.1247***	0.0015***
			(3.69)	(3.61)	(3.71)	(3.63)
TAX LIABILITIES$_{t-1}$			5.5371***	0.0673***		
			(20.40)	(13.19)		
INVESTMENT TURNOVER$_{t-1}$			-0.0045***	-0.0001***	-0.0045***	-0.0001***
			(-3.65)	(-3.50)	(-3.66)	(-3.52)
SOCIAL SEC. LIABILITIES$_{t-1}$					9.6421***	0.1178***
					(16.17)	(11.94)
OTHER TAXES$_{t-1}$					4.5341***	0.0554***
					(14.71)	(11.34)
LEVERAGE$_{t-1}$	1.3440***	0.0189***	0.7078***	0.0086***	0.7064***	0.0086***
	(10.47)	(9.18)	(5.61)	(5.38)	(5.58)	(5.35)
DEBT COVERAGE$_{t-1}$	-1.0915***	-0.0153***	-1.8201***	-0.0221***	-1.7671***	-0.0216***
	(-6.05)	(-5.45)	(-9.97)	(-8.06)	(-9.64)	(-7.91)
INTEREST COVERAGE$_{t-1}$	-0.0004**	-0.0000**	-0.0005**	-0.0000**	-0.0005**	-0.0000**
	(-2.08)	(-2.05)	(-2.30)	(-2.27)	(-2.28)	(-2.25)
SD CASHFLOW$_{t-1}$	3.6358***	0.0511***	2.5948***	0.0315***	2.6409***	0.0323***
	(12.10)	(9.57)	(8.14)	(7.23)	(8.27)	(7.34)
SALES GROWTH$_{t-1}$	-0.2315***	-0.0033**	-0.3534***	-0.0043***	-0.3571***	-0.0044***
	(-2.61)	(-2.56)	(-3.74)	(-3.60)	(-3.78)	(-3.64)
SIZE$_{t-1}$	0.0599***	0.0008***	0.2329***	0.0028***	0.2286***	0.0028***
	(2.86)	(2.84)	(10.97)	(9.20)	(10.76)	(9.10)
AGE	-0.3823***	-0.0054***	-0.4116***	-0.0050***	-0.4130***	-0.0050***
	(-9.20)	(-7.52)	(-9.68)	(-7.86)	(-9.71)	(-7.90)
CHANGE-EMPLOYEES$_{t-1}$	-0.5788***	-0.0081***	-0.5653***	-0.0069***	-0.5587***	-0.0068***
	(-4.46)	(-4.23)	(-4.23)	(-4.03)	(-4.18)	(-3.99)
CREDIT LINES$_{t-1}$	-0.1533***	-0.0022***	-0.1402**	-0.0017**	-0.1384**	-0.0017**
	(-2.63)	(-2.69)	(-2.32)	(-2.38)	(-2.29)	(-2.34)
BANKING RELATIONSHIPS$_{t-1}$	-2.4250***	-0.0341***	-2.3297***	-0.0283***	-2.3152***	-0.0283***
	(-21.59)	(-11.82)	(-20.02)	(-11.92)	(-19.92)	(-11.99)
CHANGE_BANK_REL$_{t-1}$	0.0710***	0.0010***	0.0940***	0.0011***	0.0943***	0.0012***
	(2.81)	(2.72)	(3.70)	(3.54)	(3.70)	(3.55)
2007	-0.5294***	-0.0074***	-0.6506***	-0.0079***	-0.6510***	-0.0080***
	(-8.67)	(-7.77)	(-10.27)	(-8.91)	(-10.27)	(-8.93)
2008	-0.1477***	-0.0021***	-0.1799***	-0.0022***	-0.1757***	-0.0021***
	(-2.72)	(-2.72)	(-3.26)	(-3.23)	(-3.18)	(-3.16)
Nr. Observations	119,553		119,553		119,553	
Nr. Firms	54,003		54,003		54,003	
Log-likelihood	-8,731.5		-8,615.9		-8,587.3	
Log-likelihood constant	-10,024.5		-10,024.5		-10,024.5	
Pseudo-R2	0.129		0.141		0.143	
Wald Chi2	1,666.5		1,645.6		1,675.9	
Prob > Chi2	0.00		0.00		0.00	
sigma_u	0.42		0.73		0.72	
rho	0.05		0.14		0.14	
Chi2_c	0.83		8.17		7.75	
BIC	17,802		17,618		17,572	
AIC	17,521		17,298		17,243	

TABLE A.5. Logit regression - Dependent variable: default - with lag regressors

Notes: ***, **, and * denote statistical significance levels at 1, 5, and 10 per cent, respectively. All models estimated using a random-effects logit estimator, where the dependent variable, default, is a binary variable related to credit overdue. Z-scores are presented in parentheses. The first column of each Model presents the estimated coefficients, while the second column shows the marginal effects. The marginal effects correspond to the average effects, assuming as baseline firms with credit lines and changes in the number of bank lending relationships. In all regressions a constant and business sector dummies were included. The Pseudo-R^2 is a measure of goodness of the fit, being computed as function of the model's log-likelihood and of the log-likelihood of the constant-only model, for the sub-sample used in each estimation. The Wald test evaluates the overall statistical significance of the estimated coefficients. Rho measures the proportion of the total variance resulting from the panel-level variance component. If rho is zero, the panel-level variance is not relevant and the panel estimator is not different from the pooled estimator.

A model with financial frictions and a banking system for the Portuguese economy

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Abstract
The recent financial crisis has made clear the importance of the linkages between the financial sector and the macroeconomy, both as a trigger to the crisis but also as having an instrumental role in the propagation of the initial shock to other sectors of the economies. This has led a reassessment of the need to introduce financial frictions into what was then the workhorse macroeconomic structural model and thus to a considerable number of contributions to the literature introducing financial frictions in structural models. The introduction of financial frictions in New-Keynesian DSGE models has led to the possibility to use this models to study new questions but it has also enriched the transmission channels embedded in these models. In this paper we take a large scale open economy dynamic structural model including frictions in the financial sector, called EAGLE-FLI, and calibrate it to the Portuguese economy. The EAGLE-FLI model is built on the New-Keynesian framework and incorporates financial frictions and country-specific banking sectors. The detailed structure of the model makes it an appropriate tool to assess domestic and cross-country macroeconomic effects of financial shocks. We run simulations of several shocks in order to understand their transmission mechanisms in the model and their macroeconomic impact. We analyse not only shocks originating in the financial sector but also explore the way other shocks transmit in this model where financial frictions matter. (JEL: E51; E32; E44; F45; F47.)

Introduction

The recent financial crisis has made clear the importance of the linkages between the financial sector and the macroeconomy, both as a trigger to the crisis but also as having an instrumental role in the propagation of the initial shock to other sectors of an economy. This has led a reassessment of the need to introduce financial frictions into what was then the workhorse macroeconomic structural model (e.g. Smets and Wouters (2003), Christiano *et al.* (2005), Smets and Wouters (2007) or Christoffel *et al.* (2008) models). A considerable number of contributions to the literature introduced financial frictions in structural models, both in theoretical models but also in models developed and used at policy institutions (see for example the extension of the ECB's NAWM in Lombardo and McAdam (2012)). The introduction of

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financial frictions in New-Keynesian dynamic general equilibrium models has led to the possibility to use this models to study new questions but it has also enriched the transmission channels embedded in these models.

In this paper we take a large scale open economy dynamic structural model including frictions in the financial sector and calibrate it to the Portuguese economy. The model we use is called the EAGLE-FLI (Euro Area and Global Economy with Financial LInkages) model. This is a multi-country model of the euro area economy within the world. It is built on the New-Keynesian framework and incorporates financial frictions and country-specific banking sectors. The model includes four blocs that in the current application are calibrated to Portugal, the rest of the euro area, the US and the rest of the world. Banks collect deposits from domestic households, raise capital to finance loans issued to domestic households and firms and participate and in a cross-country interbank market. In order to borrow from local (regional) banks, households use domestic real estate as collateral whereas firms use both domestic real estate and physical capital. The detailed structure of the model makes it an appropriate tool to assess domestic and cross-country macroeconomic effects of financial shocks. We run simulations of several shocks in order to understand their transmission mechanisms in the model and their macroeconomic impact. We analyse not only shocks originating in the financial sector but also explore the way other shocks transmit in this model where financial frictions matter.

The EAGLE-FLI setup builds on several earlier contributions. In particular, the distinction between borrowers that are more impatient than savers follows Iacoviello (2005) and the banks capital requirement ratio follows Kollmann (2013) and Kollmann *et al.* (2013). Regarding the modelling of the banking sector the are several earlier contributions that include a banking sector in DSGE models. Focusing on open economy models, differently from Kollmann (2013) and Kollmann *et al.* (2013) that consider the case of a global bank (i.e. on e bank that lends domestically and abroad), the EAGLE-FLI model considers instead country-specific banks that lend to and receive deposits from domestic agents.[1]. This setup with "region-specific" banking sectors is also used in Brzoza-Brzezina *et al.* (2015), but in a smaller scale model.

The remainder of the paper is organized in the following way. The next section presents the model. We then describe the simulations. Finally, the last section concludes.

1. Allowing banks to lend and borrow at international level is different from allowing households to do the same, as they maximize different objectives subject to different constraints, such as the capital requirement. EAGLE-FLI features financial spillovers that directly affect banks behavior, and only indirectly (via banks) the foreign borrowers while in Kollmann (2013) and Kollmann, Ratto and Roeger (2013) there is a direct spillover from bank to foreign borrowers.

The EAGLE-FLI model in a nutshell

The EAGLE-FLI model developed by Bokan *et al.* (2016) incorporates financial frictions and a banking sector into an existing multi-country dynamic general equilibrium model of the euro area (see Gomes *et al.* (2012)). In this section we briefly describe the novel features of the slightly modified version of the EAGLE-FLI model used here. For a detailed description of the model's features see Bokan *et al.* (2016).[2]

The EAGLE-FLI model is a multi-country model of a monetary union within the world economy. In the model the world consists of four blocs (that may represent a country or a region), labeled Home (the H bloc, i.e. the Portuguese bloc), the rest of the euro area (REA), the US (US) and the rest of the world (RW). The size of the world economy is normalized to one and $s^H, s^{REA}, s^{US} > 0$ are respectively the sizes of Home, REA and US blocs, $s^H + s^{REA} + s^{US} < 1$. For each bloc, the size of the economy corresponds to the size of population (sum of households, bankers, entrepreneurs) and to the size of each firms' sector (intermediate tradable, intermediate nontradable, final nontradable sectors). Blocs H and REA are members of a monetary union, the euro area (EA), thus sharing the monetary policy authority and the nominal exchange rates against the remaining two blocs.

We will focus our description on the H bloc. We describe the banking sector, households' and entrepreneurs' behaviour, the monetary authority, market clearing conditions, net foreign asset position and international relative prices. The remaining blocs are broadly similar, except that the US and RW blocs have a national monetary policy authority whereas for the other two blocs the monetary authority (and policy) is common.

In each bloc there are two types of infinitely lived households, entrepreneurs, firms, banks, a fiscal authority and a monetary authority (that in the case of the euro area blocs is common to the two blocs). We start by describing the banking sector. This sector is country-specific, meaning that banks intermediate funds between domestic agents. There is a continuum of banks (a fraction $0 < \omega_B < 1$ of the population of bloc H) that act under perfect competition and, hence, maximize profits taking interest rates as given. We assume that all banks have the same preferences, constraints and initial asset positions, thus they make the same optimal choices, and as such we can consider a representative bank that maximises its expected lifetime flow of (real) dividends. In order to have a meaningful banking sector we assume that a bank intermediates funds between agents that cannot directly lend to and borrow from each other. The bank extends loans to domestic impatient households (the "borrowers") and to domestic entrepreneurs,

2. For an application of the standard EAGLE model for the Portuguese economy see Gomes *et al.* (2013).

collects deposits from domestic patient households (the "savers") and raises capital as a way to finance the extended loans.[3] Interest rates paid on loans and deposits are predetermined (i.e. paid at the beginning of the next period but known in the current period). The bank faces quadratic costs the bank faces when adjusting the amount of loans granted and the excess bank capital, defined in the following way. As in Kollmann (2013), we assume that the bank faces a regulatory capital requirement, i.e., its period t nominal capital defined as loans minus deposits should not be less than a (possibly time-varying) fraction of its loans to domestic households and entrepreneurs in the same period. We assume it is costly for the bank to deviate from the long-run (steady-state) value of bank capital in excess to this requirement, according to a quadratic cost function.[4]

Focusing now on the household sector, the Home economy is populated by a continuum of two types of households that differ in terms of their discount factors. Patient households' (I-type) discount factor is larger than that of impatient households (I-type), i.e. $\beta_I > \beta_J$. Thus, in equilibrium, impatient households are net borrowers while patient households are net lenders *vis-à-vis* the domestic bank.[5] The savers are a fraction $(1-\omega_J-\omega_E-\omega_B)$ of the H population, where ω_J and ω_E ($\omega_J, \omega_E > 0$, $\omega_J+\omega_E+\omega_B < 1$) are the shares of impatient households and entrepreneurs in bloc H population, respectively.[6] Both types of households maximize lifetime utility under its budget constraint. Households gain utility from consuming non-durables (subject to external habit formation) and housing services and disutility from working. Each household offers a differentiated labour service to domestic firms and acts as wage setter, under monopolistic competition. Each nominal wage is set according to a Calvo-type mechanism (Calvo (1983)) with indexation.[7] Savers own firms and have access to multiple financial assets while constrained households can only borrow from the domestic banking sector. Savers hold positions in euro-denominated domestic sovereign bonds, in internationally traded US dollar-denominated bonds and euro-denominated bonds (the last assumption holds only for households in

3. Deposits and loans are all defined as one-period euro-denominated nominal assets or liabilities.

4. If we define period t capital as $K_t^B = L_t - D_t$, where L_t are loans and D_t deposits, then excess bank capital is defined as $X_t \equiv (1-\Upsilon_{K,t})L_t - D_t$.

5. For discount factor heterogeneity, see Iacoviello (2005).

6. Within each type, agents have the same preferences, constraints and initial asset positions. We assume there is perfect wage risk-sharing across households of the same type. Thus, it is possible to assume a representative patient household and a representative impatient household.

7. Under this scheme each household is able to optimally reset wages in a given period t with a certain probability (say $1-\xi_N$, $0 \leq \xi_N \leq 1$). All households that are able to re-optimize their wage contracts in a given period t choose the same price. Those households which do not re-optimize are allowed to adjust their wages according to a rule that indexes it to a weighted average of past and steady state inflation.

the two EA blocs). They also make deposits in the domestic bank. In contrast, impatient households, borrow funds from banks. To borrow funds, they need collateral, represented by the expected value of their housing stock. In other words, impatient household can borrow up to a fraction (the so-called loan-to-value, LTV, ratio) of the expected value of their housing stock. This borrowing constraint is akin to usual lending criteria for mortgage loans, which limit the amount lent to a fraction of the value of the asset. Consequently, when maximising utility the impatient households are also constrained by their borrowing limit, that is endogenously determined.

In each bloc there is also a representative entrepreneur (a fraction ω_E of the H population). The entrepreneur owns the physical capital stock (that depreciates at a constant rate) and part of the aggregate domestic stock of real estate (that also depreciates at a constant rate and is in fixed supply). Both are rented in a competitive market to firms operating in the domestic intermediate sectors. Entrepreneurs can borrow funds from domestic banks.[8] Entrepreneurs invest in physical capital, subject to quadratic adjustment costs. The entrepreneur can borrow funds from the domestic banking sector against collateral. In particular she can funds up to a fraction of the owned stock of real estate and a fraction of owned physical capital shock. The entrepreneur maximizes lifetime utility of consuming subject to the budget and borrowing constraints.[9]

Regarding the production setup, there are two types of firms: one type produces intermediate goods and the other type of firms produces nontradable final goods (the size of the sector is s^H). The intermediate goods are both internationally tradable or nontradable. Each intermediate good variety is produced by a firm belonging to the continuum of mass s^H ($h \in \left[0, s^H\right)$) in the case of tradable goods and s^N ($n \in \left[0, s^H\right)$) in the non-tradable case. Each nontradable and tradable intermediate good, respectively n and h, is produced using a Cobb-Douglas technology with three inputs: physical capital rented from domestic entrepreneurs; domestic labour; real estate rented from domestic entrepreneurs.[10] Each firm sells its differentiated output under monopolistic competition. The firm producing the tradable intermediate good charges different prices in local currency at home and in each foreign region (i.e. the local currency pricing assumption holds). There is

8. Changing the borrowing position is subject to an adjustment cost.

9. Like for impatient households, the choices of consumption and housing are directly affected by the introduction of the borrowing restriction. The borrowing constraint introduces a wedge between the price of the real estate and its rental rate.

10. The labour input is a combination of two types bundles of the labour varieties supplied by domestic households. I-type households represent a share $1-\omega$ of domestic households and are indexed by $i \, \varepsilon \, \left[0, s^H(1-\omega)\right]$ while J-type households represent a share ω and are indexed by $j \, \varepsilon \, \left(s^H(1-\omega), s^H\right]$. Each firm n uses a CES combination of the two types of labour.

sluggish price adjustment due to staggered price contracts à la Calvo (1983) with indexation.[11]

The nontradable final goods are used for consumption and investment purposes. Firms producing final nontradable goods are symmetric, act under perfect competition and use nontradable as well as domestic and imported tradable intermediate goods as inputs. The intermediate goods are assembled according to a constant elasticity of substitution (CES) technology, using as inputs all intermediate goods (see Gomes *et al.* (2012) for details).

The monetary policy authorities in the model follow Taylor-type rules that are a function of inflation and output growth, with some smoothing of interest rate assumed. In particular case of the EA, there exists a single monetary authority that targets a weighted (by regional size) average of regional (Home, H, and REA) annual consumer price inflation and real quarterly output growth. In the other blocs the monetary authority responds to developments of country specific variables.

In each bloc there is also a fiscal authority that purchases a final good (which is a composite of nontradable intermediate goods only). The fiscal authority also makes transfers to households, issues bonds to refinance its debt, and levies taxes. There are several distortionary taxes in each bloc[12] but all tax tax rates are assumed to be exogenously set by the fiscal authority and for the current exercises are kept constant. There are also lump-sum taxes that are adjusted as a function of government debt to output ratio so to make public debt stable.

Calibration

The model is calibrated at a quarterly frequency. The world economy is composed of Portugal (the Home bloc), the rest of the euro area, the US and the rest of the world. In the current exercises we mostly take this bloc as residual as its main role here is to allow for a full and consistent calibration of the trade matrix. The parameterization is otherwise kept similar to the other blocs in the model.

11. Under this scheme each firm is able to optimally reset prices in a given period t with a certain probability (say $1 - \xi_F$, $0 \leq \xi_F \leq 1$). All firms that are able to re-optimize their price contracts in a given period t choose the same price. Those firms which do not re-optimize are allowed to adjust their prices according to a rule that indexes it to a weighted average of past and steady state inflation. The probability of being able to re-optimize and the degree of indexation are the same within a sector but may differ across sectors, namely the domestic tradable, non-tradable and export sectors.

12. Distortionary taxes include taxes on consumption, on capital, on dividend income and on wages, namely a pay-roll tax levied on household wage income and a tax levied on wages paid by firms (i.e. social contributions).

The parameters in the model are calibrated to be consistent with data obtained from several sources or to be consistent with empirical evidence or similar models in the related literature, such as EAGLE, GEM and NAWM. In particular, several parameters are calibrated in order to match the so-called "great ratios" and also the banking variables (as a ratio to GDP). The remaining parameters are calibrated in line with the literature, in particular with the calibration of models .

Tables 1 to 8 in the Appendix summarize the calibration of the model. Table 1 reports banks' balance sheet variables as a ratio to annualized GDP. The data to calibrate these ratios is taken from Eurostat Annual Sector Accounts and the Federal Reserve Board Financial Accounts and the 1999-2013 period is considered.[13] The calibration of the financial bloc of the model is challenging due to data availability issues. In particular, no data are available on collateralized loans for other purposes but housing. As such we choose to match the average share of total loans to households. Our calibration strategy follows Bokan *et al.* (2016) in emphasizing the role of bank loans. Therefore we give a broad interpretation to bank deposits, namely given the fact that there are no other financing sources such as bank bonds in the model. Consistently, given the matched values for steady state loans to households, the assumed zero excess bank capital in the steady state, the calibration of the capital requirement and the loan-to-value ratios (see below), we allow deposits to endogenously adjust consistently with the bank's balance sheet.

Table 2 reports the great ratios that are matched to the National Accounts data for the EA regions and the US taken from Eurostat. We set region sizes to match the share of world GDP (IMF data). The EA and US net foreign asset position data are calibrated with data from the Eurostat and the Bureau of Economic Analysis, respectively.[14]

The parameters driving financial frictions and describing the banking sector are reported in Table 3. We set the loan-to-value ratio of impatient households to 0.7 in both EA regions, in line with Lombardo and McAdam (2012) for the EA and Banco de Portugal (2017) for Portugal (see also Calza *et al.* (2013) for the case of Germany). The entrepreneurs' loan-to-value ratio associated with housing collateral is also set to 0.7, while the loan-to-value ratio associated with capital collateral is set to 0.30, broadly in line with the literature. Regarding adjustment costs, we set the adjustment costs related parameters to low values so to limit their role for the dynamics of the model, while, at the same time, preserving the model stationarity. Finally, the capital requirement parameter is set to 8% in the EA and the US, consistent with the BASEL III minimum requirement for total capital.

13. All data refer to nominal outstanding amounts at the end of the year divided by annual nominal GDP.

14. Given the import shares, net foreign asset position and international interest rate, the steady-state trade balance and real exchange rate level endogenously adjust.

Table 4 reports population shares, preference and technology parameters. The share of patient households in each region is set to 30%, the share of impatient households to 50% while the share of entrepreneurs is set to 10% (as reported in Table 3, the share of bankers is set to 10%). Preferences are assumed to be the same across household types and regions and the parameterisation, as summarised in Table 4, is broadly in line with the related literature. Particular notice to the calibration of the discount factors since in our setup a necessary condition for entrepreneurs to be constrained is that their discount factor is lower than the inverse of the return on loans (see Iacoviello (2015)). When this condition is satisfied entrepreneurs will be constrained in a neighborhood of the steady state.[15] We set the discount factor of patient households so that it implies a steady-state annualized real interest rate of about 3%). The discount factor of impatient households and entrepreneurs are thus set to a lower value.

The production side parameters are summarized in Table 4. The bias towards capital in the Cobb-Douglas production functions of tradable and nontradable intermediate goods is set to around 0.30 and the bias towards housing to 0.01. As for the final goods baskets, the degree of substitutability between domestic and imported tradables is higher than that between tradables and nontradables, consistent with existing literature. The weight of domestic tradable goods in the consumption and investment tradable baskets is different across countries, to be coherent with multilateral import-to-GDP ratios.

Markups in the EA nontradables sector (a proxy for the services sector) and labour market are higher than the corresponding values in the US and RW (see Table 5). We assume that the tradable sector is as competitive in the euro area as in the US so the markup in the tradables sector (a proxy for the manufacturing sector) has the same value in all regions.[16]

Table 6 reports nominal and real rigidities. We set Calvo price parameters in the domestic tradables and nontradables sector to 0.83, correponding to an average duration of cantracts of around 6 quarters in the EA, broadly consistently with estimates by Christoffel *et al.* (2008) and Smets and Wouters (2003). Corresponding nominal rigidities outside the EA are equal to 0.75, implying an average frequency of adjustment equal to 4 quarters, in line with Faruqee *et al.* (2007). Calvo wage parameters are set to 0.75 in all regions and price parameters in the export sector are equal to 0.67 in all the regions

15. Similarly, banks are "constrained"by their capital requirement (which holds as strict equality in a neighborhood of the steady state) as long as their discount factor is lower than the returns on deposits.

16. Our calibration of the price markups is broadly in line with estimates by Høj *et al.* (2007), Christopoulou and Vermeulen (2012) and Bouis and Klein (2008). Given the lack of information on the wage markup, we assume that the wage markup is equal to the price markup in the non-tradable (services) sector.

(around 3 quarters). The indexation parameters on prices and wages are equal respectively to 0.50 and 0.75, so to get sufficiently hump-shaped response of wages and price. For real rigidities, we set adjustment costs on investment changes to 6 in the EA and to 4 in the case of the US and RW; and adjustment costs on consumption and investment imports to 2 and 1, respectively.

We set weights of bilateral imports on the bundles to match the trade matrix reported in Table 7.The trade matrix is calibrated using Eurostat and IMF trade statistics. Table 8 reports parameters in the monetary policy rules and fiscal rules. For fiscal rules, steady-state ratios of government debt over output are equal to 2.40 in all the regions (0.6 in annual terms). Tax rates are set to be consistent with empirical evidence (Coenen *et al.* (2008)).

Simulations

In this section we run several simulations that illustrate how the model works. First we run an expansionary monetary policy shock. In order to document the amplification role of the household sector financial frictions , we also run the monetary policy shock under an alternative loan-to-value ratio. Given the novel features of the model, we run a financial shock, in particular we show the results of a permanent change in the loan-to-value ratio faced by impatient households in the Portuguese economy. The simulations are carried out under perfect foresight.

The monetary policy shock

We simulate a shock that leads to a reduction of the euro area annualised monetary policy rate of 25 basis points on impact. Figures 1 and 2 report the results, focusing on the two euro area blocs. Given that this shock is common to both euro area regions and due to the fact that the two blocs are not fundamentally different, the responses of the two blocs to this shock are rather similar. The monetary policy shock has a broadly expansionary impact on the main macroeconomic variables, namely GDP, consumption and investment, that as expected shows a larger increase than GDP. The increased demand in the euro area induces an increase in imports and exports also increase, given the depreciation of the euro exchange rate.

The cut in the policy rate is transmitted into the loans and deposits interest rates, that also go down. Together with the drop in interest rates, the expansionary impact of the shock implies an increased demand for loans, both by impatient households and entrepreneurs. The higher bank lending is financed by an increase in deposits (bank capital, not shown in the figures, drops slightly). Given that loans are collateralized this pushed upwards the demand of housing and the housing price. The increased housing price

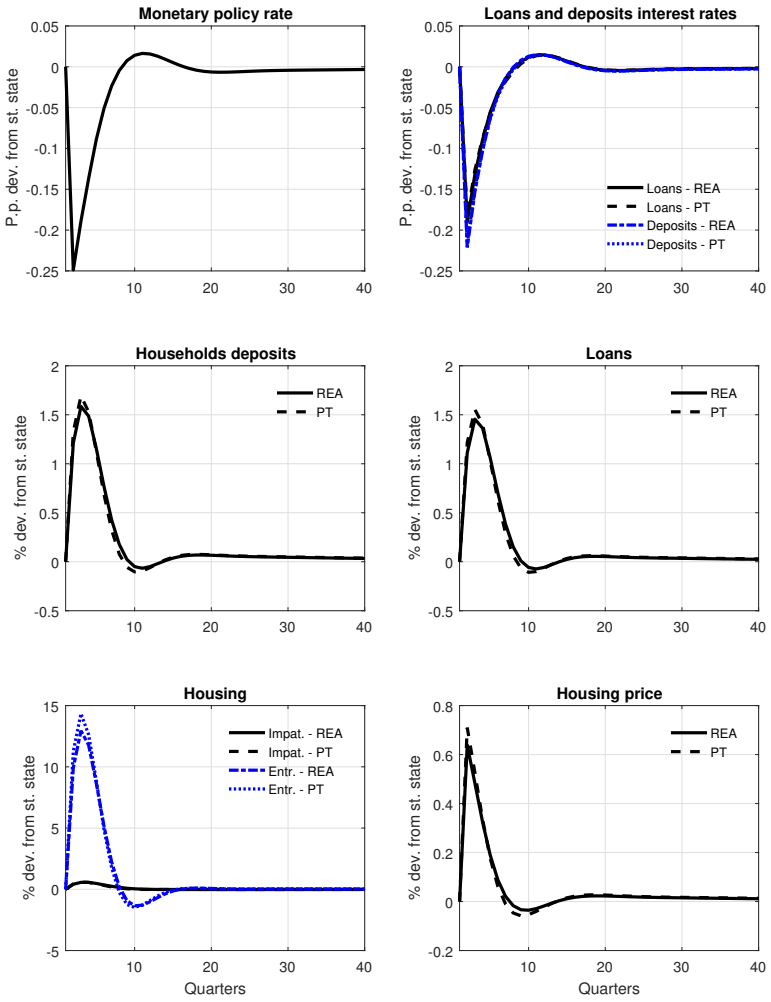

FIGURE 1: Reduction in the EA interest rate (0.25 p.p.)

reinforces impact of the shock given that the value of collateral increases thus allowing agents to borrow more against their housing stock.

To understand better the amplifying role of the households side financial frictions, we run an additional experiment where we run the same shock as above but considering an alternative calibration of the loan-to-value ratio. In particular we consider the alternative case where the loan-to-value ratio is set to a higher value. In this scenario impatient households are allowed to borrow ut to 90% of the (expected) value of their collateral, compared to 70% in the benchmark case. As shown in Figure 3 the expansionary effect of the shock is higher in the case of a higher loan-to-value ratio calibration. In terms of the GDP components, the amplification is larger for private consumption, as would be expected given that we increase the

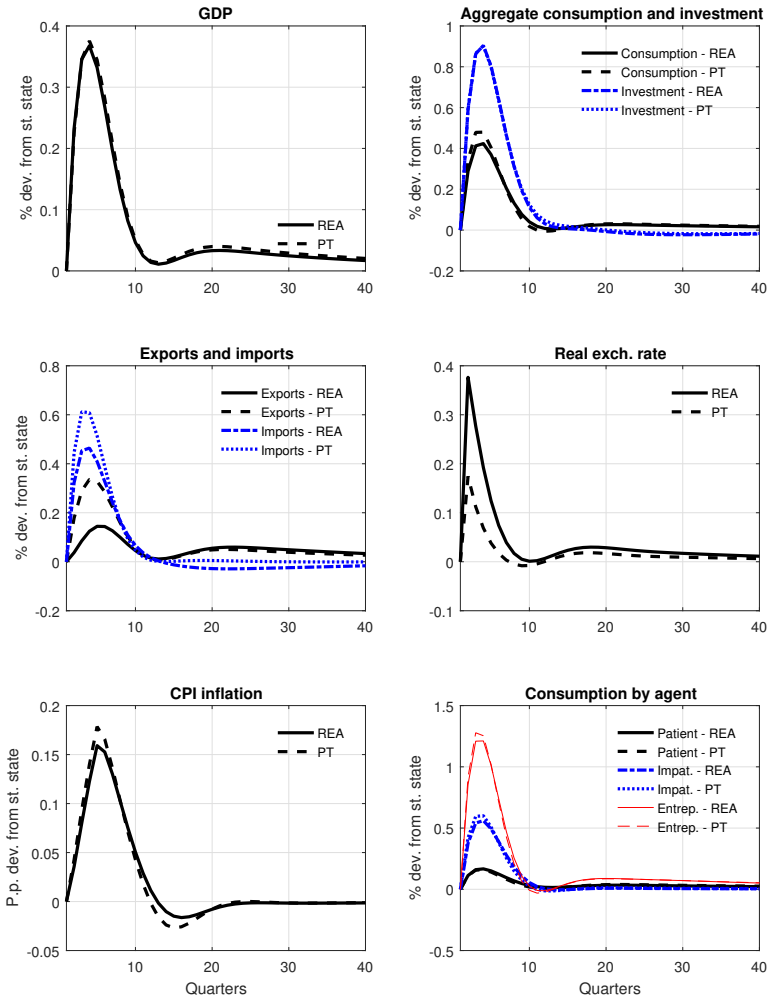

FIGURE 2: Reduction in the EA interest rate (0.25 p.p.) - Continued

loan-to-value of impatient households (but keep the loan-to-value ratios faced by entrepreneurs unchanged at their initial level). In fact the impact of increasing the loan-to-value calibration is more noticeable in lending to impatient households that are the ones facing a relaxation of the borrowing constraint.

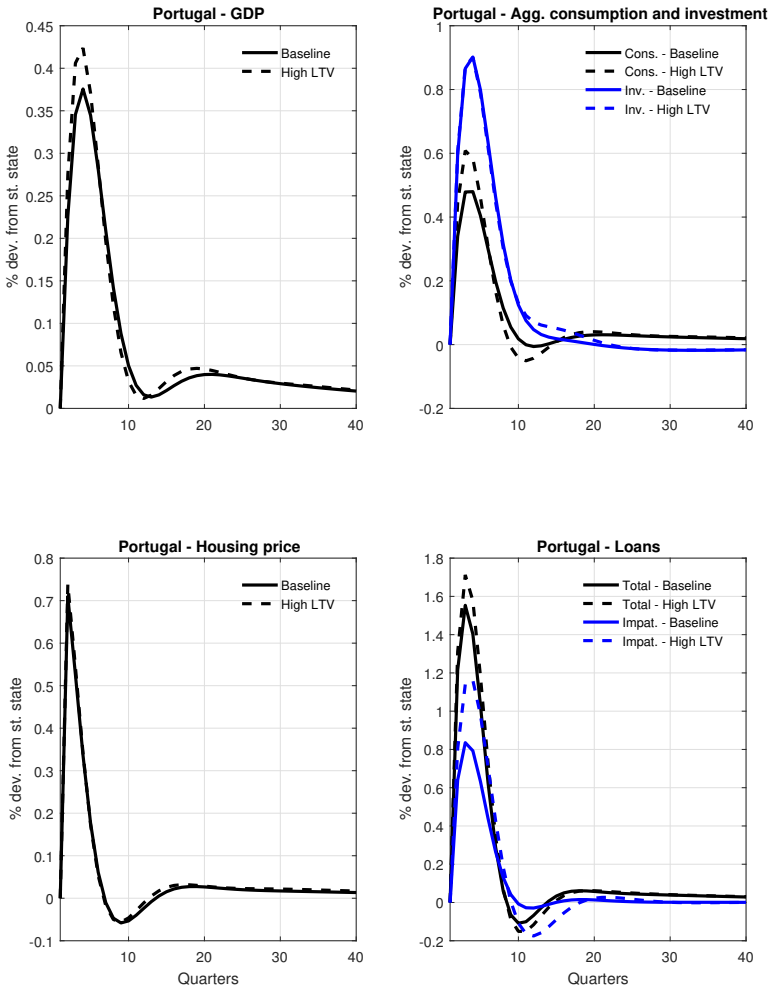

FIGURE 3: Reduction in the EA interest rate (0.25 p.p.) – Higher LTV

The loan-to-value shock

In this section we analyse the model impact of a decrease in the loan-to-value ratio for loans collateralized with the housing stock in Portugal. The loan-to-value ratio is decreased by 1 percentage point on impact and then returns gradually to the steady state level. In particular, the loan-to-value is assumed to return to steady sate following an AR(1) process with coefficient equal to 0.9. This means that after ten years the loan-to-value ratios are virtually back at the initial level (see Figure 4). The agents in the economy perfectly anticipate this adjustment path of the loan-to-value ratio.

Figures 5 and 6 summarise the results. This scenario illustrates a change in lending standards for reasons exogenous to the model, that could result from

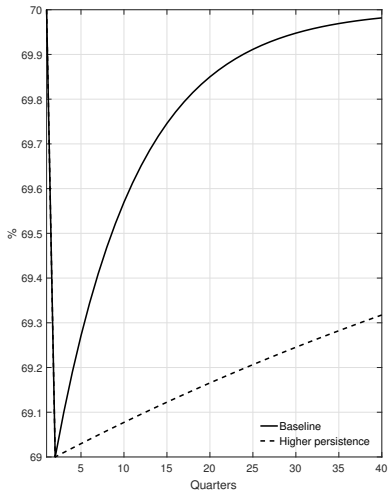

FIGURE 4: The loan-to-value paths

banks lending policy or from an change imposed by a regulatory authority. Either way, this change results in a decrease in the demand for loans, as it tightens the collateral constraint. The change leads impatient households and entrepreneurs to demand less loans at any given level of interest rates, since the loan-to.value ratio has decreased. The lower demand results in less loans being extended domestically at a lower interest rate. Given the decrease in loans extended, banks reduce their demand for deposits, pushing down the respective interest rate. Given the lower demand for loans, the demand for real estate also falls, driving down prices. The decrease in the value of the housing collateral further pressures down borrowing.

Overall the shock leads to a drop in GDP driven by the domestic demand components. After a few quarters, Portuguese exports decrease, given the real exchange rate appreciation. Imports fall as well, following the reduction in domestic aggregate demand. Given that the shock is on the loan-to-value ratios faced by borrowers, the main impact comes from their reduced borrowing capacity mainly depressing consumption of borrowers (both households and entrepreneurs).

Spillovers to the Home bloc are small. Given the small size of the Portuguese bloc, euro area GDP hardly changes, and the same happens with inflation. Since monetary policy reacts to union wide variables, the policy rate virtually does not change either. So in the case of a very small economy in a monetary union, monetary policy does not counteract the impact of the shock.

In this simulation we assume the loan-to-value is back to its initial level after ten years. To analyse the impact of this assumption on our results we run the same simulation again but assuming a much more gradual return of the loan-to-value ratio. In this case, after ten years the ratio is just adjusted by 0.3 percentage points (see Figure 4) . As shown in Figure 7, the drop in GDP is

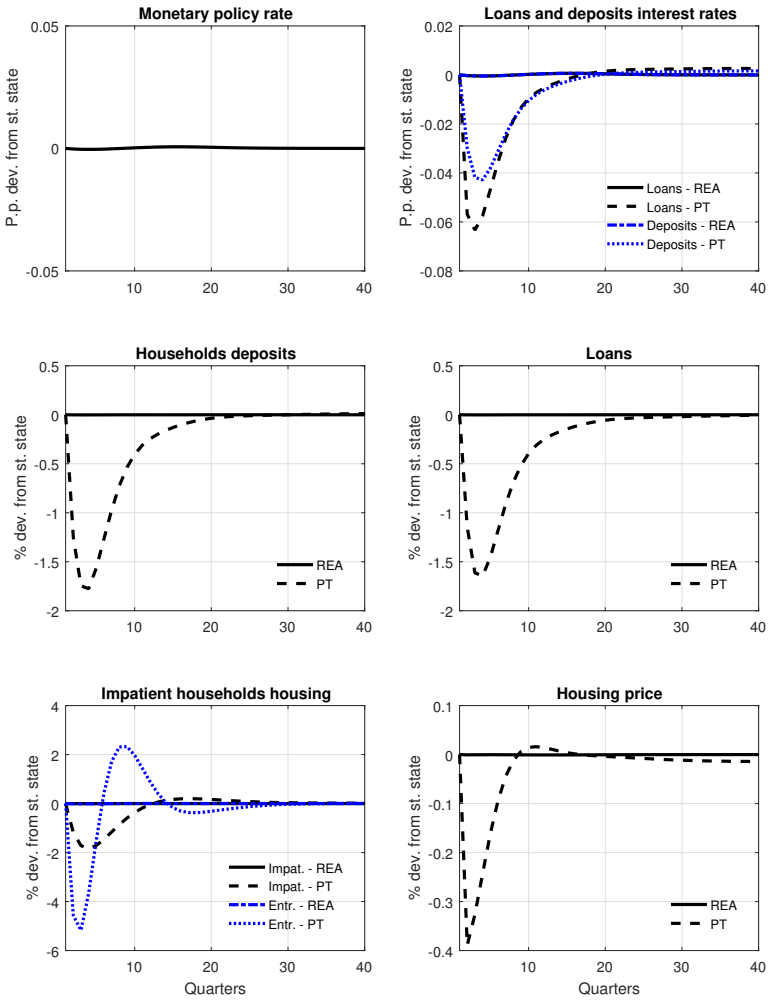

FIGURE 5: Reduction of the loan-to-value

much more pronounced and the responses of the variables to the shock are not only larger but also more persistent, as the shock is.

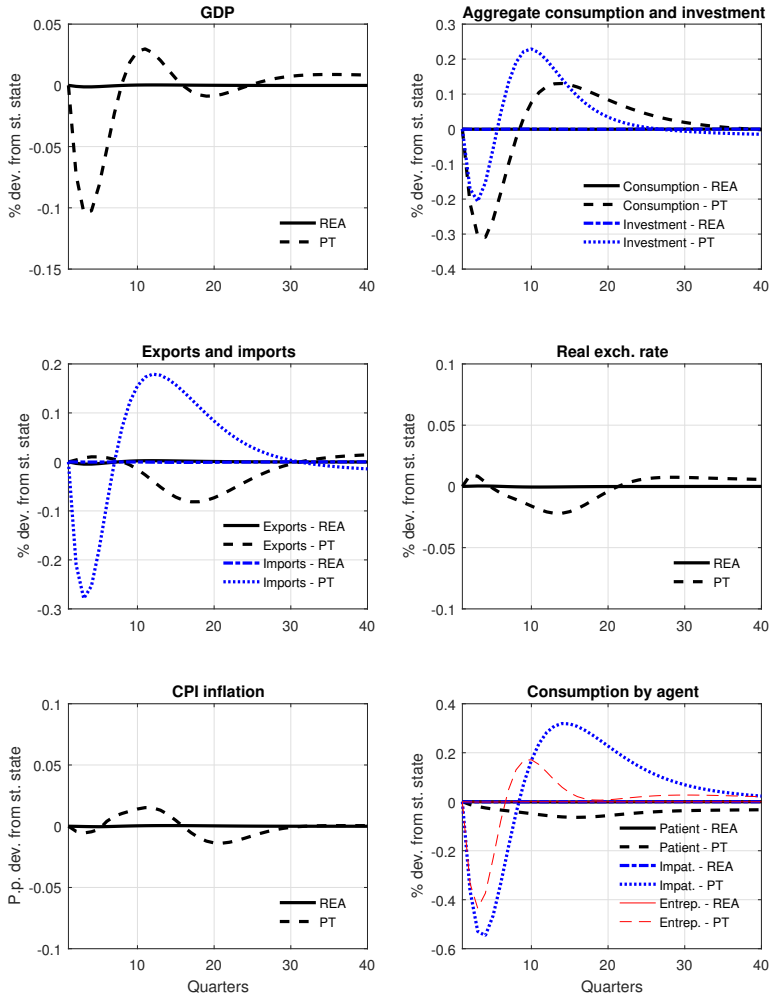

FIGURE 6: Reduction of the loan-to-value – Continued

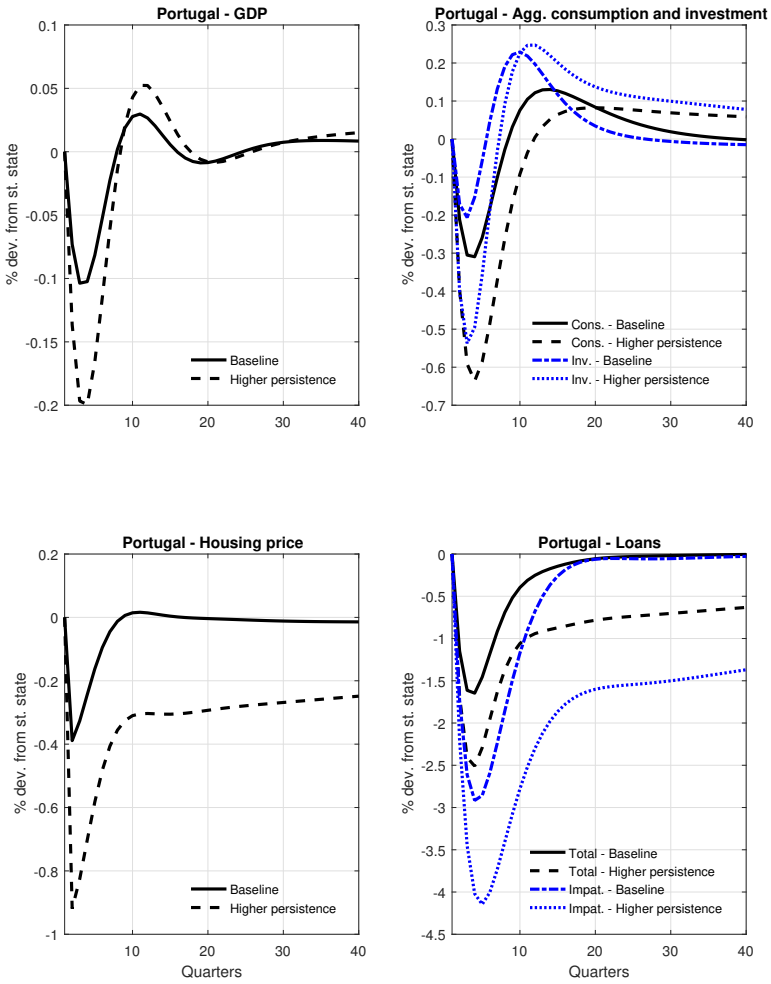

FIGURE 7: Reduction of the loan-to-value – Different persistence

Conclusions

The recent global financial crisis highlighted the importance of including real-financial linkages in structural models. In this paper we take a large scale multi-country model of the euro area that includes financial frictions. In the model the euro area is modelled as a two-bloc monetary union and for the current exercise we calibrate those blocs to a small economy in the union, namely Portugal, and the rest of the euro area. The version of the EAGLE model used here, namely the EAGLE-FLI model, allows us to analyse the behaviour of financial variables and to analyse different channels that originate from the inclusion of a financial sector in the model. We run several simulations in order to illustrate the transmission mechanisms of different shocks and how the financial features interact with the real side of the model. In fact, the large scale of the model together with its microfoundations makes it an interesting laboratory to analyse the macroeconomic implications of financial factors in euro area countries, in a theoretically consistent setup.

Our simulations illustrate how the macro-financial linkages present in the model are important for the interpretation of how macroeconomic variables respond to shocks. First we focus on a standard monetary policy shock to show that the model presents results that are consistent with earlier literature but also to illustrate how the impact of this shock may be amplified and made more persistent due to the presence of financial frictions. In addition, we also explore the transmission mechanism of a shock originating in the financial sector, in particular related to the tightness of the collateral constraint faced by borrowers.

Even though the model is already quite rich, further improvements could be envisaged. The literature on financial frictions and structural models has grown extensively over the last decade, including non-linear extensions (such as occasionally binding constraints) or the introduction of transmission channels related to unconventional monetary policy. The estimation of the model would make it even more useful for policy advice. We leave this for further research.

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Appendix

	PT	REA	US	RW
Loans	137	132	161	146
Loans to households	61	64	90	76
Loans to entrepreneurs	76	68	71	70
Interbank	0.0	0.0	n.a.	n.a.
Deposits	126	122	148	134
Excess bank capital	0.0	0.0	0.0	0.0

TABLE 1. Steady-State Financial Accounts (Ratio to annual GDP, %)

Note: PT: Portugal; REA=Rest of Euro Area; US=United States; RW=Rest of World

	PT	REA	US	RW
Domestic demand				
Private consumption	55	59	63	62
Cons. patient households	23	28	28	30
Cons. impatient households	2	25	9	18
Private investment	23	20	21	21
Public consumption	20	21	15	18
Trade				
Imports (total)	38	20	15	12
Imports of consumption goods	24	12	8	5
Imports of investment goods	15	9	7	6
Net foreign assets (ratio to annual GDP)	-82	-8	-18	13
Production				
Tradables	63	43	44	41
Nontradables	37	57	56	59
Labour	44	43	48	47
Share of World GDP	3	21	21	58

TABLE 2. Steady-State National Accounts (Ratio to GDP, %)

Note: PT: Portugal; REA=Rest of Euro Area; US=United States; RW=Rest of World

	Home	REA	US	RW
Households LTV ratio (V_J)	0.7	0.7	0.7	0.7
Entrepreneurs LTV ratio (V_{H_E})	0.7	0.7	0.7	0.7
Entrepreneurs LTV ratio (V_{K_E})	0.3	0.3	0.3	0.3
Households Loans smoothing (ρ_{B_J})	0.4	0.4	0.4	0.4
Entrepreneurs loans smoothing (ρ_{B_E})	0.4	0.4	0.4	0.4
Capital requirement (Υ^K)	0.08	0.08	0.08	0.08
Banks discount factor (β_B)	$1.03^{-\frac{1}{4}}$	$1.03^{-\frac{1}{4}}$	$1.03^{-\frac{1}{4}}$	$1.03^{-\frac{1}{4}}$
Banks share in the population (ω_B)	0.10	0.10	0.10	0.10
Adjustment costs				
Deposits (γ_{DH})	0.0001	0.0001	0.0001	0.0001
Excess bank capital (γ_X)	0.001	0.001	0.001	0.001
Interbank (γ_{IB})	0.001	n.a.	n.a	n.a
Loans - banks (γ_L)	1.5	1.5	1.5	1.5
Loans - impatient hous. (γ^{BJ})	1.5	1.5	1.5	1.5
Loans - entrepreneurs (γ^{BE})	1.5	1.5	1.5	1.5

TABLE 3. Financial and Banks Parameters

Note: PT=Portugal; REA=Rest of Euro Area; US=United States; RW=Rest of World

	Home	REA	US	RW
Share in the population				
Patient households (ω_I)	0.30	0.30	0.30	0.30
Impatient households (ω_J)	0.50	0.50	0.50	0.50
Entrepreneurs (ω_E)	0.10	0.10	0.10	0.10
Households and entrepreneurs				
Patient hous. discount factor (β_I)	$1.03^{-\frac{1}{4}}$	$1.03^{-\frac{1}{4}}$	$1.03^{-\frac{1}{4}}$	$1.03^{-\frac{1}{4}}$
Imp. households discount factor (β_J)	0.96	0.96	0.96	0.96
Entrepreneurs discount factor (β_E)	0.99	0.99	0.99	0.99
Intertemporal elasticity of substitution (σ^{-1})	1.00	1.00	1.00	1.00
Inverse of the Frisch elasticity of labour (ζ)	2.00	2.00	2.00	2.00
Housing services (ι_I, ι_J)	0.10	0.10	0.10	0.10
Habit persistence (κ)	0.70	0.70	0.70	0.70
Capital depreciation rate(δ_K)	0.025	0.025	0.025	0.025
Housing depreciation rate(δ_H)	0.01	0.01	0.01	0.01
Intermediate-good firms (trad. and nontrad. sectors)				
Substitution btw. labour and capital	1.00	1.00	1.00	1.00
Bias towards capital - tradables (α_T)	0.30	0.30	0.30	0.30
Bias towards housing - tradables (α_{HT})	0.01	0.01	0.01	0.01
Bias towards capital - nontradables (α_N)	0.37	0.40	0.31	0.43
Bias towards housing - nontradables (α_{HN})	0.01	0.01	0.01	0.01
Substitution btw. I-type and J-type labour (η)	3.86	3.86	5	5
Final consumption-good firms				
Substitution btw. domestic and imported trad. goods (μ_{TC})	2.50	2.50	2.50	2.50
Bias towards domestic tradables goods (v_{TC})	0.22	0.52	0.54	0.84
Substitution btw. tradables and nontradables (μ_C)	0.50	0.40	0.35	0.35
Bias towards tradable goods (v_C)	0.70	0.20	0.20	0.20
Substitution btw. consumption good imports (μ_{IMC})	2.50	2.50	2.50	2.50
Final investment-good firms				
Substitution btw. domestic and imported trad. goods (μ_{TI})	2.50	2.50	2.50	2.50
Bias towards domestic tradables goods (v_{TI})	0.19	0.45	0.48	0.74
Substitution btw. tradables and nontradables (μ_I)	0.50	0.50	0.50	0.50
Bias towards tradable goods (v_I)	0.85	0.85	0.85	0.85
Substitution btw. investment good imports (μ_{IMI})	2.50	2.50	2.50	2.50

TABLE 4. Households, Entrepreneurs and Firms Behavior

Note: PT: Portugal; REA=Rest of Euro Area; US=United States; RW=Rest of World

	Tradables (θ_T)	Nontradables (θ_N)	Wages ($\eta_I = \eta_J$)
PT	1.15 (7.67)	1.35 (3.86)	1.35 (3.86)
REA	1.15 (7.67)	1.35 (3.86)	1.35 (3.86)
US	1.15 (7.67)	1.25 (5.0)	1.25 (5.0)
RW	1.15 (7.67)	1.25 (5.0)	1.25 (5.0)

TABLE 5. Price and Wage Markups (Implied Elasticities of Substitution)

Note: PT: Portugal; REA=Rest of Euro Area; US=United States; RW=Rest of World

	PT	REA	US	RW
Adjustment costs				
Imports of consumption goods (γ_{IM^C})	2.00	2.00	2.00	2.00
Imports of investment goods (γ_{IM^I})	1.00	1.00	1.00	1.00
Capital utilization (γ_{u2})	2000	2000	2000	2000
Investment (γ_I)	6.00	6.00	4.00	4.00
Intermediation cost function - USD bond (γ_{B^*})	0.01	0.01	...	0.01
Intermediation cost function - Euro bond ($\gamma_{B^{EA}}$)	...	0.01	...	...
Calvo parameters				
Wages - households I and J (ξ_I and ξ_J)	0.75	0.75	0.75	0.75
Prices - domestic tradables (ξ_H) and nontradables (ξ_N)	0.83	0.83	0.75	0.75
Prices - exports (ξ_X)	0.67	0.67	0.67	0.67
Degree of indexation				
Wages - households I and J (χ_I and χ_J)	0.75	0.75	0.75	0.75
Prices - domestic tradables (χ_H) and nontradables (χ_N)	0.50	0.50	0.50	0.50
Prices - exports (χ_X)	0.50	0.50	0.50	0.50

TABLE 6. Real and Nominal Rigidities

Note: PT: Portugal; REA=Rest of Euro Area; US=United States; RW=Rest of World

	Home	REA	US	RW
Consumption-good imports				
Substitution btw. consumption good imports (μ_{IMC})	2.50	2.50	2.50	2.50
Total consumption good imports	23.6	11.5	8.3	5.3
From partner				
PT	-	0.3	0.01	0.05
REA	15.6	-	1.1	3.2
US	0.3	0.9	-	2.1
RW	7.7	10.4	7.2	-
Investment-good imports				
Substitution btw. investment good imports (μ_{IMI})	2.50	2.50	2.50	2.50
Total investment good imports	14.7	9.0	6.9	6.2
From partner				
PT	-	0.1	0.01	0.03
REA	9.2	-	1.0	3.4
US	0.5	1.3	-	2.8
RW	5.0	7.5	5.9	-

TABLE 7. International Linkages (Trade Matrix, Share of Domestic GDP, %)

Note: PT: Portugal; REA=Rest of Euro Area; US=United States; RW=Rest of World

	Home	REA	US	RW
Monetary authority				
Inflation target ($\overline{\Pi}^4$)	1.02	1.02	1.02	1.02
Interest rate inertia (φ_R)	0.87	0.87	0.87	0.87
Interest rate sensitivity to inflation gap (φ_Π)	1.70	1.70	1.70	1.70
Interest rate sensitivity to output growth (φ_Y)	0.10	0.10	0.10	0.10
Fiscal authority				
Government debt-to-output ratio ($\overline{B_Y}$)	2.40	2.40	2.40	2.40
Sensitivity of lump-sum taxes to debt-to-output ratio (φ_{B_Y})	5.00	5.00	5.00	5.00
Consumption tax rate (τ_C)	0.185	0.192	0.078	0.123
Dividend tax rate (τ_D)	0.00	0.00	0.00	0.00
Capital income tax rate (τ_K)	0.19	0.19	0.16	0.16
Labour income tax rate (τ_N)	0.079	0.151	0.154	0.100
Rate of social security contribution by firms (τ_{W_f})	0.092	0.15	0.078	0.109
Rate of social security contribution by households (τ_{W_h})	0.063	0.077	0.067	0.079

TABLE 8. Monetary and Fiscal Policy

Note: PT: Portugal; REA=Rest of Euro Area; US=United States; RW=Rest of World