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Global capital flows and the role of macroprudential policy[☆]

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ABSTRACT

Can countercyclical bank capital buffers reduce the negative effects of global liquidity shocks? We use the Lehman Brothers bankruptcy as a natural experiment to document the role of the banking system as a transmission channel of global financial disturbances to the real economy. Using central bank administrative data, our results suggest that in the aftermath of the Lehman collapse the banking channel is responsible for 1.44% of the aggregate drop in investment and 0.58% of the drop in aggregate employment. In order to evaluate the effectiveness of counter-cyclical macroprudential policies, we model an open-economy with a banking sector. We compare the drop in actual GDP during the 2008 financial crisis against the counterfactual GDP had Basel III style counter-cyclical capital buffers (CCyB) been in place. We find that the GDP drop in the counterfactual scenario would have been 6 p.p. lower than in the data. We also demonstrate the beneficial effects of the CCyB in mitigating tail risk (GDP at Risk). We show that, over a 3–5 year horizon, the GDP distribution with an operational CCyB would have a higher mean and a much thinner left tail when compared to an economy without a CCyB.

1. Introduction

A central question in international finance is the role of macroprudential policy in curbing the effects of global financial cycles on capital inflows and asset prices.[1] Global banks serve as the main transmission channel, fueling financial shocks from core financial centers to domestic economies.[2] A weakened financial system and its negative consequences on the economy revived the need to rethink policy prescriptions to deal with systemic risk in financial markets. At the forefront is the debate on the effectiveness of macroprudential regulation.[3]

In this paper, we make two main contributions. One is empirical and the other is theoretical.

Our main empirical contribution is to show how the banking system served as a pass-through of global financial shocks, contributing to the decline in economic activity in the aftermath of the great financial crisis. We use the Lehman Brothers bankruptcy as a natural experiment. Exploiting the heterogeneous exposure of Portuguese banks to the international wholesale market, we show how a weakened banking sector responded by lowering credit supply, causing a decrease in investment and employment in Portugal.

The 2008 financial recession brought a liquidity drought in the international interbank wholesale market,[4] spilling over to the Portuguese economy. In fact, after the Lehman Brothers collapse, credit growth started to decrease in Portugal.[5] Contemporaneous with the Lehman fall, investment and employment by Portuguese firms also collapsed.[6], [7] From this sequence of events, one could conclude that causality runs from disturbances in a core financial center to negative consequences for economies abroad. However, credit levels are the equilibrium outcome of maximizing decisions made by creditors and debtors. Banks may be unable or unwilling to supply credit to the

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1 See Rey (2013) on global financial cycles.
2 A non-exhaustive list is: Cetorelli and Goldberg (2012, 2011), Kalemli-Ozcan et al. (2013), Haas and Van Horen (2013), Haas and Lelyveld (2014).
3 See, for example, Blanchard et al. (2010), and Financial Stability Board-bank for International Settlements-International Monetary Fund (2016).
4 See Fig. 7 on cross-border flows between domestic and foreign banks
5 See Fig. 6 in Appendix A.1.
6 Two years after the Lehman fall, employment in Portugal decreased by 5.4% and gross fixed capital formation (GFCF) dropped by 14.3%.
7 See Figs. 10 and 11 in Appendix A.1.

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economy due to worsening international wholesale market conditions (*credit supply channel*). The same equilibrium credit level drop might also be caused by a fall in demand for credit (*credit demand channel*).

The richness of our data uniquely allows us to focus on the *credit supply channel*. We use highly granular and confidential data from the Bank of Portugal to build a dataset consisting of loan-level data covering virtually the entire population of banks and firms operating in the Portuguese territory.[8]

Our identification strategy divides the causal chain into two parts. In the first part, we use a difference-in-difference design comparing lending before and after September 2008, exploiting the quasi-experimental variation in the dependence of Portuguese banks on international interbank markets. Our main identification strategy hinges on isolating a firm borrowing from banks with different exposure to international markets (Khwaja and Mian (2008)). We find that following the Lehman collapse, the drop in credit supply is higher for banks more dependent on international financial markets. After establishing the drop in credit supply following the Lehman fall, the second part of the causal link uses an instrumental variable approach to show how lower credit supply fuels into a drop in aggregate investment and employment. We report that a one-percentage point (p.p.) decrease in credit supply lowers investment by 0.636 p.p. and employment by 0.058 p.p.. A back-of-the-envelope analysis suggests that, during the 2004–2012 period, the liquidity shock to banks' balance sheet, brought about by the fall of Lehman Brothers, 1.44% of the drop in investment and a 0.57% share of the drop in employment. Therefore, we provide empirical evidence supporting the hypothesis that the banking sector acts as a crucial pass-through of foreign disturbances to the real economy.

Our empirical findings contribute to the literature that studies the international transmission of financial crises. The literature provides ambiguous results on the importance of financial links in crisis transmission.[9] Rose and Spiegel (2010, 2011) find weak evidence for the role of financial linkages to cross-country crises transmission. The richness of our data allows us to disentangle credit supply from credit demand shocks and, consistent with Cetorelli and Goldberg (2011) and Kalemli-Ozcan et al. (2013), report evidence of the importance of cross-border lending to the fall in bank credit supply. Or paper is closest to Iyer et al. (2014) who also use the Portuguese credit register and a similar estimation methodology. A main distinction of our paper compared with Iyer et al. (2014) is the analysis of the real effects of the credit supply shock. There is growing literature on the effect of bank credit shocks on the real economy. Paravisini et al. (2015) studies how a credit shortage affects exports, and Chodorow-Reich (2014) provides evidence of a decrease in employment in the US in the aftermath of the 2008 financial crisis. In Italy, Cingano et al. (2016) finds a sizeable negative impact of the credit freeze on firm investment and Bentolila et al. (2018) analyze the drop in employment for Spanish firms linked to weaker banks. Recent papers also study the impact of financial shocks on firm behavior, showing how leveraged firms tend to increase worker layoffs (e.g. Giroud and Mueller (2017) and Buera and Karmakar (2021)). By building a rich dataset of loan-level data, this paper contributes to this literature by supporting the above mentioned findings and showing how a global shock to banks' balance sheets lowers domestic investment and employment.

Finally, we also contribute by using empirically estimated micro-identified elasticities to inform the calibration of our macro-structural model. There is an emerging and active research agenda on the use of microdata to create identified moments used to parameterize aggregate structural models. A selected list of notable examples are Nakamura and Steinsson (2014), Gopinath et al. (2017), Beraja et al. (2019), and Arellano et al. (2019). See also Nakamura and Steinsson (2018) for a survey of the literature. Our paper is, to our knowledge, the first to create micro estimates from firm-bank data to inform the popular class of bank models akin to Gertler and Kiyotaki (2010).

Our main theoretical contribution uses a dynamic stochastic general equilibrium model to quantify the beneficial impact of imposing countercyclical bank capital buffers (CCyB) to curb the impact of these exogenous disturbances. We also contribute to the growing strand of literature on GDP at risk to quantify the beneficial effects of the CCyB at the tail of the GDP distribution. We build an open-economy model with a banking sector borrowing from domestic and international depositors. We calibrate the model by resorting to indirect inference to estimate key parameters. To this end, we use the empirical model as an auxiliary model to calibrate the employment and investment block of the structural model.

We use our theoretical model together with a particle filter to extract the sequence of shocks hitting the economy during the great recession and perform the following counterfactual experiments. First, we answer the following question, what would happen to the Portugueses economy if the domestic banking sector was not negatively affected by the distress in global financial markets? We find that domestic GDP would have dropped 2.5 p.p. less at the end of 2009.

Second, what would have been the path of gross domestic product (GDP) during the 2008 financial crisis if macroprudential policy had been in place? We find that the sharp decrease in GDP during the 2008–2010 period would have been 6 p.p. smaller with an active macroprudential policy. This result is mainly due to the presence of capital buffers that banks are expected to build up during periods of economic boom and subsequently release them in times of economic distress. A release of the capital buffer translates into higher credit during the crisis, fostering economic activity.

Third, besides studying the impact of CCyB on the path of GDP, we also analyze the effectiveness of the policy in mitigating tail risk. The high capital inflow in the years prior to the 2008 financial crisis fueled credit and GDP. However, this higher level of economic activity might hide the build-up of economic vulnerabilities. We study the build-up of such vulnerabilities by looking at the entire distribution of GDP, a concept the literature labeled GDP growth at risk (GAR). We find that during a recession CCyB regulation both increases mean GDP as well as mitigates tail risk (lower kurtosis).

We contribute to the literature on macroprudential capital requirements. Our theoretical framework builds on the work of Gertler and Karadi (2011) that introduces financial intermediaries in a standard business-cycle model.[10] Contrary to most of this literature, our main focus is on the international consequences of the 2007–2009 financial crisis. To do so, we extend the aforementioned authors' framework by including international investors lending to the domestic banking sector. There is a growing body of literature studying the effect of macroprudential regulation. Notable examples are Aoki et al. (2016) focus on macroprudential capital taxes and Akinci and Queralto (2017) study the effectiveness of bank equity injections and constant bank capital requirements. Contrary to these authors, we study the effectiveness of CCyB in curbing the negative effects of external shocks on the banking sector. There is also a strand of papers studying normative implications of capital requirements (e.g. den Heuvel (2008), Repullo and Suarez (2013) and Karmakar (2016)).[11] The goal of our paper is not

[8] Portugal serves as a suitable test laboratory for our natural experiment for three main reasons: (i) the Lehman collapse was exogenous to the Portuguese economy (ii) there was no real estate bubble and (iii) Portuguese firms are highly dependent on credit from the banking sector.

[9] Earlier examples are Peek and Rosengren (1997, 2000) that study the transmission of Japanese banking crises to the United States.

[10] Other examples are Kiyotaki and Moore (1997), Bernanke et al. (1999), and Brunnermeier and Sannikov (2014).

[11] Jiménez et al. (2017) provides an empirical study of the introduction of dynamic provision macroprudential tool in Spain. The authors provide empirical evidence on how countercyclical capital buffers can smooth credit in recessions. We build a structural model to echo and complement their findings.

normative and we focus on the quantitative implications of CCyB using a nonlinear DSGE model. We contribute to the literature in two ways. First, we quantify the negative impact of foreign interest rate shock during the 2008–2009 financial crisis. Second, we quantify the benefits of imposing CCyB both before and after a financial crisis. The unique nonlinear nature of our model allows us to find the uneven impact of CCyB in different points of the business cycle.

We also contribute to the literature on GDP growth at risk. This emerging strand of literature aims to quantify how easy current financial conditions can lead to worse realizations of GDP in the medium term – a concept labeled GDP growth at risk (GAR). We add to the empirical GAR literature such as Aikman et al. (2021), Adrian et al. (2019), Aikman et al. (2019) by using a nonlinear DSGE model to show how capital flows could lead to a fatter left tail of the GDP distribution and how macroprudential policy could improve outcomes.

The rest of the paper is organized as follows. In Section 2 we present the empirical strategy and empirical results. Section 3 provides a description of the aggregate structural model. Section 4 explains how we proceed with our quantitative exercise. In Section 4.2 we quantify the impact of foreign interest rates and analyze the mechanism through which capital flows fuel into the domestic economy. Section 5 studies the use of countercyclical bank capital requirements and Section 6 examines the impact of CCyB regulation on GAR. We conclude in Section 7.

2. A natural experiment on the impact of capital inflows on the domestic economy

This section has two main purposes. First, showing the causal impact of a foreign exogenous disturbance on the domestic supply of credit and the subsequent impact on domestic aggregate macroeconomic variables. Second, it provides estimated parameters to inform the calibration exercise of the theoretical model in Section 3. We use the Lehman brothers collapse to show how such an episode can trigger a causal chain going from capital inflow reversals and an international shock to the balance sheet of Portuguese banks culminating in lower credit supply to Portuguese firms and subsequent drop in investment and employment. The section proceeds in five steps: Section 2.1 discusses the Portuguese economic and financial environment during the financial crisis. Section 2.2 presents the identification strategy. Section 2.3 is the first step in the causal chain, showing how the Lehman fall resulted in a lower credit supply. Section 2.4 is the second step and shows the fall in investment and employment due to the fall in credit supply.

2.1. Lehman Backruptcy and the behavior of Portuguese firms and banks

The euro area (EA) money market experienced three different stages. Until August 2007, EA money markets were liquid and rates were stable. After August 2007, the US sub-prime mortgage market convolutions spilled over to the EA money markets with an increase in the spread of the Euribor versus the Euro Overnight Index Average (Eonia) rate (Fig. 9). The Lehman Brothers collapse in September 2008 brought further tensions to the EA money markets with further increases in spreads. On September 15, 2008, the Lehman Brothers investment bank filed for bankruptcy, making it the biggest bankruptcy case in US history, and becoming the most important chapter of the subprime mortgage crisis. The recession was triggered by a real state bubble and a sharp fall in housing prices. We use the Lehman episode period as our initial shock. Besides the sharp increase in spreads both in 2007 and 2008, the Lehman shock also affected cross-border banking flows (Figs. 6, 11) and investment by Portuguese firms (Fig. 10).

Although the subprime crisis had repercussions worldwide, on the impact they did not affect the Portuguese economy. There are two main reasons why the subprime crisis had a smaller impact in Portugal: (i) Over the period 1970–2014 the economy witnessed a flat path of real house prices (Lourenço and Rodrigues (2015)). (ii) Portuguese banks had scarce exposure to mortgage-backed securities (MBS) and collateralized debt obligations (CDS).

Portugal is a small and open economy where the banking sector – due to low domestic savings – relies heavily on funds raised internationally. Moreover, the high reliance of firms on credit from the banking sector is a feature of the European market shared by Portuguese non-financial companies. We use the heterogeneous exposure of Portuguese banks to the international interbank market as a source of variation to understand the effect of the Lehman default on the behavior of investment and employment. Although our focus is on supply-side explanations, we knowledge the importance of demand-side reasons for the decline of several macroeconomic variables. Section 2.4 discusses the relative significance of both sources of variation. Appendix A.2 provides a detailed description of the empirical data sources.

2.2. Empirical strategy

In this section, we describe how we identify the causal impact of the Lehman collapse on domestic macroeconomic variables. There are empirical obstacles posing a threat to the causal link between the Lehman bankruptcy and the drop in investment and employment in Portugal.[12] To tackle these issues, we perform our empirical analysis in two steps. First, we will show how the Lehman collapse caused a decline in credit supply by Portuguese banks. Our main identification strategy will rely on a given firm borrowing from two (or more) banks with different levels of exposure to global interbank markets. If a firm receives less credit from a bank more exposed to international credit markets then, *ceteris paribus*, we can conclude that an exogenous disturbance causes a fall in domestic credit supply. Specifically, we will construct a within-firm difference-in-difference model of credit. Second, we establish that a fall in credit supply led to an investment drop by Portuguese firms. To perform this last step, we use an instrumental variable approach in which we use the weighted exposure of each firm to international markets as an instrument. Therefore, our empirical model is

$$\Delta \ln(X_{f,t}) = \beta_1 + \beta_2 \Delta \ln(Credit_{f,t}) + \varepsilon_{f,t} \tag{1}$$

where $X = \{Investment, Employment\}$. The dependent variable is the change in the log of total investment by firm f at time t and the independent variable is the change in the log of overall credit supplied by the domestic banking sector to firm f during period t. The coefficient β_2 of regression (1) gives the elasticity of investment to credit supply. The following sections describe the steps needed to arrive at our main goal while addressing all identification problems recognized above.

2.3. From capital inflows to credit supply

This section is the first estimation step in our causal chain, identifying the causal relation between an exogenous disturbance and changes in domestic credit supply. We use the fall of Lehman Brothers as an exogenous shock. Our empirical design builds on a firm-bank level difference-in-difference specification comparing lending before and after the Lehman bankruptcy by exploiting the variation in bank exposure to international wholesale markets. The model is given by

$$\Delta \ln(Credit_{f,b,t}) = \alpha_f + \mu \ln(Bank\ \ Exposure_b) + \gamma_{b,t}\mathbf{X}_{b,t} + \eta_{f,b,t} \tag{2}$$

where the dependent variable is change in log of average credit from bank b to firm f at time t. Time $t = \{Pre, Post\}$ takes two periods: the period before and after November 2008 (the quarter of the Lehman

[12] See the online appendix for a detailed description of the empirical strategy.

collapse).[13] Each period corresponds to four years. The independent variable corresponds to the ratio of interbank borrowing, to total assets, by a domestic bank b from international institutions[14]. To correct for endogeneity concerns, we use information on $Bank\ Exposure$ during the Pre period.

α_f are firm fixed effects that control for all time-invariant unobserved heterogeneity at the firm level and serve as proxies for the demand for credit (Khwaja and Mian (2008)). This specification requires firms to hold credit relationships with at least two banks, which is true for 55% of firms in our dataset. γ_{bt} is a vector of coefficient on variables controlling for bank specific observable characteristics. The coefficient μ measures how changes in capital inflows through the banking channel influence credit supply by domestic banks.

$\mathbf{X}_{b,t}$ is a vector of bank observables that serve as controls. Namely, we include return on assets and return on equity, serving as a proxy for Tobin's Q. As further controls we also include capital ratio, debt-to-equity, current ratio, quick ratio and leverage ratio. Standard errors are clustered at the firm level.

The main identification assumption in our within-firm estimation of Eq. (2) is that banks and firms did not anticipate the exogenous shock and acted accordingly by changing their credit behavior. This seems an innocuous assumption as the Lehman collapse was due to financial disturbances originating in the US financial system and are unrelated to the Portuguese financial sector. To make sure our identification results hold, we use $Bank\ Exposure_b$ as the ratio of interbank deposits to total assets measured in 2004.

Results. Column (2) of Table A.3 presents our main result for this subsection. The estimation of Eq. (2) shows how, following the fall of Lehman Brothers, banks more exposed to international interbank credit markets lower credit supply more than banks relying more on funding from the domestic market. This relationship is statistically significant and shows that a one percentage point increase in the ratio of banks' foreign liabilities to total assets results in a reduction in credit supply of 0.0248 p.p.[15] A firm borrowing from two (or more) banks will see credit supply decrease by the more exposed bank *via-à-vis* remaining (less exposed) banks. Column (1) report the estimation results when we do not control for firm fixed-effects. Qualitative results using OLS are still in line with the results using the within-firm specification. Our results suggest that a country with a banking sector with more exposure to international capital flows will have a larger drop in credit supply following a negative disturbance arising in international financial markets.

2.4. From credit supply to real outcomes

Having established in the previous subsection how negative foreign financial disturbances fuel into lower credit supply, this section provides evidence of the connection between a lower credit supply and a decrease in aggregate investment and employment. The goal is to estimate Eq. (1) using the following model

$$\Delta \ln(X_{ft}) = \beta_1 + \beta_2 \Delta \ln(Credit_{ft}) \times Post_t + \varepsilon_{ft} \tag{3}$$

where $X = \{investment, employment\}$ and β_2 measures the impact of credit supply on a firm's investment (and employment) decisions.

So far we have been employing a firm-bank level estimation procedure. In contrast to the model in the previous section, the empirical model in this section is at the firm level, restricting the ability to use within-firm estimation to disentangle credit supply from credit demand. We use a 2SLS specification where in the first stage we use $Bank\ Exposure$ at the firm level as an instrument. We have defined capital flows before as the share of bank exposure (to the international interbank market) to assets. In this section, we revise the definition since we only operate at the firm level. We now define $Firm\ Exposure$ as indirect exposure of each firm f to the international wholesale market, weighted by the share of credit from each bank b. The first stage model is defined as

$$\Delta \ln(Credit_{ft}) = \alpha_f + \mu\Delta(\overline{Firm\ Exposure}_f) + \gamma_{bt}\mathbf{X}_{bt} + \overline{\eta}_{ft} \tag{4}$$

where

$$\overline{Firm\ Exposure}_f = \sum_b w_{fb}(Bank\ Exposure_b)$$

weights w_{fb} representing the share of credit from bank b to firm i in 2004.

An OLS regression of (4) would be biased since the between-firm specification cannot account for firm fixed effects coefficient α_f. We correct for the bias by substituting α_f using an estimated $\hat{\alpha_f}$ computed using Eq. (2)[16] (di Patti and Sette (2012)).

Results. Table A.4 provides estimates for Eq. (3). Following the Lehman Brothers bankruptcy firms borrowing from domestic banks more exposed to international markets experienced a larger decline in investment and employment. Column (1) shows that a one p.p. decrease in credit supply lowers investment by 0.636 p.p.s. In other words, there is a 0.636 p.p. pass-through of the credit shock into investment. Column (2) shows how a one p.p. decrease in credit supply lowers employment by 0.058 p.p. The smaller elasticity of employment to credit supply is not surprising as investment tends to be much more volatile than employment. We can conclude that a negative disturbance in international financial centers has a sizeable negative impact on domestic macroeconomic variables, namely investment, and employment.

Aggregate implications. To provide some further economic meaning to our results, we can perform a (partial equilibrium) back-of-the-envelope calculation to understand what was the aggregate impact of the banking channel as a pass-through of a global shock into the domestic economy. The average share of bank foreign liabilities over assets during the 2004 period was around 20%. For simplicity, we operate under the assumption that credit supply by banks not exposed to the international interbank market is constant (This is a conservative assumption since we could safely assume that these banks also decreased credit supplied to firms during the period of the shock.). From Table A.3 we learn that a 1 p.p. increase in the share of foreign liabilities causes a 0.636 drop in credit supply. Thus, the aggregate drop in credit supply was 0.5%. From Table A.4 we have the coefficients from the impact of a drop in credit supply on investment and employment. Therefore, we can calculate an overall decrease in investment of 0.32% due to the drop in credit supply and also an aggregate drop in employment of 0.03% due to lower credit supply. Using aggregate values for the change in average investment and employment following the fall of Lehman Brothers, we can arrive at an aggregate drop in employment of 5% and investment of 22%. We conclude that our back-of-the-envelope calculation suggests that a liquidity shock in banks' balance sheet accounts for 1.44% of the drop in investment over the pre and post period and a 0.57% share of the drop in employment.[17]

[13] We motivate our use of two periods – before and after the shock – and averaging along periods by the fact that economic variables tend to be correlated over time, leading to serially correlated errors (Bertrand et al. (2004)).

[14] These international lenders are comprised of international finance granting institutions providing deposits up to two years.

[15] Results are qualitatively in line with those of Iyer et al. (2014). The quantitative differences could be explained by the different (i) time window; (ii) shock period (iii) different estimation specification.

[16] See Bentolila et al. (2018) for an alternative strategy to deal with bias created by not including firm fixed-effects.

[17] Paravisini et al. (2015) also study the effect of a liquidity shock on real outcomes. They design a similar experiment and find that in Peru the share of missing volume of trade due to a credit shock was 16%.

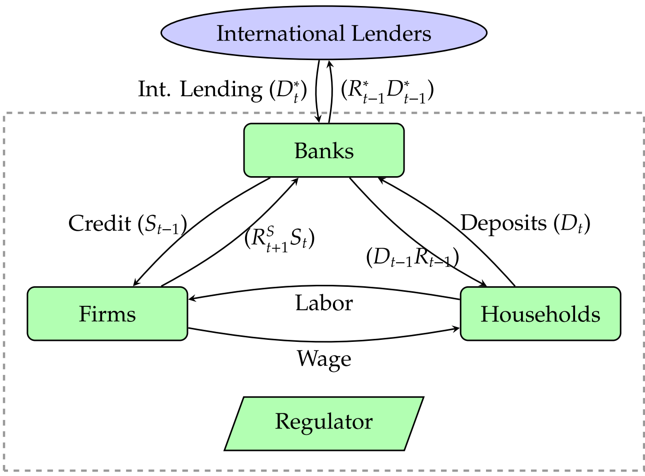

Fig. 1. Model Structure.

3. An open-economy model with a banking sector

The previous section established that international banks act as a pass-through channel of global capital inflows into the real economy. The main purpose of this section is to use a general equilibrium model to perform a series of counterfactual experiments. By design, the empirical model in the previous section cannot address all general equilibrium forces or speak to the spillover effects of exogenous disturbances to the banking sector. However, it will be key in our calibration exercise in which we use the model of Section 2.2 as an auxiliary model to pin-down key model parameters.

The economy is modeled as an open economy real business cycle (RBC) model with a banking sector as in Gertler and Karadi (2011) and Aoki et al. (2016). Time is discrete and indexed as $t = 1, 2, 3, \dots$. The economy is populated by five types of agents: Households, capital (and final) goods producers, a banking sector, international lenders, and a government agency in charge of financial sector regulation. Fig. 1 summarizes the interaction between economic agents. Household members can assume one of two tasks: bankers or workers. Workers supply their labor endowment to final output firms and place their wealth as one-period (risk-free) deposits in banks. In the canonical real business cycle model, there is no role for financial intermediation. A key feature of the European 2009 – and beyond – financial recession was a deterioration of the balance sheet of financial intermediaries. Therefore, we follow Gertler and Karadi (2011) and introduce bankers as financial intermediaries channeling household deposits to finance firms. A key feature of this class of models is the introduction of investment adjustment costs as in Bernanke et al. (1999) which allow both for a smoother path of investment decisions – as we witness in the data – and a higher amplification of real and financial variables which allow the model to better fit the data via the financial acceleration channel of Gertler and Kiyotaki (2010).[18] Furthermore, to understand the credit market freezes that happened in several countries in Southern Europe we also allow bankers to receive funds from international lenders and invest in state-contingent claims issued by non-financial intermediaries. Due to lower monitoring costs, banks intermediate the flow of funds from depositors to firms. Banks are subject to an incentive-compatible constraint that will restrict the amount of lending every period. There are two goods in the economy: a perishable consumption good and a capital good. There are three types of firms: capital goods producers, final goods producers, and non-financial intermediaries. It is a stochastic economy with three sources of uncertainty: leverage constraint shock, world interest rate shock, and capital quality shock. The next sections introduce the agents and the relevant equilibrium concept.

[18] See Section 4.2 for further explanation of the model mechanics.

3.1. Households

Households are divided into two types of members: Depositors and Bankers. Depositors have measure $(1-f)$ and bankers measure f. Each period workers supply labor, H_t, to final output firms and deposit their wealth, D_{t-1}, in banks. Π_t are profits to the household from ownership of non-financial corporations and banks. The remaining funds are consumed, C_t. The representative depositor solves the following optimization problem

$$\mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\gamma}}{1-\gamma} - \zeta_0 \frac{H_t^{1+\zeta}}{1+\zeta} \right) \right] \tag{5}$$

subject to

$$C_t + D_t = w_t H_t + \Pi_t + R_{t-1} D_{t-1} \tag{6}$$

where β is the discount factor and $\mathbb{E}_t$ is the expectation operator. R_t is the non-state contingent return on deposits and w_t the wage rate.

3.2. Producers

There are two types of goods in this economy: perishable consumption goods and durable goods. There are also three types of non-financial firms: capital good producers, final goods producers, and non-financial intermediaries. Non-financial intermediaries purchase capital goods from capital producers, store capital for one period and finally rent capital to final good producers. The timing of events is the following: at the end of period $t-1$ non-financial intermediaries issue S_{t-1} state contingent claims (bought by Banks) and use this securities to purchase from capital good producers K_{t-1} units of capital goods at price Q_{t-1}. By no-arbitrage condition, in equilibrium the price of each unit of capital equals the price of each unit of securities issued by intermediaries. That is, $Q_{t-1} K_{t-1} = Q_{t-1} S_{t-1}$. At the beginning of period t final good producers pay price Z_t for each unit of capital goods rented from non-financial intermediaries. Final good producers use capital and labor to produce final output goods. At the end of period t, final producers return $(1-\delta)K_t$ units of undepreciated capital to non-financial intermediaries that re-sell those units of capital to capital producers at price Q_t. Let Ψ_t be a capital quality shock. Therefore, the return on each unit of capital is

$$R_t^K = \left(\frac{Z_t + (1-\delta) Q_t}{Q_{t-1}} \right) \Psi_t \tag{7}$$

3.2.1. Final good producers

A set of perfect competitive final good firms combine capital and labor to produce final output goods using the following technology

$$Y_t = A_t (\Psi_t K_{t-1})^{\alpha_K} (H_t)^{1-\alpha_K} \tag{8}$$

where A_t is a technology shock and Ψ_t is a capital quality shock. Since the market structure is one of perfect competition and technology exhibits constant returns to scale, I will consider a representative final goods firm. The first order conditions with respect to capital and labor are:

$$Z_t = \alpha_K \frac{Y_t}{\Psi_t K_t} \tag{9}$$

$$W_t = (1-\alpha_K) \frac{Y_t}{H_t} \tag{10}$$

3.2.2. Capital producers

At the end of the period, capital good producers purchase economy wide stock of undepreciated capital from non-financial intermediaries at price Q_t to produce new units of capital goods. The objective is to choose an investment level, I_t, to maximize

$$\max_{I_t} \left[Q_t K_t - (1-\delta) \Psi_t Q_t K_{t-1} - I_t \right] \tag{11}$$

The law of motion for capital is

$$K_t = (1-\delta)\Psi_t K_{t-1} + \Phi\left(\frac{I_t}{\Psi_t K_{t-1}}\right)\Psi_t K_{t-1} \tag{12}$$

As in Bocola (2016), I use the following functional form for Φ: $\Phi_t(x) = a_1 x^{1-\zeta_k} + a_2$. The first order condition is

$$Q_t = \left[\frac{I_t}{\delta \Psi K_{t-1}}\right]^{\zeta} \tag{13}$$

3.3. Bankers

Bankers intermediate funds between international depositors and domestic depositors and the productive side of the economy – the firms. As discussed at the beginning of this section, the canonical real business cycle model has no role for financial intermediation. I assume that bankers are more efficient at monitoring the productive sector than households, creating a role for bankers to channel depositor's savings to fund firms' investment projects.

There is a continuum of bankers indexed by $i \in [0,1]$. Banker i starts each period with a given amount of domestic deposits, D_{it}, paying a return, R_t, and foreign deposits, D^*_{it}, paying return R^*_t. Both returns are non-state contingent. Bankers also purchase state-contingent claims, S_{it}, on firm's investment project returns, R^K_t. bankers' net worth, N_{it+1} evolves according to

$$N_{i,t+1} = R^S_{t+1} Q_t S_{i,t} - R_t D_{i,t} - R^*_t D^*_{i,t} \tag{14}$$

Bankers become involved in maturity transformation, holding long-term assets and borrowing in short-term deposits. In particular, bankers receive one-period risk-free deposits from domestic depositors and international depositors and purchase firm claims on the return of physical capital sold by non-financial intermediaries. The balance sheet of bank i is

$$Q_t S_{it} = D_{it} + N_{it} + D^*_{it} \tag{15}$$

where Q_{it} is the market price of claims.

Bankers lack full commitment to fulfilling debt obligations with both domestic and foreign creditors, raising a moral hazard problem that limits the ability of bankers from raising funds from both types depositors. In particular, at the beginning of period t bankers receive funds from domestic and foreign depositors, and bankers decide whether to divert a certain fraction of assets. If Bankers decide to default on debt obligations then they face bankruptcy and become depositors. Default happens stochastically with probability $(1-\theta)$. In such cases, bankers return their net worth to the household and exit the financial intermediation industry. For this reason, creditors impose an incentive compatibility constraint such that bankers do not have reasons to default. We thus assume bankers can divert a fraction θ^b_t of the asset's market value

$$V^b_{i,t} \geq \theta^b_t Q_t S_t \tag{16}$$

Banker's optimizing decision problem is thus

$$V^b_{j,t}(n_{j,t}) = \max_{\{S_{j,t}, D_{j,t}, D^*_{j,t}\}} \left\{ \mathbb{E}_t \Lambda_{t,t+1}\left[(1-\theta)n_{j,t+1} + \theta V^b_{j,t+1}(n_{j,t+1})\right]\right\} \tag{17}$$

subject to (14), (15), and (16).

Proposition 1. Banker's value function is linear in net worth

$$V^b_{j,t}(n_{j,t}) = \phi_{j,t} n_{j,t} \tag{18}$$

Proof. Proof: See section (B.2) of the online appendix.

Aggregation. As Proposition 1 shows, the individual banker's problem is homogeneous of degree one in banker's specific net worth and does not depend on other banker's specific variables. Each Banker makes optimizing decisions based on their own net worth position. This allows us to use a symmetric equilibrium and aggregate across banks. This feature becomes useful as we only need to keep track of banks' aggregate net worth and not the distribution of net worth across banks.

3.4. International lenders

The country is a small-open economy and the domestic interest rate depends on the world's interest rate. Following the open-economy literature, we assume

$$R_t = R^*_t + \varphi_R \log\left(\frac{D^*_t}{Y_t} - \frac{\bar{D}}{\bar{Y}}\right) \tag{19}$$

where $\bar{D}$ is the steady-state domestic debt and R^*_t is the stochastic world's interest rate, following an AR(1) process.

3.5. Market equilibrium

The capital market clearing condition equates claims on assets issued by non-financial intermediaries and the aggregate capital stock

$$S_t = K_t \tag{20}$$

The aggregate resource constraint is

$$Y_t = C_t + I_t + D^*_t - R^*_t D^*_{t-1} \tag{21}$$

The net worth of surviving bankers can be written as

$$N^S_t = \theta N_t = \theta\left[(R^K_t - R_{t-1})Q_{t-1}K_{t-1} + D^*_{t-1}\left(R_{t-1} - R^*_{t-1}\right) + R_{t-1}N_{t-1}\right] \tag{22}$$

net worth of new bankers

$$N^N_t = \iota(1-\theta)Q_{t-1}K_{t-1} \tag{23}$$

Aggregate net worth

$$N_t = N^S_t + N^N_t \tag{24}$$

$$= \theta\left[(R^K_t - R_{t-1})Q_{t-1}K_{t-1} + D^*_{t-1}\left(R_{t-1} - R^*_{t-1}\right) + R_{t-1}N_{t-1}\right] \tag{25}$$

$$+ \iota(1-\theta)Q_{t-1}K_{t-1} \tag{26}$$

3.6. Equilibrium concept

Let $\mathbb{S}_t = \{K, D^*, P, A, \Psi, R^*\}$ be the state vector. A *stationary recursive competitive equilibrium* is a set of value functions for households, V^h, and bankers, V^b, policy functions for households, $\{C, H, D\}$, and for bankers, $\{D, D^*, S\}$ such that, given value functions and policy functions both households and bankers can solve their maximization problems subject to their own constraints.

4. Quantitative analysis

This section presents the functional forms for the theoretical model and describes the calibration strategy. The model is solved using numerical methods to look for a global solution. The need for solving a non-linear version of the model follows from the fact that the occasionally binding constraints create non-differentiability in decision rules. The problem is amplified as the area in which these kinks arise is not known $a-priori$. Moreover, solving the model using local solutions would require unrealistic large shocks to produce endogenous crises. Specifically, we use projection with time iteration. A detailed explanation of the numerical solution method is provided in the online appendix.

4.1. Calibration and functional forms

The parameters of the model are calibrated. Table 1 reports these numerical values. The frequency of the model is quarterly.

Table 1
Calibrated parameter values.

Description	Parameter	Value	Target/Source
Households and Producers			
Discount factor	β	0.991	*Bank of Portugal*
Capital Share	α_K	0.263	Author's Calculation
Capital dep. rate	δ	0.027	Author's Calculation
Coef. of Relative Risk Aversion	γ	1	Standard
Persistence of TFP	ρ_z	0.95	Author's Calculation
Persistence of foreign i.r.	ρ_{fr}	0.988	Author's Calculation
s.d. of TFP innovation	σ_z	0.01	Author's Calculation
s.d. of foreign i.r. innovation	σ_{fr}	0.018	Author's Calculation
Banks			
Survival rate	θ	0.95	Bocola (2016)
Divertable share	μ	0.256	Bocola (2016)
Start-up share	ι	0.007	Bocola (2016)
International			
Debt elast. of interest rate	φ_R	0.001	

Notes: Appendix B.2 provides further details on the calibration strategy and data sources.

Table 2
Indirect inference.

	Aux. Model Δ ln Invest	Theo. Model Δ ln Invest	Aux. Model Δ ln Employ	Theo. Model Δ ln Employ
Δ ln Credit	0.636*** (0.201)	0.733	0.058*** (0.0444)	0.039
N	41,064	2000	306,271	2000
Sector FE	✓		✓	

Table 3
Internal calibration.

Description	Parameter	Target	Data	Model
Inverse Frisch elasticity	ζ	Aux. Model	0.058	0.039
Investment Adjustment costs	ζ_k	Aux. Model	0.636	0.733
Labor Disutility	ζ_0	$\frac{L}{Y}=33\%$	0.33	0.26
foreign debt/output ratio	$\bar{D}^*$	$\frac{D^*}{Y}=93\%$	93	60.9

External calibration. Some parameters are standard in the literature when calibrating the model to the U.S. economy. However, we re-computed some of these parameters given that our model needs to match the Portuguese economy. The value of the discount factor parameter can be inferred directly from the real domestic interest rate. We use data on Portuguese government bond yields for the period 2005–2015. We calibrate the foreign interest rate using the 3 months Euro Interbank Offered Rate (Euribor).[19] The parameter governing the banker's survival probability is set to 0.95 as in Bocola (2016). We use a value of 0.007 for the start-up share also following Bocola (2016).

Internal calibration. The remaining parameters are internally calibrated. The internal calibration is a mixture of simulated method of moments (SMM) and indirect inference. The parameter governing labor disutility, and the debt-to-output ratio parameter are chosen to target data moments. We use indirect inference to calibrate the Frisch elasticity parameter and the adjustment cost parameter. To that extent, we use the empirical values found in Section 2.2 to inform our calibration strategy.

We proceed as follows. The SMM estimator is

$$\widehat{b_{N,T}}(W) = \arg\min_b \left[\sum_{t=1}^{T}\left(M_T(x_t) - \frac{1}{N}\sum_{i=1}^{N} M_N(y(u_t^i,\ b))\right)\right]' W_T^{-1} \left[\sum_{t=1}^{T}\left(M_T(x_t) - \frac{1}{N}\sum_{i=1}^{N} M_N(y(u_t^s,\ b))\right)\right] \tag{27}$$

where b ia a 4×1 vector of parameters, $b=\{\zeta,\zeta_k,\zeta_0,\bar{D}^*\}$. Let $\{x_t\}_{t=1}^T$ be a sequence of observed data. Also, let $M_T(x_t)$ the moments from observed data. Also, let $\{y_n(u^s,b)\}_{n=1}^N$ be a sequence of simulated data, depending on the vector of structural shocks and coefficient values. $M_N(y(u^s,b))$ are the model moments from the simulated data. The $M_T(x_t)$ vector contains both data moments, but also the empirical coefficients from Section 2.2.

We try to match a labor-to-output ratio equal to 33%. We also target the ratio of external debt to output. The annual value for Portugal is around 100% in recent years. Since the model is at a quarter frequency, we target a value of 400% of external debt to GDP.

The remaining parameters are estimated using the method of indirect inference. Indirect inference is a method similar to simulated method of moments, but differs in the use of an *auxiliary model* that can be viewed as a reduced form of the structural model. In our case, the reduced form model of Section 2.2 can be seen as a mapping from the structural model along some dimensions. To be concrete, we proceed by estimating the coefficient of Frisch elasticity and investment adjustment costs. The reduced form model in Section 2.2 is used as an auxiliary model in which the causal impact of credit supply on employment is going to help inform estimation of the employment block of the model, whereas the effect of credit supply on investment accounts for the estimation of the investment adjustment cost parameter. That is, we regress external credit on employment (and investment) using data simulated from the model and require the regression coefficient to match the counterpart coefficient calculated in Section 2.

To be specific, we match the empirical and simulated coefficients as

$$M_T(x_t) - M_N(y_t) = \Omega_E - \Omega_S$$

where the empirical coefficient, Ω_E, is the product of the two-step causal impact of credit supply on macroeconomic variables. Therefore, we use the coefficients from Section 2.4, from which the impact of credit supply on employment is 0.058 and the effect of a drop in credit supply on investment is 0.636. The coefficients using the model simulation are computed as[20]

$$\log(X^S) = \Omega_S \log(Credit^S) \tag{28}$$

where $X^S = \{Employment, Investment\}$.

As we can see in Table 2, the model does relatively well in matching the estimation of credit on employment, as well as matching the investment regression.

Table 3 reports the calibration performance. The model finds it more difficult to match the ratio of foreign debt-to-output as in the data. This happens because the 100% debt-to-gdp ratio takes into account public debt, and the model does not contain a government sector. Moreover, the level of debt-to-gdp is hard to match even for standard models in the literature that analyze government debt problems. The standard model in this literature (Arellano (2008)) requires an unreasonable value for the discount factor and only the class of models with long-term debt (e.g. Chatterjee and Eyigungor (2012)) can reasonably match the debt-to-gdp statistics.

4.2. Foreign interest rates and the 2008 financial crises

We have documented how the banking system can serve as a pass-through of foreign shocks to the economy and an amplification mechanism of economic crises. During this period, the banking system

[19] Optimally we would use data on the specific costs of interbank loans from international banks to domestic Portuguese banks during the Euro crises. To our knowledge no sources of data are available. We thus use the best available option, the 3-months Euribor rate. As a robustness test, in Appendix B.3 we also compute GIRF's using the 6 month and 12 month rate to show that results are not affected by the choice of frequency.

[20] Notice that the structural model counterpart regression is a level regression.

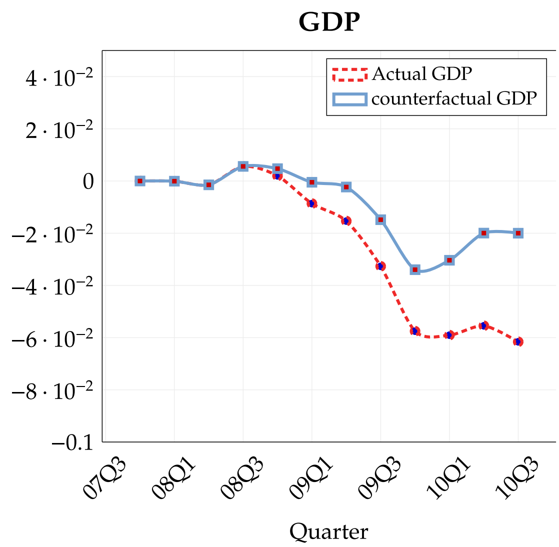

Fig. 2. Counterfactual – no foreign disturbances during the 2008 Financial Crises. Notes: Figures show the time-series for filtered GDP (in red) and counterfactual GDP (in blue). The GDP series is filtered using a particle filter. The counterfactual GDP shows the path of GDP if the level of foreign interest rate shocks kept at the 2008Q1 levels. The online appendix presents the computational algorithm to retrieve the state space. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

entered a period of stress that translated into higher interest rate spreads. In this section, we seek to understand what would be the path of domestic GDP without the negative impact of foreign interest rates. To perform this counterfactual experiment we use an (auxiliary) particle filter (Pitt and Shephard (1999)) to extract the sequence of densities for the state of the economy in each time period. This sequence provides both endogenous variables and also the sequence of exogenous shocks' densities hitting the country in each time period. To be concrete, define the non-linear state space model as

$$\mathbf{Y}_t = f(\mathbf{S}_t;\alpha) + \eta_t, \qquad \eta_t \sim N(0,\Sigma) \tag{29}$$

$$\mathbf{S}_t = g(\mathbf{S}_{t-1},\varepsilon_t;\alpha), \qquad \varepsilon \sim N(0,I) \tag{30}$$

The nonlinear state space model is defined by the above two equations: the first equation is a measurement function and the second equation is a state transition function. Let α be a vector of structural parameters, $\mathbf{S}_t = \{K_t, P_t, D_t^*, A_t, \Psi_t, R_t^*\}$ be the vector of state variables and $\mathbf{Y}_t$ the vector of observable variables. Observed variables are GDP, foreign interest rates and the time-series of foreign interbank borrowing. A detailed description of the particle filter can be found in the online appendix.

Fig. 2 shows the results of our counterfactual experiment. The red line shows the actual (filtered) drop in GDP in Portugal during the financial recession. The blue line depicts the path of GDP had foreign interest rate levels stayed at their 2007Q4 values. As we can see, foreign interest rates served as a negative shock to the domestic economy. Without foreign disturbances in the domestic banking sector, GDP would have dropped 2.5 p.p. less at the end of 2009. To provide some intuition, Appendix 12 shows the reaction of our calibrated economy to a shock to the foreign interest rate.[21] The first impact of higher Foreign interest rates is through higher domestic rates incentivizing household consumption smoothing and lower investment (intertemporal channel). The second channel works via the financial sector. Higher real rates increase banks' funding costs, negatively impacting the aggregate demand for capital and lowering asset prices. Lower asset prices decrease the bank's net worth, tightening the banker's incentive constraint. Lower net worth and tighter bank constraints lead to a further contraction in asset prices. This is the *financial accelerator effect* as in Gertler and Karadi (2011). There is also a feedback loop spillover effect from the financial sector to the real economy: lower asset prices depress investment, credit, and capital accumulation with a negative effect on GDP, which also feeds back into the financial sector via lower bank's net worth.[22]

5. Macroprudential policy during the financial crisis

In this section, we start by modifying our model in order to include macroprudential policy, in the form of time-varying bank capital requirements, in the spirit of Basel III. We then perform our main counterfactual experiment and assess the ability of macroprudential policy to mitigate the adverse impact of the 2009 financial crisis.

To perform the counterfactual experiment of computing the path of output in an economy with countercyclical capital buffers, we follow the following steps. First, we recover the path of structural shocks' densities for the model with constant capital requirements using the particle filter described above. Second, using the path of shocks, compute the filtered time-series for GDP. Third, using the same path of structural shocks, compute the path of the counterfactual GDP, but this time using the optimal decision variables of the model with countercyclical capital buffers.

5.1. Mapping basel III into our model

In Section 2, we documented the pass-through of exogenous disturbances to the domestic economy via the banking sector. One might ask what kind of policies are best suited to deal with such negative events. During financial crises, countries see their policy toolkit severely constrained. Several countries lack effective monetary policy, either because monetary policy is set abroad (as is the case of countries in the European Monetary Union) or because monetary policy is constrained at the zero lower bound. In addition, during periods of economic recession, fiscal policy is severely restrained due to tighter government budget constraints. Can macroprudential policies offer some relief in such situations to deal with exogenous disturbances? This section tackles this question by arming the domestic policy maker with a specific type of macroprudential policy, namely countercyclical capital requirements.

During economic recessions, banks' equity and asset prices decrease. To meet capital requirements, the banking system needs to cut down on credit supply, as raising equity can be costly. This drop in financial intermediation lowers investment and consumption, leading to a prolonged recession. To address the potential problems caused by pro-cyclical bank capital regulation, the Basel III accord by the Basel Committee on Banking Supervision (BCBS) suggested the use of countercyclical bank capital requirements for all its member countries. Prior to Basel III, financial institutions had to keep a constant fraction of capital as equity. This changed with Basel III, whereby the fraction of capital that banks are required to hold became time-varying and countercyclical. In terms of the model, the coefficient of the constraint on banks' activity (Eq. (16)), becomes a function both of the fixed capital requirement, θ^b, and the difference between aggregate TFP and

[21] We can think of this foreign interest rate increase as the increase in shadow rates that happened during the 2008 financial crises.

[22] Compared with other models in the literature (e.g. Aoki et al. (2016)), for tractability our model does not include nominal rigidities. Moreover, the objective of our paper is not to analyze the coordination between monetary and macroprudential policy. In any case, the presence of nominal rigidities would lead to higher real interest rates due to the increase in inflation. In any case, Aoki et al. (2016). Fig. 4 shows that both classes of models produce similar IRF. The generalized impulse response functions in 12 are of similar magnitude as in Aoki et al. (2016) or Ferrante and Gornemann (2022).

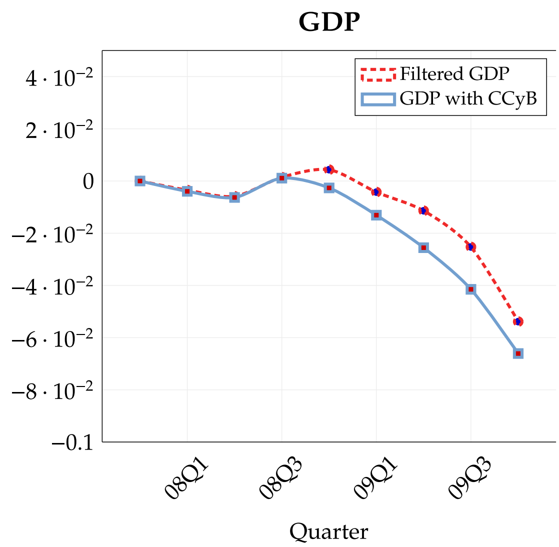

Fig. 3. Macruprudential imposed at the peak of the business cycle.
Notes: Figures show the time-series for filtered GDP (in red) and counterfactual GDP (in blue). The GDP series is filtered using a particle filter. The counterfactual GDP shows the path of GDP if the level of foreign interest rate shocks kept at the 2008Q1 levels. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

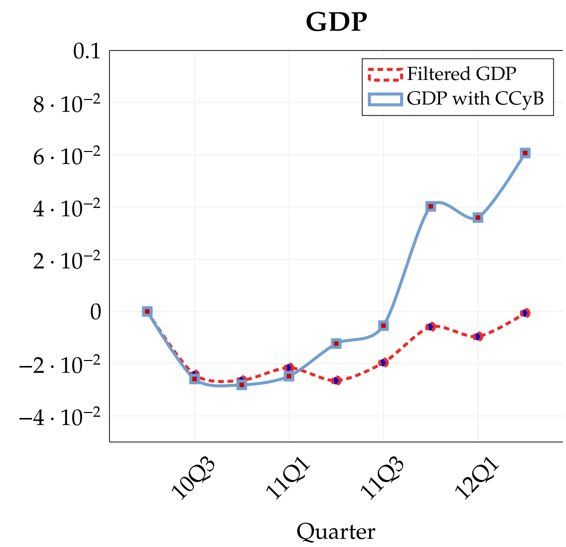

Fig. 4. Macruprudential imposed at the bottom of the business cycle.
Notes: Figures show the time-series for filtered GDP (in red) and counterfactual GDP (in blue). The GDP series is filtered using a particle filter. The counterfactual GDP shows the path of GDP if the level of foreign interest rate shocks kept at the 2008Q1 levels. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

its steady-state value. The time-varying capital requirement is therefore modeled as

$$\theta_t^{Basel\ III} = \theta^b + \rho\left(A_t - A^{SS}\right) \quad (31)$$

Parameters θ^b and ρ are calibrated as follows. The first parameter is set to 7% following the recommendations of the European systemic risk board (ESRB). This parameter value includes the capital conservation buffer (CCoB) of 2.5% on the bank's total exposures and the minimum requirement for common equity tier 1 capital of 4.5%. The CCyB parameter is harder to pin down as there are no specific recommendations and most of the literature makes *ad hoc* choices (e.g. Maria and Júlio (2019)). It is up to every national authority to set its own CCyB rates and in the European Union, these values range from 0% to 2%. We calibrate our CCyB parameter such that it equals 1% when the economy is expanding and −1% when the economy is contracting.

5.2. Macroprudential policy over the business cycle during the 2009 financial crisis

In this section we show that the effects of banks' time-varying capital requirements can imply a different behavior of aggregate output depending on the state of the business cycle. First, we show that imposing CCyB ex-ante can dampen the fall in aggregate output. Moreover, loosening CCyB requirements ex-post also brings economic benefits. Second, we show that imposing these capital requirements well before the 2009 crisis brings benefits in terms of lower volatility, but also lower overall economic activity.

In Figs. 3 and 4 we demonstrate the counterfactual path of GDP had time-varying capital requirements been in place during the financial crisis. The red line shows the actual (filtered) GDP series in Portugal during the financial crisis. The blue line depicts the path of GDP had CCyB been implemented. Until late 2009, TFP in Portugal was above the steady state level implying that, had the national regulator impose CCyB measures prior to the crises, banks would need to raise capital requirements above normal levels; Banks would not able to extend as much credit to the economy, dampening the rise in investment and aggregate output (Fig. 3). In 2010, when the economic situation in Portugal worsened and productivity was low, the buffer would be released, leading to higher credit expansion and supporting the economy in a crisis (Fig. 4). This is essentially the way in which macroprudential policy works – building up buffers in good times to be used in downturns. We observe that if such a policy had been in place, the magnitude of the drop in GDP would have been 1.2 p.p. greater in the counterfactual economy with CCyB. On the other hand, the capacity of the economy to recover from the financial recession would be significantly better if CCyB would have been in place at the end of 2008. Our results show an improvement of GDP of 6 p.p. in the counterfactual economy during 2012.

Table 4
Statistics over the business cycle (2003–2010).

	Mean	Std. Dev.
With CCyB		
GDP	0.04%	−0.22%
Investment	−5.31%	−12.12%
Labor	0.03%	−0.23%

Notes: The table reports values for variables of the model with CCyB as a percentage of the filtered values without CCyB over the period 2003–2010.

We conclude that imposing CCB would have smoothed the 2009 financial recession as output was substantially less volatile. This result is due to the nature of time-varying capital requirements as they incentivize the build-up of capital buffers during economic expansions, that can be used during times of financial distress. Also, the policy has uneven business cycle effects, creating stronger smoothing effects on the downside by diminishing the negative power of the financial accelerator channel.

So far we have shown how bank's countercyclical capital requirements can be an effective tool during periods of economic and financial distress. Next, we ask the following question: what would be the effect of imposing such measures over an entire business cycle. To do so, we perform the following experiment. We allow the national regulator in our model to implement the CCyB tool since 2003 and report the time series statistics in Table 4.

Table 4 reports the mean and standard deviation of GDP, investment, and labor from our model in which the regulator imposes CCyB since 2003 and compares it to our model with constant capital requirements. Variables from the model with CCyB are less volatile and investment is the variable with a higher drop in volatility consistent with business cycle facts. Interestingly, in a model with CCyB average GDP is slightly higher (0.04%). Although the difference is not significant, it is consistent with the above figures and may be explained due to the fact that during a boom period GDP is not remarkably different from a world with constant capital requirements, but in a recession, the buffer released by the banking sector is key to dampen the fall in GDP. Investment is also lower with CCyB which is consistent with the fact that during a crisis investment is kept to a minimum and without CCyB is allowed to jump higher during a boom period. Finally, CCyB also allows labor the be less volatile and slightly higher.

It is also important to address the European Central Bank (ECB) interventions during this period. The financial problems in the Eurozone can be divided into two consecutive crises: in 2009 due to the Lehman collapse and in 2012 and beyond with the Eurozone debt crises. The ECB responded in May 2010 with open market operations buying government and private debt securities and in December 2011 started implementing longer-term refinancing operations (LTRO) with the goal of loosening funding pressures on the banking sector of distressed economies. Although the analysis in this paper pertains mostly to the Lehman-brothers' spillovers to the European economy and subsequent bank freezes of 2009, it is also important to mention the potential effects of these ECB policies on the above results. The open market operations carried by the ECB would have helped relax bank liquidity constraints and stimulate lending. However, although these policies might improve bank's balance sheet, it is also important to mention that both the theoretical literature (Bocola (2016)), as well as empirical studies (e.g. Acharya et al. (2019)), find a reduced impact of these policies on real economic activity mostly due both to credit misallocation and lack of bank lending to the productive sector of the economy.

Finally, it is important to mention that this analysis fits the 2009–2012 period that features the precarious bank sector's balance sheet. Since then, several measures have been put in place, and the banking sector has been improving its capital requirements situation. Our model can also account for this feature due to the occasionally binding property of Eq. (16). In periods of lower financial stress, the constraint does not bind and the model produces less volatility of financial and real economic variables.

6. Growth at risk (GAR) and macroprudential policy

Besides studying the impact of our macroprudential tool on the path of GDP, we also analyze the effectiveness of the policy in mitigating tail risk. The high inflow of capital in the years prior to the 2008 financial crisis fueled credit and GDP. However, this higher level of economic activity might hide the build up of economic vulnerabilities,due to the increase in asset prices, higher lending capacity and risk appetite of financial intermediaries. These vulnerabilities might not seem obvious when one looks at the first moment of the distribution of GDP because they mainly increase the probability of future recessions (tail risk). In this section we study the impact of such vulnerabilities by looking at the entire distribution of GDP, a concept the literature has labeled as "GDP at Risk" or "Growth at risk" (GAR). An emerging strand of literature aims to quantify how easy current financial conditions could lead to worse realizations of GDP in the medium term (Aikman et al. (2021), Adrian et al. (2019), Aikman et al. (2019)). We use our model to show how capital flows could lead to a fatter left tail of the GDP distribution and how macroprudential policy could help mitigate that.

We perform an exercise to compare a world with constant bank capital requirements and one with an operational CCyB. Note that this is different from the alternative exercise of imposing CCyB in an economy with constant capital requirements. This later exercise would be problematic due to the Lucas critique, where agents would need to re-optimize given the new environment and policy change. In both cases, we start in a recession (in which the productivity shock is 1 p.p. below the steady state level) and simulate the path of GDP in 3–5 years time, the typical policy horizon for most central banks. As an average, we plot the GDP distribution after 4 years. The blue distribution is the economy with constant capital requirements, while the orange represents the economy with CCyB. In the presence of countercyclical capital requirements, banks accumulate capital during the boom phase of the business cycle and are able to release it in a recession. This is precisely what we see in Fig. 5, where the lower deleveraging pressures lead to a quicker recovery than in a world with fixed capital requirements, which tend to be procyclical. Procyclical requirements could amplify the shock and lead to more frequent tail events. This is averted by the presence of a CCyB in the model.

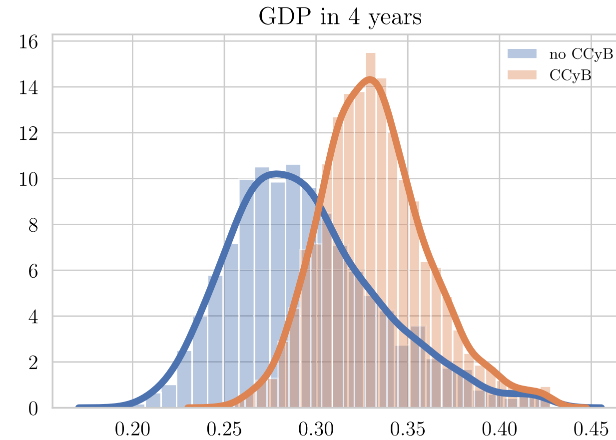

Fig. 5. GAR during the financial crises.
Notes: Figure show the histograms of the model simulations with CCyB (red) and constant capital requirements (blue). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

7. Conclusion

This paper started by showing empirically how the banking sector acts as a crucial pass-through of foreign disturbances to the real economy. We have shown how the 2008 US financial crisis induced Portuguese firms to reduce investment and employment. A partial equilibrium analysis shows that during the 2004–2012 period, the liquidity shock to banks' balance sheets brought by the Lehman fall accounts for 1.44% of the aggregate drop in investment and 0.58% of the drop in aggregate employment.

We then build a structural model to quantify the effect of countercyclical bank capital buffers (CCB) to mitigate these negative foreign disturbances to the domestic economy. Our main policy experiment studies the introduction of time-varying and counter-cyclical macroprudential policy in the spirit of Basel III. By engineering a counterfactual experiment, we show that had Basel III been implemented well before the 2008 financial crisis, the Portuguese economic crisis would have been less pronounced, with a 6 p.p. GDP increase at the end of 2012 compared with the alternative economy without CCyB. This is due to a smaller drop in credit to the economy and less outflow of capital. Most importantly, we find out that the effectiveness of CCyB policies is dependent on the state of the business cycle. If CCyB was imposed during a boom period, then CCyB would have had a negative impact in the economy. Lastly, CCyB regulation has the added effect of mitigating tail risk. We find that such policies reduce kurtosis vis-a-vis economies with constant capital requirements.

These results contribute to the important policy debate over alternative responses to the financial crisis, as they can inform policy-makers of the benefits of macroprudential policies and crucially when to apply

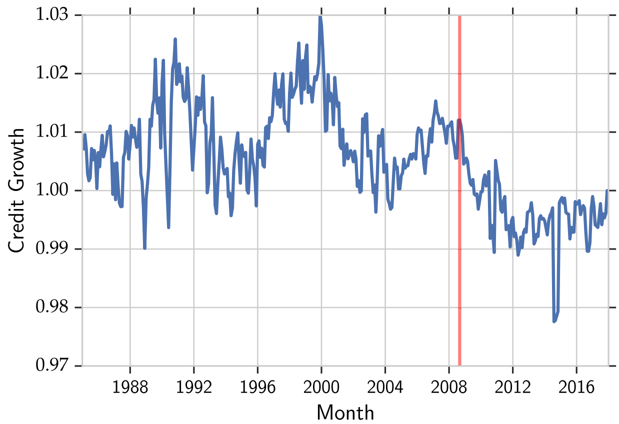

Fig. 6. Credit Growth.
Notes: The figure reports loan growth from credit granting institutions to non-financial corporations in Portugal during 1985–2018. *The time-series was transformed using a moving-average. The frequency is monthly. The source is the Bank of Portugal BPStat database. The time series name is Síntese monetária - Crédito interno a SNF.*

Table A.1
Descriptive statistics (banking sector).

	Low exposure	Medium exposure	High exposure	Total
Liquidity	.0073998	.0066075	0.0000	.0066075
	(.0116039)	(.0036116)	(.0018987)	(.0053756)
Capital ratio	.0737619	.0737163	.0515464	.0737163
	(.0403506)	(.0234647)	(.0565912)	(.0294246)
NPL	0	0	0	0
	(105587.7)	(127884.9)	(63303.35)	(122412.7)
Bank size	7.954021	10.92694	6.526495	10.62459
	(1.377844)	(1.14072)	(1.276441)	(1.545534)
Observations				80

Notes: The table reports mean coefficients and standard deviation in parentheses. The period is 2007:Q1. The variables were constructed as follows. *Liquidity* is the ratio of cash-on-hand to assets. *Capital ratio* represents the ratio of Bank capital to total assets. *non-performing loans* (NPL) is the share of loans in default over assets. *Bank size* is the log of Bank total assets and *overdue* is the ratio of loans in default over.

such policy instruments. As a caveat, this class of policies may impose unintended consequences. CCyB has the marginal benefit of reducing the probability and severity of a financial crisis but may lower long-term economic growth. We have provided results in which capital macroprudential tools play an important role in improving financial sector resilience and smoothing the credit cycle. However, these policies can also have operationalization costs that affect their efficiency in terms of negative repercussions for other policy areas (Committee on the Global Financial System (CGFS) (2012)). Moreover, national regulators have discretionary power on the magnitude and timing of imposing this class of policies, which brings the classical trade-off of rules versus discretion. All of these are examples of fruitful avenues for future research.

Appendix A. Empirical appendix

A.1. Figures

See Figs. 6–11.

A.2. Data

In this section we describe the data sources – and dataset construction – used to provide a causal link between credit supply by Portuguese banks and changes in investment and employment decisions by Portuguese firms. We build a comprehensive data set combining information from three administrative data sources: we match credit register data with bank's balance sheet data and firm's economic and balance sheet variables. The source of data is the Bank of Portugal which – being the supervisor and regulator of the Portuguese banking sector – holds confidential data on virtually all credit-market transactions made in the Portuguese territory.

The first dataset contains information on credit extended by Portuguese credit-granting institutions to households and non-financial corporations and is called "Central Credit Responsibility Database" (*central de responsabilidades de crédito*) (CCR onwards). The CCR is a confidential and very comprehensive dataset holding reports on all credit supplied by institutions operating in the Portuguese territory.[23] While most European central banks hold records of loans granted domestically, the Portuguese CCR holds special relevance since it is one of the most comprehensive country-wide CCR data sets, reporting all credit with a minimum loan registration of 50 euros.[24] For this project we focus only on credit granted to non-financial corporations and exclude credit to individuals. The frequency of the data is monthly.

The second dataset provides information on bank's balance sheet (BBS) and is extracted from the Monetary Financial Institutions Balance Sheet (*Balanço das Instituições Monetárias e Financeiras*). This data set is compiled by the central bank of Portugal, reporting detailed information on the assets and liabilities of the monetary financial institutions (MFIs) operating in Portugal. The original data in on at monthly frequency spanning 1997–2017.

The third source is a dataset on firm's financial and economic variables. The Central Balance Sheet Database (CBSD) (*central de balanços*) is a confidential data and is property of the central bank of Portugal, reporting accounting information spanning almost all firms operating in Portuguese territory. It provides very extensive information on employment, balance sheet and other economic variables. The frequency of the data is annual.

Our final dataset combines all three sources of information, encompassing 56 credit-granting institutions, more than 300.000 non-financial corporations and around 5 Million recorded loans.

Table A.2 provides an overview on the characteristics of non-financial corporations present in our dataset. The first three columns report firm characteristics based on the level of exposure of banks – to international wholesale markets – that lend those firms. The last column reports values for the whole sample. Table A.1 describes the situation of the banking sector along the most pertinent dimensions. The first three columns report bank descriptive statistics based on the level of exposure to international wholesale markets. The main take-away is that both groups of banks do not differ considerably along the reported dimensions.

A.3. Descriptive statistics

See Table A.1.

A.4. Empirical results

See Table A.2.

[23] The following is a list of entities included in CCR: banks, saving banks, mutual agricultural credit banks, financial credit institutions, leasing companies, factoring companies, securitization companies, mutual guarantee societies, and financial companies for credit acquisitions.

[24] Since 2008 the Portuguese CCR reports all loans made by Portuguese banks to Portuguese non-financial institutions with a value higher than 50 euros. Before 2008 the minimum threshold was even lower—all loans above 10 euros were reported. Reporting threshold for the Spanish credit register is 6000 EUR

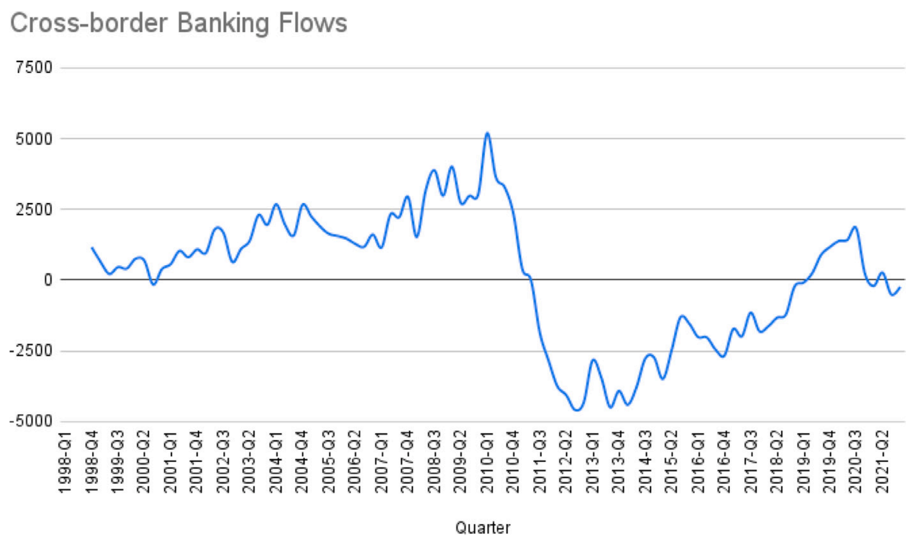

Fig. 7. Credit Growth.
Notes: The figure reports cross-border flows of funds between international and domestic Portuguese banks during 1998–2021. *The time-series was transformed using a moving-average. The frequency is quarterly. The source is the Bank of international settlements (BIS).*

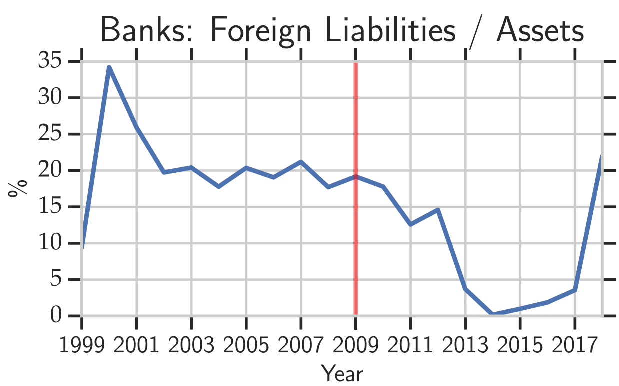

Fig. 8. Exposure of Banks to International Inter-bank Borrowing Market.
Notes: The figure reports the exposure of domestic banks to the international interbank loan market. The time-series is constructed as the ratio of short-term deposits and securities of international credit-granting institutions to domestic banks over total assets. The frequency is yearly. The source is the Bank of Portugal BPlim database.

Table A.2
Descriptive statistics (firms).

	Low exposure	Medium exposure	High exposure	Total
ROA	.02654	.02914	.03051	.02886
ROE	.07462	.05701	.07797	.06935
Liabilities	159057	321610.3	165195.2	198384.5
ln(Assets)	12.259	12.954	12.288	12.474
Capital ratio	.19808	.203105	.20268	.20158
Debt-to-Equity	.697945	.73667	.67333	.702205
Current ratio	1.1856	1.19552	1.17197	1.18366
Leverage ratio	3.533495	3.85705	3.59383	3.664735
Observations				381,280

Notes: The table reports median coefficients and standard deviation in parentheses. The period is 2007:Q1. The variables were constructed as follows. *Return on assets* (ROA) represents the ratio of cash flow on assets. *Return on assets* (ROA) represents the ratio of cash flow on equity. *Cap Ratio* is the share of capital on total assess. The *current ratio* measures the firm's ability to pay short-term obligations and the *quick ratio* is a similar measure which evaluates the firm's capacity to pay current liabilities using just cash or cash-like assets. *Leverage ratio* is total debt over equity.

Table A.3
Global financial flows and credit supply.

	(1) Δln(credit)	(2) Δln(credit)
ln(Bank exposure)	−0.0168***	−0.0248***
	(0.00129)	(0.00331)
Bank size	0.0924***	0.106***
	(0.00164)	(0.00410)
Capital ratio	0.245***	0.335**
	(0.0581)	(0.141)
Liquidity ratio	9.707***	13.76***
	(0.545)	(1.311)
N	358,399	358,399
r2	0.00875	0.678
FE		✓

Notes: The table shows results for the estimation of Eq. (2). "Bank Exposure" is the share of bank liabilities from international credit institutions. "Bank size" is the logarithm of bank assets. "Capital ratio" is the share of capital on total bank assets. "Liquidity ratio" is the share of cash on total bank assets. Standard errors in parentheses. Standard errors are clustered at the firm level. *, **, and *** indicate significance at the $0.1, 0.05$ and 0.01 level.

Appendix B. Computational appendix

B.1. Data sources

Domestic interest rate. Domestic interest rate is calculated using the cost of credit to households on housing and consumption (TAEG). The data source is the Bank of Portugal BPStat dataset. It was calculated as the weighted interest on both housing and consumption

$$R_t^{Data} = \gamma TAEG_t^H + (1-\gamma) TAEG_t^C$$

where γ is the ratio of housing credit over total credit. The data was collected as annualized net interest rate. I proceed by converted in into real quarterly gross interest rate using the following formula

$$R_t = \left(1 + \frac{R_t^{Data}}{100}\right)^{\frac{1}{4}}$$

The data source for the consumer price index (CPI) is the Bank of Portugal BPStart database. The data length is 2003:Q1-2015:Q4. Finally, the domestic interest rate is computed in real terms using the CPI.

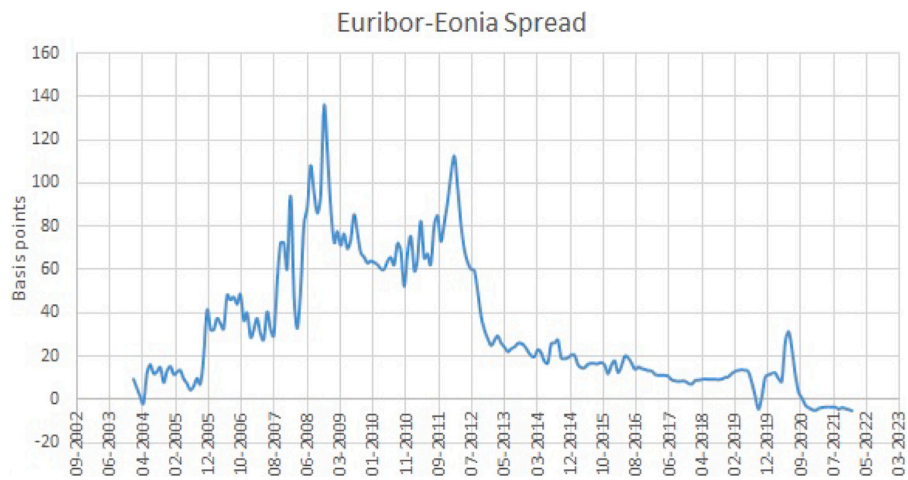

Fig. 9. Euribor (6 m)-Eonia Spread.
Notes: The figure reports the spread between the 6 months Euribor rate versus the Eonia rate. The source is the ECB Statistical Data Warehouse.

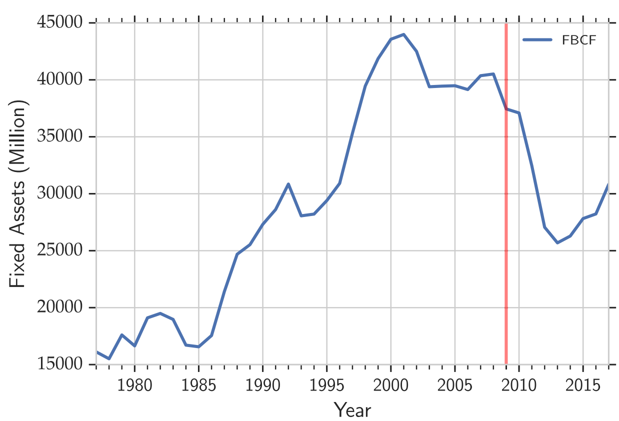

Fig. 10. Gross Fixed Capital Formation.
Notes: The figure reports gross fixed capital formation in Portugal during 1977–2017. *The series was transformed into constant prices using a deflator with base in* 2011. *The frequency is yearly. The source is the Bank of Portugal BPStat database.*

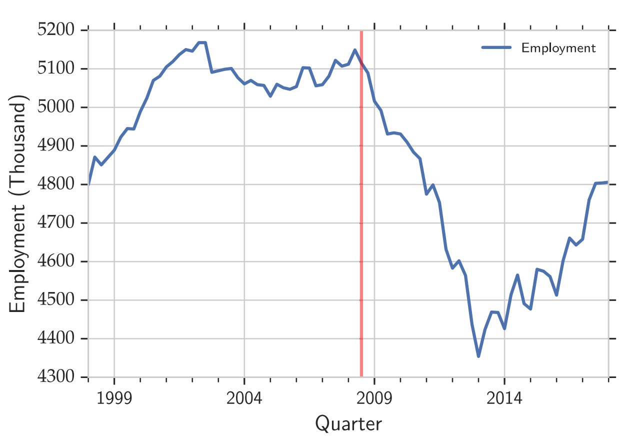

Fig. 11. Employment.
Notes: The figure reports Employment in Portugal during 1998–2018. *The frequency is quarterly. The source is the Instituto Nacional de Estatística and was accessed using the Bank of Portugal BPStat database.*

Foreign interest rate. We are not aware of good sources of data on the cost of interbank loans from international banks to domestic Portuguese banks. It is although possible to gather data on interest rates paid on deposits made by foreign NFI and households on domestic banks and these are highly correlated with the Euro Interbank Offered Rate (EURIBOR). Thus, we use foreign interest rate as 3 months EURIBOR. The data length and frequency is 2003:Q1-2015:Q4. EURIBOR was transformed into quarterly gross interest rate using the above formula. Finally, EURIBOR is expressed in real terms using Euro-area CPI. The data source for the consumer price index (CPI) is the Bank of Portugal BPStart database (the same data series as in EuroStat).

Table A.4
Transmission of global financial flows to the macroeconomy.

	(1) Δln(Investment)	(2) Δln(Employment)
Δ ln Credit	.6364967***	.0584723***
	(.1630172)	(.0189564)
ROA	.2910055***	.1841587***
	(.0896491)	(.0074306)
ROE	.0098356	.0019306***
	(.0068414)	(.0005679)
Cap ratio	.4117056***	−.0599638***
	(.0830616)	(.0086001)
Debt-to-Equity	−.0159378**	.0032409***
	(.0071604)	(.0006166)
Current ratio	−.0021031	−.0020925***
	(.0034082)	(.0002817)
Quick ratio	.0021737	.0010285***
	(.0043122)	(.0003531)
Leverage ratio	−.0004584	−.0006003***
	(.0015131)	(.0001634)
N	109,164	190,015
r2	0.0016	0.0234
Sector FE	✓	✓

Notes: The table shows results for the estimation of Eq. (3). "Capital Inflows" is the share of bank liabilities from international credit institutions. The variables were constructed as follows. *Return on assets* (ROA) represents the ratio of cash flow on assets. *Return on assets* (ROA) represents the ratio of cash flow on equity. *Cap Ratio* is the share of capital on total assess. The *current ratio* measures the firm's ability to pay short-term obligations and the *quick ratio* is a similar measure which evaluates the firm's capacity to pay current liabilities using just cash or cash-like assets. *Leverage ratio* is total debt over equity. Standard errors are clustered at the firm level. *, **, and *** indicate significance at the 0.1, 0.05 and 0.01 level.

Gross domestic product. The data source for quarterly gross domestic product (GDP) at constant prices is the IMF database. I transform into real per capita GDP using total population collected from the Bank of Portugal BPStat database. I extract the cyclical component using an HP filter with 1600 penalty (the standard value for quarterly data).

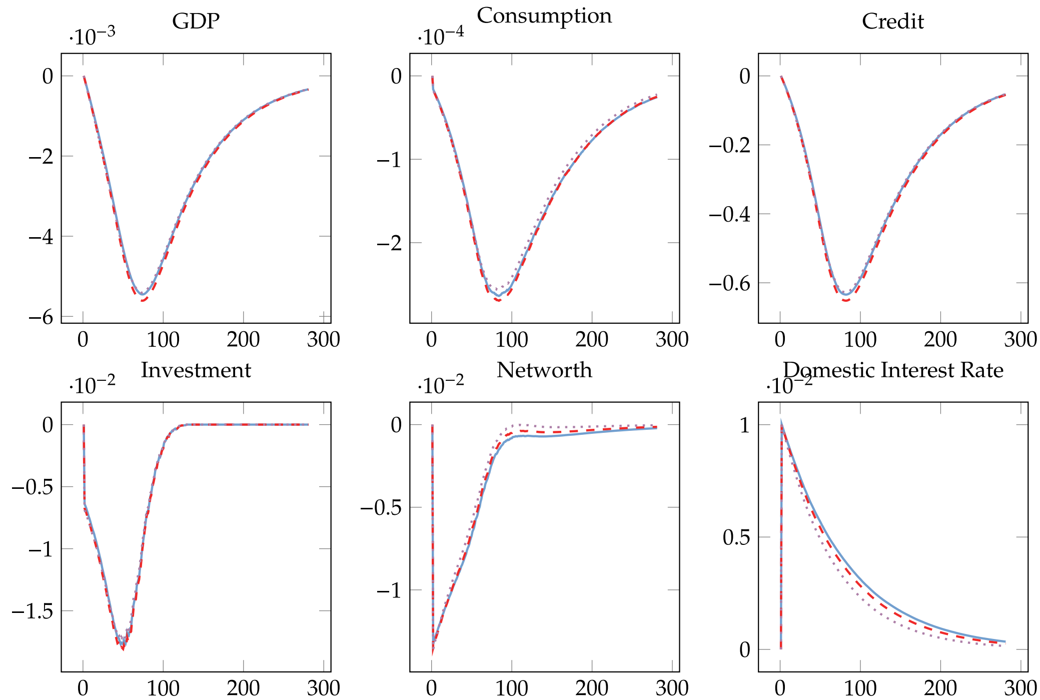

Fig. 12. Foreign i.r. shock and Model dynamics.
Notes: Graphs plot the generalized impulse response functions for a positive 1% shock to the foreign interest rate. In solid blue is the GIRF with Euribor at 3 m*, in dashed red is the GIRF with Euribor at* 6 m*, and in dotted plum is the GIRF with Euribor at* 12 m*. Variables are reported as percentage deviations from the stochastic steady state, computed by model simulation initialized at the mean of the ergodic distribution. The online appendix presents the computational algorithm to compute the generalized impulse response functions.*

B.2. Calibration

Share of labor income. Share of labor income is calculated as the ratio of labor income to total income

$$(1-\alpha) = \frac{CE}{GDP - HHGPS + CFC - T}$$

where CE is compensation of employees, GDP is gross domestic product (expenditure), CFC is household consumption of fixed capital and T is taxes net of transfers. Variables are computed as their average over 1980–2015. The data sources is the *OECD annual national accounting*.

Depreciation rate. The depreciation rate is computed using the perpetual inventory method. Data on Investment and GDP and consumption of fixed capital comes from the *OECD annual national accounting*.

Total factor productivity. Total factor productivity (TFP) is computed using the Solow residual method. The capital stock is computed using the perpetual inventory method. After linear de-trending the TFP sequence, I proceed by estimating an AR(1) process of the residual to compute the auto-correlation and standard deviation of the TFP process. Data on working population is from the *AMECO database*.

B.3. Generalized impulse response functions

See Fig. 12.

Appendix C. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.jfs.2023.101137.

References

Acharya, Viral V, Eisert, Tim, Eufinger, Christian, Hirsch, Christian, 2019. Whatever it takes: The real effects of unconventional monetary policy. Rev. Financ. Stud. 32 (9), 3366–3411.

Adrian, Tobias, Boyarchenko, Nina, Giannone, Domenico, 2019. Vulnerable growth. Amer. Econ. Rev. 109 (4), 1263–1289.

Aikman, David, Bluwstein, Kristina, Karmakar, Sudipto, 2021. A tail of three occasionally-binding constraints: a modelling approach to GDP-at-risk. In: Bank of England Staff Working Paper, No. 931.

Aikman, David, Bridges, Jonathan, Sinem, Hacioglu Hoke, O'Neill, Cian, Raja, Akash, 2019. Credit, capital and crises: a GDP-at-risk approach. In: Bank of England Staff Working Paper, No. 824.

Akinci, Ozge, Queralto, Albert, 2017. Credit Spreads, Financial Crises, and Macroprudential Policy. Federal Reserve Bank of New York Staff Reports, No. 802.

Aoki, Kosuke, Benigno, Gianluca, Kiyotaki, Nobuhiro, 2016. Monetary and Financial Policies in Emerging Markets. London School of Economics. [652], unpublished paper.

Arellano, C., 2008. Default risk and income fluctuations in emerging economies. Am. Econ. Rev. 98, 690–712.

Arellano, Cristina, Bai, Yan, Kehoe, Patrick J., 2019. Financial frictions and fluctuations in volatility. J. Polit. Econ. 127 (5), 2049–2103.

Bentolila, Samuel, Jansen, Marcel, Jiménez, Gabriel, 2018. When credit dries up: Job losses in the great recession. J. Eur. Econom. Assoc. 16 (3), 650–695.

Beraja, Martin, Hurst, Erik, Ospina, Juan, 2019. The aggregate implications of regional business cycles. Econometrica 87 (6), 1789–1833.

Bernanke, Ben, Gertler, Mark, Gilchrist, Simon, 1999. The financial accelerator in a quantitative business cycle framework. The Handbook of Macroeconomics.

Bertrand, Marianne, Duflo, Esther, Mullainathan, Sendhil, 2004. How much should we trust differences-in-differences estimates? Q. J. Econ. 119 (1), 249–275.

Blanchard, Olivier, Dell'Ariccia, Giovanni, Mauro, Paolo, 2010. Rethinking macroeconomic policy. J. Money Credit Bank. 42 (s1), 199–215.

Bocola, Luigi, 2016. The pass-through of sovereign risk. J. Polit. Econ. 124 (4), 879–926.

Brunnermeier, Markus K., Sannikov, Yuliy, 2014. A macroeconomic model with a financial sector. Amer. Econ. Rev. 104 (2), 379–421.

Buera, Francisco, Karmakar, Sudipto, 2021. Real effects of financial distress: The role of heterogeneity. Econ. J. 132 (644), 1309–1348.

Cetorelli, N., Goldberg, L., 2011. Global banks and international shock transmission: Evidence from the crisis. IMF Econ. Rev. 59 (1), 41–76.

Cetorelli, N., Goldberg, L., 2012. Liquidity management of U.S. global banks: Internal capital markets in the great recession. J. Int. Econ. (88), 299–311.

Chatterjee, Satyajit, Eyigungor, Burcu, 2012. Maturity, indebtedness, and default risk. Amer. Econ. Rev. 102 (6), 2674–2699.

Chodorow-Reich, Gabriel, 2014. The employment effects of credit market disruptions: Firm-level evidence from the 2008-09 financial crisis. Q. J. Econ. 129 (1).

Cingano, Federico, Manaresi, Francesco, Sette, Enrico, 2016. Does credit crunch investment down? New evidence on the real effects of the bank-lending channel. Rev. Financ. Stud. 29 (10), 2737–2773.

Committee on the Global Financial System (CGFS), 2012. Operationalising the Selection and Application of Macroprudential Instruments. CGFS Papers No. 48, Committee on the Global Financial System Basel.

den Heuvel, Skander J. Van, 2008. The welfare cost of bank capital requirements. J. Monetary Econ. 55 (2), 298–320.

di Patti, Emilia Bonaccorsi, Sette, Enrico, 2012. Bank Balance Sheets and the Transmission of Financial Shocks to Borrowers: Evidence from the 2007–2008 Crisis, No. 848. Economic Working Papers, Bank of Italy.

Ferrante, Francesco, Gornemann, Nils, 2022. Devaluations, deposit dollarization, and household heterogeneity. In: International Finance Discussion Paper, No. 1336.

Financial Stability Board-bank for International Settlements-International Monetary Fund, 2016. Elements of effective macroprudential policies, lessons from international experience.

Gertler, Mark, Karadi, Peter, 2011. A model of unconventional monetary policy. J. Monetary Econ. 58 (1), 17–34.

Gertler, Mark, Kiyotaki, Nobuhiro, 2010. Financial intermediation and credit policy in business cycle analysis. In: Handbook of Monetary Economics, No. 3. pp. 547–599.

Giroud, Xavier, Mueller, Holger, 2017. Firm leverage, consumer demand, and employment losses during the great recession. Q. J. Econ. 132 (1), 271–316.

Gopinath, Gita, Kalemli-Özcan, Şebnem, Karabarbounis, Loukas, Villegas-Sanchez, Carolina, 2017. Capital allocation and productivity in south Europe*. Q. J. Econ. 132 (4), 1915–1967.

Haas, Ralph, Lelyveld, Iman, 2014. Multinational banks and the global financial crisis: Weathering the perfect storm? J. Money Credit Bank. 46 (s1), 333–364.

Haas, Ralph De, Van Horen, Neeltje, 2013. Running for the exit? International bank lending during a financial crisis. Rev. Financ. Stud. 26 (1), 244–285.

Iyer, Rajkamal, Peydró, José-Luis, da Rocha-Lopes, Samuel, Schoar, Antoinette, 2014. Interbank liquidity crunch and the firm credit crunch: Evidence from the 2007–2009 crisis. Rev. Financ. Stud. 27 (1), 347–372.

Jiménez, Gabriel, Ongena, Steven, Peydró, José-Luis, Saurina, Jesús, 2017. Macroprudential policy, countercyclical bank capital buffers, and credit supply: Evidence from the Spanish dynamic provisioning experiments. J. Polit. Econ. 125 (6), 2126–2177.

Kalemli-Ozcan, Sebnem, Papaioannou, Elias, Perri, Fabrizio, 2013. Global banks and crisis transmission. J. Int. Econ. 89 (2), 495–510.

Karmakar, Sudipto, 2016. Macroprudential regulation and macroeconomic activity. J. Financ. Stab. 25, 166–178.

Khwaja, Asim Ijaz, Mian, Atif, 2008. Tracing the impact of bank liquidity shocks: Evidence from an emerging market. Amer. Econ. Rev. 98 (4), 1413–1442.

Kiyotaki, Nobuhiro, Moore, John, 1997. Credit cycles. J. Polit. Econ. 105 (2), 211–248.

Lourenço, R., Rodrigues, P. M., 2015. House prices: bubbles, exuberance or something else? evidence from euro area countries.. In: Bank of Portugal Working Paper.

Maria, José R., Júlio, Paulo, 2019. The countercyclical capital buffer: A DSGE approach. In: Economic Bulletin and Financial Stability Report Articles and Banco de Portugal Economic Studies.

Nakamura, Emi, Steinsson, Jón, 2014. Fiscal stimulus in a monetary union: Evidence from US regions. Amer. Econ. Rev. 104 (3), 753–792.

Nakamura, Emi, Steinsson, Jón, 2018. Identification in macroeconomics. J. Econ. Perspect. 32 (3), 59–86.

Paravisini, Daniel, Rappoport, Veronica, Schnabl, Philipp, Wolfenzon, Daniel, 2015. Dissecting the effect of credit supply on trade: Evidence from matched credit-export data. Rev. Econom. Stud. 82 (1), 333–359.

Peek, Joe, Rosengren, Eric, 1997. The international transmission of financial shocks: The case of Japan. Am. Econ. Rev. 87 (4), 495–505.

Peek, Joe, Rosengren, Eric, 2000. Collateral damage: Effects of the Japanese bank crisis on real activity in the United States. Am. Econ. Rev. 90 (1), 30–45.

Pitt, Michael K., Shephard, Neil, 1999. Filtering via simulation: Auxiliary particle filters. J. Amer. Statist. Assoc. 94 (446), 590–599.

Repullo, Rafael, Suarez, Javier, 2013. The procyclical effects of bank capital regulation. Rev. Financ. Stud. 26 (2), 452–490.

Rey, Helene, 2013. Dilemma not trilemma: The global financial cycle and monetary policy independence. In: Federal Reserve Bank of Kansas City Economic Policy Symposium.

Rose, Andrew, Spiegel, Mark, 2010. Cross-country causes and consequences of the 2008 crisis: International linkages and American exposure. Pac. Econ. Rev. 15 (3), 340–363.

Rose, Andrew, Spiegel, Mark, 2011. Cross-country causes and consequences of the crisis: An update. Eur. Econ. Rev. 55 (3), 309–324.