Small Firms and Domestic Bank Dependence in Europe's Great Recession*

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Abstract

After the inception of the euro, the real economy in most member countries remained dependent on credit by domestic banks, which increasingly funded themselves through cross-border interbank funding. We find that this pattern of 'double-decker' banking integration exposed domestic banks to sharp declines in cross-border interbank lending during the eurozone crisis. As a result, domestic banks reduced lending, which led to large declines in output in sectors with many small (bank-dependent) firms. We propose a quantitative small open economy model to account for these patterns and conclude that a global banking shock leading to a sudden stop in cross-border interbank lending in the eurozone is required to account for them.

Keywords: small and medium enterprises, sme access to finance, banking integration, domestic bank dependence, interbank dependence, international transmission, eurozone crisis
JEL-Codes: F30, F36, F40, F45

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1 Introduction

From the inception of the euro until 2008, cross-border lending to banks in the eurozone increased considerably, while cross-border lending to the non-bank sector hardly increased. Thus, the real economy in most member countries remained dependent on the provision of credit by domestic banks, which in turn funded themselves through cross-border interbank borrowing. This pattern of 'domestic bank dependence' coupled with a dependence of domestic banks on interbank funding ('interbank dependence')—termed 'double-decker' banking integration by Bruno and Shin (2015)—left economies and sectors that were reliant on domestic banks for finance exposed during the the eurozone crisis when cross-border interbank lending declined sharply, while cross-border bank lending to the real sector remained relatively stable. We provide empirical evidence consistent with this mechanism and propose a model which explains how the global retrenchment in cross-border interbank flows disproportionately affects countries with a high share of domestic banks and sectors with many small and medium-sized enterprises (SMEs). The predictions of the model qualitatively and quantitatively match the empirical patterns, while reasonable alternative scenarios cannot by themselves replicate these empirical patterns.

Sectors and countries with many SMEs are particularly dependent on domestic banks for the provision of credit, because SMEs are too small and opaque to borrow from banks in other countries or from the bond market. Domestic banks have better information about local small firms and often engage in long-term relationships with their borrowers, which allows SMEs to satisfy their demand for funds that are not easily available to them from large foreign banks that mainly lend at arms-length. However, domestic bank dependence makes small firms vulnerable to shocks that affect the domestic banking sector because they can only imperfectly substitute other sources of credit for domestic bank loans.

Consistent with this firm-borrowing channel, we document the following main empirical facts. First, using bank-level data for eleven eurozone countries, we show that domestic banks that were relatively more reliant on interbank funding reduced their lending relatively more in response to the euro area-wide decline in interbank lending. Second, using the granular responses of domestic banks to shocks in interbank markets, we construct an instrument for domestic lending supply to show that output in SME-intensive sectors declined more as a result of such shocks.

In order to provide a fully articulated interpretation of our findings, we build a dynamic stochastic general equilibrium (DSGE) model. The model allows for foreign ('global') and domestic ('local') banks and includes two sectors producing intermediate goods—one which is populated by 'large' firms, that borrow cross-border directly from global banks, and another one which is populated by 'small' firms, that borrow from local banks—as well as a final goods producer. Local banks collect deposits in their home country and also fund themselves in the European cross-border interbank market by borrowing cross-border from global banks, which in turn refinance themselves through wholesale funding in the global interbank market (interpreted as the U.S. money market).

The central assumption of our model is that global banks' cross-border lending to large firms is subject to higher intermediation frictions than cross-border lending to banks, making the supply of the latter more elastic than that of the former. This assumption is supported by the observations of Buch, Koch and Koetter (2011), who show that only large productive banks lend directly to large firms via subsidiaries, and by Kerl and Niepmann (2015) who find, using German data, that it is costly to set up foreign affiliates, which combined with fixed costs of lending to firms, leads to interbank lending being more volatile than bank-to-firm lending. Therefore, cross-border lending to banks contracts more than cross-border lending to the real sector following a global deleveraging shock. The contraction in cross-border interbank lending reduces local banks' lending capacity, and it disproportionately hurts SMEs because they depend on local banks. We perform simulations for a baseline case of a global banking shock leading to a sudden stop in cross-border interbank lending. Regressions run on data generated from the model quantitatively replicate the patterns we uncover in our empirical regressions. The model therefore provides a structural interpretation of our empirical regressions, suggesting that the global banking shock can quantitatively account for the patterns in the data.

We examine if this interpretation is robust to a number of plausible alternative shock scenarios that might explain the strong impact of the crisis on SME-intensive sectors. In these scenarios, we mute the global bank shock in the model and allow for either internationally synchronized drops of total factor productivity (TFP) for SMEs, or internationally synchronized deposit supply shocks for local banks (i.e., local banking shocks). These alternative model scenarios cannot explain the pertinent patterns in the data, because empirical regressions run on simulated data from these scenarios deliver statistically insignificant coefficients of interest. We conclude that a sudden stop in cross-border interbank lending is required to quantitatively account for the decline in economic output seen during the eurozone crisis, in the sectors most dependent on domestic banks.

The remainder of the paper is structured as follows: Section 2 provides a first look at the data and some initial stylized facts. Section 3 places our analysis in the context of the literature. Section 4 motivates our empirical specifications and discusses identification, while Section 5 presents our empirical results. Our DSGE model is laid out and brought to the data in Section 6, while Section 7 summarizes the quantitative results obtained from model simulations. Section 8 offers conclusions.

2 A look at the data

European Monetary Union has given a boost to banking integration in Europe: Figure 1, which is based on locational banking statistics from the Bank for International Settlements

(BIS), displays lending by foreign banks for a range of EMU countries, separately and combined. Flows of bank loans surged in the first decade of the EMU, but most of this growth was due to increased foreign bank lending to domestic banks—foreign bank lending to the domestic non-bank sector (which here includes the domestic private sector and government) increased less and has remained relatively flat.

We argue that foreign lending to domestic banks versus lending to the non-bank sector are not simple substitutes and, indeed, foreign lending to the non-bank sector proved resilient during the financial and sovereign debt crisis, while bank-to-bank lending imploded. The synchronization of the collapse in cross-border bank-to-bank lending is noteworthy in this context. Even though the post-2008 experiences varied considerably across countries in terms of the severity of banking and sovereign crisis, the initial trigger (the U.S. subprime crisis spilling over to Europe and leading to a worldwide crisis in interbank markets) was a common factor with differential impacts across countries.

Figure 1 sets the scene for our empirical analysis. Banking sector integration in Europe was lopsided in the sense that there was too little 'real' banking integration: the real sector was unable to diversify its sources of finance away from domestic banks. Domestic real-sector lending continued to be financed by domestic banks, which funded themselves by borrowing from foreign banks; specifically, banks in the EMU periphery countries mainly borrowed from banks located in core economies which in turn borrowed in the U.S. money market (Hale and Obstfeld (2016)). This led to the pattern apparent from Figure 1 in which the growth in cross-border lending was driven by bank-to-bank lending.

Figure 2 illustrates how this pattern of banking integration left countries in the eurozone periphery vulnerable to both international liquidity shocks and domestic real shocks. In the absence of direct cross-border real sector lending (thin or absent gray arrows) and in spite of high levels of bank-to-bank integration (thick red arrows between the two countries' banking sectors), local firms are cut off from credit when domestic banks are hit by adverse liquidity shocks. Furthermore, domestic banks with their geographically concentrated loan portfolios remain fully exposed to any real-sector shocks in the home economy.

Figure 2 suggests that the impact of a domestic banking sector shock on the domestic economy will depend on the extent to which real sector credit is provided by domestic banks. As a measure of domestic bank dependence in country c—abbreviated as DBD^c—we propose the share of total real sector credit that is provided by domestic banks:

$$\text{DBD}^c = \frac{\text{Domestic bank lending to the real private sector in country } c}{\text{Total credit to the real private sector in country } c}, \tag{1}$$

which we construct using data from the Private Sector Credit Database (PSCD) compiled by the BIS.

Figure 3 and Figure A.1 (in the appendix) use data from the 2011 edition of the European Central Bank's and EU Commission's Survey of Access to Finance by Enterprises (SAFE) to illustrate the importance of domestic bank dependence for SME financing conditions. While Figure A.1 shows that bank loans are indeed the most important source of external finance for SMEs in the eurozone countries, Figure 3 illustrates that the share of SMEs reporting problems with obtaining external finance or higher net interest expenses during the financial crisis was higher in countries with high domestic bank dependence, DBD^c.

To study more closely how the reliance of domestic banks on cross-border interbank finance impacted SME-intensive sectors during the crisis, we define the 'global banking shock,' GBS_t, as the growth rate of aggregate cross-border interbank lending to the countries in our sample defined as

$$\text{GBS}_t \equiv \Delta \log \sum_c \text{B2B}_t^c, \tag{2}$$

where B2B_t^c is cross-border interbank ('bank-to-bank') lending to domestic banks in country c from the BIS data shown in Figure 1. We use GBS_t as our main shock variable in the empirical specifications throughout the paper. We compute time series of average growth rates of gross value added (GVA) for the most and least domestic-bank-dependent sectors across the countries in our sample—those with particularly high or low SME shares and, in Figure 4, plot GBS_t along with these growth rates. The figure shows how the financial crisis was associated with a sudden stop of cross-border interbank lending to eurozone countries: output contracted in all sectors, but high-SME sectors contracted significantly more.

3 Related literature

Our analysis draws on several strands of the literature. The first strand concerns the role of banking integration in the transmission of macroeconomic shocks. The second strand encompasses empirical work that emphasizes the financing constraints faced by SMEs during the European financial and sovereign debt crisis.

Regarding the empirical literature on the international transmission of banking sector shocks, we build on Peek and Rosengren (2000), who show how the burst of Japan's property bubble in the 1990s was reflected in contraction of lending by Japanese banks in the United States. Our paper is also related to work by Cetorelli and Goldberg (2012) in its emphasis on the role of global banks in international transmission and to work by Kalemli-Ozcan, Papaioannou and Peydro (2013), who show that the impact of banking integration on business cycle synchronization differs between crisis and tranquil periods.

Ferrando, Popov and Udell (2019) use firm-level data to document that SME-financing constraints are exacerbated in countries which were under macroeconomic and sovereign risk 'stress' during the financial crisis. Using firm survey data, Bremus and Neugebauer (2018) show that the reduction in cross-border credit affected financing conditions for small firms. More generally, Chang, Gomez and Hong (2021) show, using U.S. data, that weaker banks contracted lending to riskier firms dramatically during the great recession and provide a structural model that explains this. Our model captures the gist of this mechanism in reduced form by assuming that, because of informational frictions, SMEs can only borrow from local banks. Different from the studies discussed so far, our analysis of international transmission focuses on the interaction of SME prevalence and the nature of banking integration in the eurozone, with its focus on bank-to-bank integration as a key factor in the transmission of the crisis across countries and sectors.

Our emphasis on the differential impact of international and domestic bank lending on sector-level growth during the eurozone crisis closely connects our work to that of Schnabel and Seckinger (2019). While they focus on external finance dependence, we draw attention to the particular dependence of small firms on the local provision of credit and the interbank funding dependence of domestic banks as a key friction. Our paper also relates closely to Schnabl (2012) and Baskaya et al. (2017), who document the role of wholesale funding dependence for the transmission of capital inflow shocks in Peruvian and Turkish data, respectively.

Our DSGE model builds on Kalemli-Ozcan, Papaioannou and Perri (2013) and extends it along several dimensions. First, building on the setup in Uribe and Yue (2006), we introduce an interbank market to allow for a distinction between cross-border lending to domestic banks and the real sector. Second, we introduce a sector populated by SMEs that is dependent on domestic banks, but we allow large firms to borrow directly from global banks. Domestic banks, in turn, fund themselves from global banks in the interbank market and from domestic deposits. We use this model to replicate the stylized facts documented in the empirical analysis and to quantitatively evaluate plausible alternative interpretations of our empirical findings.

Bruno and Shin (2015) formulate a model of double-decker banking integration allowing global banks to interact with local banks, while Kerl and Niepmann (2015) explain the choice between direct and interbank cross-border lending as a function of barriers to entry into foreign banking markets. In our model, entry barriers take the form of frictions which give local banks an advantage in lending to SMEs and, because we embed direct and interbank cross-border bank lending into a fully dynamic model, we can study how the modality of cross-border bank lending affects the dynamics and transmission of macroeconomic shocks.

The idea that small firms rely on relationship lending and therefore require local access to credit is well-established in the banking literature. Berger and Udell (1995) show that small firms are more likely to borrow from small local banks, which have a comparative advantage in relationship lending, and Degryse and Ongena (2005) emphasize the role of distance for the intensity of banking relationships and for the intensity of banking competition. While long-standing banking relationships may help a firm obtain credit more easily when facing adverse firm-specific shocks (Petersen and Rajan (1994)), relationship lending also creates a hold-up problem if a negative shock affects the lender. In this situation, it may be difficult to turn to alternative sources of finance (Sharpe (1990)). Our macroeconomic model captures these mechanisms in reduced form.

Starting with Khwaja and Mian (2008), the micro-banking literature has begun to explore the real effects of banking shocks in matched bank-firm-level data. In this paper, our interest is in understanding the macroeconomic relevance of the above mechanisms for the EMU as a whole. In particular, we are interested in how the structure of cross-border lending (interbank vs. direct lending to firms) affects the transmission of macroeconomic shocks. We are not aware of matched bank-firm-level data sets that would allow us to study this nexus; i.e., that would be (a) representative at the level of individual countries (and in particular, would also cover small firms); (b) would allow us to distinguish between direct and indirect (via the impact of the interbank market on domestic banks) exposures of firms; and (c) at the same time would cover sufficiently many EMU countries (Hale, Kapan and Minoiu (2019) examine the role of cross-border interbank exposures for firm-level lending using syndicated loan data for large firms).

We therefore proceed in three steps to strike a balance between the high levels of internal validity achieved by the literature using bank-firm-level data and the external validity of a more macroeconomic approach. First, we use international micro (bank-level) data to show that more interbank dependent domestic banks reduced lending more in response to the shock in interbank markets. Second, we exploit the granular structure of the bank-level data to construct an instrument and additional controls for our empirical analysis at the country-sector level, discussing identification assumptions and potential challenges in detail. Third, we use a DSGE model to target the empirical country-sector-level specifications and as a laboratory in which we simulate the impact of confounding factors on our empirical results.

4 Empirical framework

Econometric specifications As a starting point for our empirical analysis, we posit the following reduced-form link between fluctuations in domestic real sector credit and output growth:

$$\Delta \log \text{GVA}_t^{c,s} = \gamma^{c,s} \times \text{CreditGrowth}_t^c + \eta_t^{c,s}, \tag{3}$$

where $\Delta \log \text{GVA}_t^{c,s}$ is the growth rate of gross valued added in country c, sector s, CreditGrowth_t^c is the growth of domestic bank credit to the real sector ('credit' for brevity) in country c, and $\eta_t^{c,s}$ is a country-sector specific credit demand shock. This specification allows for firms to be heterogeneous in their ability to substitute fluctuations in the availability of credit for other forms of funding. We can think of the coefficient $\gamma^{c,s}$ as capturing this ability, which is likely to vary by sector and/or country. For instance, if $\gamma^{c,s} = 0$, firms can fully offset variations in credit by turning to internal or non-bank finance (e.g., by issuing bonds). If $\gamma^{c,s} > 0$, fluctuations in credit cannot be fully offset and will have real effects. Based on our earlier discussion, we conjecture that country-sectors with higher SME shares will be more sensitive to variation in credit growth, so that

$$\gamma^{c,s} = \kappa + \gamma \times \textsc{sme}^{c,s}. \tag{4}$$

In our empirical work, $\textsc{sme}^{c,s}$ stands for the share of SMEs in value added in country c, sector s, in 2008, and we expect to find $\gamma > 0$.

Our focus is on understanding how the collapse in cross-border interbank lending apparent from Figure 1 affected credit and thus real outcomes across the eurozone. We interpret the eurozone crisis as a shock to interbank funding that was common to all eurozone countries, but affected countries differentially according to the respective dependence of their banks on wholesale borrowing and their respective dependence on domestic banks.

We model the link between domestic credit and shocks to cross-border bank lending using granular bank-level data for all domestic banks in the eleven countries of our sample. Specifically, we conjecture that domestic banks that were particularly reliant on wholesale funding also were particularly exposed to the drop in cross-border interbank lending. To evaluate the strength of this mechanism, we run bank-level regressions of the form

$$\text{LendingGrowth}_t^b = \alpha \times \underbrace{\text{IBD}_{t-1}^b \times \text{GBS}_t}_{=:G_t^b} + \mu^b + f_t^c + \text{CONTROLS}_t^b + \zeta_t^b, \tag{5}$$

where $\textsc{ibd}_{t-1}^b$ is interbank dependence of bank b at time $t-1$, and $\textsc{gbs}_t$ is the global banking sector shock.

The coefficient α is the causal effect of funding conditions in the European interbank market on banks' lending. Consistent with a recent literature (Baskaya et al. (2017); Ivashina, Scharfstein and Stein (2015)), we exploit the interaction of a common exogenous shock ($\textsc{gbs}$) with pre-determined bank-level heterogeneity in interbank dependence for identification. Our identifying assumption is that there are no unobserved bank-level characteristics which cause interbank dependence and simultaneously affect current lending growth in periods with global banking shocks through a different channel than interbank dependence. This assumption can be justified by our rich set of controls and in particular by the inclusion of country-time and bank fixed effects in regression (5). First, $\textsc{gbs}_t$ is an aggregate (global) variable that is clearly exogenous with respect to individual banks' lending while any country-specific shocks to credit demand or lending are absorbed into country-time fixed effects, f_t^c. Second, the bank-level specification controls for permanent unobserved heterogeneity of banks—via the inclusion of bank fixed effects μ^b—as well as for observed time-varying bank-level characteristics; in particular, deposit growth and bank size. Third, the inclusion of country-time effects also effectively controls for any confounding country-specific historical factors and regulations that could affect interbank dependence and its impact on lending.[1]

Having documented our mechanism at the bank level, we exploit the granular structure of our data to achieve identification in the estimation of our country-sector-level regression (3). Specifically, we construct the contribution of the global banking shock to aggregate domestic credit growth, $\mathcal{G}_t^c$, by aggregating the exposures of individual banks to the global banking shock, $G_t^b = \textsc{ibd}_{t-1}^b \times \textsc{gbs}_t$, across all domestic banks within the country:

$$\mathcal{G}_t^c = \sum_{b \in \mathcal{B}(c)} \omega_{t-1}^b \times G_t^b, \tag{6}$$

where $\mathcal{B}(c)$ is the set of domestic banks in country c and ω_{t-1}^b is the share of total private sector credit in country c issued by bank b. Note that the global banking shocks affect $\mathcal{G}_t^c$ in a way that varies by country and time: first, via G_t^b, which is a function of the bank's dependence on wholesale funding (and thus its exposure to $\textsc{gbs}_t$) and, second, via the bank's time-varying share of the domestic credit market. Note also that our definition of ω_{t-1}^b as the bank's share in domestic credit implies that $\sum \omega_{t-1}^b = \textsc{dbd}_{t-1}$, so that $\mathcal{G}_t^c$ is a function of domestic bank dependence.

From (4), we obtain the following consolidated version of equation (3):

$$\Delta \log \textsc{gva}_t^{c,s} = \gamma \times \textsc{sme}^{c,s} \times \text{CreditGrowth}_t^c + \text{CONTROLS}_t^{c,s} + \eta_t^{c,s}, \tag{7}$$

which we estimate using $\textsc{sme}^{c,s} \times \mathcal{G}_t^c$ as an instrument for $\textsc{sme}^{c,s} \times \text{CreditGrowth}_t^c$.

The inclusion of a saturated set of fixed effects in the controls of regression (7) adjusts for any violation of the exclusion restriction that could arise from sector- or country-specific variables that might be correlated with the instrument ('confounders'). For example, variations in private-sector credit demand that affect all sectors in a country equally would be absorbed by the country-time effects, while sector-time effects would absorb variation in credit demand in particular sectors.

Further, unobserved country-time factors may affect sectors differently. If such factors are correlated with $\textsc{gbs}_t$, our coefficient of interest would be biased in case these factors differ in their impact on sectoral output in a way that is correlated with $\textsc{sme}^{c,s}$.[2] Our granular bank-level analysis provides us with estimates $\widehat{f_t^c}$ of country-time effects that absorb any

[1] For example, following the inception of the euro, countries with high growth expectations could have financed lending predominantly with foreign wholesale funding. This could have led to high IBD prior to the crisis followed by large downturns in lending. Also, different national histories of financial development are likely to affect the business model of banks and thus the degree of interbank dependence and a country's level of financial integration more generally (see Hoffmann and Okubo (2022) for how historical patterns of comparative advantage affected regional banking integration in Japan). In our specification, country-time effects would absorb such confounders.

[2] More formally, let $\mathcal{F}_t^{(c)}$ be such an unmodeled (and potentially country-specific) factor which loads on output in country-sector c, s with loading $\delta^{c,s}$. Whenever $\mathcal{F}_t^{(c)}$ is correlated with $\mathcal{G}_t^c$ such that $\text{cov}(\mathcal{F}_t^{(c)}, \mathcal{G}_t^c) \neq 0$, identification would require us to assume that the *cross-sectional* covariance $\text{cov}(\delta^{c,s}, \textsc{sme}^{c,s})$ equals zero. See Hoffmann and Okubo (2022) for a detailed discussion.

country-specific influences on bank lending. By including the interaction $\text{SME}^{c,s} \times \widehat{f}_t^c$ in our country-sector panel regressions, we control for the potential correlation of $\text{SME}^{c,s} \times \text{GBS}_t$ with unobserved country-specific factors that load differently on different country-sectors in a way that is cross-sectionally correlated with $\text{SME}^{c,s}$. See Cingano, Manaresi and Sette (2016) and Hoffmann and Stewen (2020) for a similar approach.

Data To implement the bank-level regression (5), we compile annual bank-level balance sheet data from Fitch Connect on loans (`fc_net_loans_bnk`), the total of deposits and short-term funding (`fc_total_deposits_mm_st_funding_bnk`), total assets (`fc_total_assets_bnk`), deposits (`fc_total_customer_ deposits_bnk`), and total funding (`fc_total_funding_bnk`).

We measure interbank dependence (IBD) as the ratio of short term funding to total funding, where short term funding is the difference between the total of deposits and short-term funding and deposits. Ivashina, Scharfstein and Stein (2015), Baskaya et al. (2017), and Bremus and Neugebauer (2018) measure bank-level exposures to international bank-funding shocks in a similar way.

We distinguish between domestic and foreign banks because affiliates or subsidiaries of foreign banks will be affected less as they may tap into the internal capital markets of their bank holding company. To make this distinction between domestic and foreign banks operational, we use the ultimate parent ID in the Fitch Connect data base. A bank is classified as domestic if it has no parent or its ultimate parent resides in the same country, and as foreign if the ultimate parent resides in another country in our sample, and we drop banks whose ultimate parent resides in a country outside our sample.

Table A.1 in the online appendix provides summary statistics for both domestic and foreign banks which are quite similar in terms of average loan and deposit growth rates, although foreign banks are bigger (in terms of total assets) on average and have somewhat higher levels of interbank dependence than domestic banks.

To estimate the country-sector-level regression (7), we compute output growth using annual data from each of the countries in our sample on real gross value added at the sectoral level from Eurostat (*Gross value added and income A*64 industry breakdowns* file, `nama_10_a64`), while country-level credit growth is the sum of outstanding loans on the liability side of the balance sheets of the private non-bank sector (corporate sector and households, from Eurostat's *Financial balance sheets* file, `nasa_10_f_bs`). For all output measures, we obtain per capita values by using population data from Eurostat (*Population and employment* file, `nama_10_pe`).

SME-importance is from the 2018 issue of the annual database accompanying the European Commission's SME performance review. We construct our measure $\text{SME}^{c,s}$ as the share in value added at factor costs (million euros at current prices) at the country-sector level of firms with fewer than 250 employees. Data on the value added of small businesses is not available before 2008, and we use the 2008 values to construct $\text{SME}^{c,s}$. Domestic banking dependence, DBD, is constructed using data from the Private Sector Credit Database (PSCD) compiled by the BIS, where the private sector comprises private non-financial corporations, households, and non-profit institutions serving households. The data covers eleven EMU countries and eleven one-digit sectors with sample period 1999–2013.[3]

5 Main empirical results

Bank-level regressions Table 1 presents estimates of the bank-level regression (5) using the sample of domestic banks. The results show that the global banking shock disproportionately affects banks that are relatively more dependent on wholesale funding as the coefficient α on the interaction term $\text{IBD}_{t-1}^{b} \times \text{GBS}_t$ is positive and significant in all our specifications. In column (1), we display results when no controls are included besides bank and country-time fixed effects and the stand-alone term IBD_{t-1}^{b}. We add bank-level controls in columns (2)-(4): the logarithm of lagged assets as a measure of bank size in column (2), the growth of customer deposits in column (3), and both controls together in column (4). Neither set of controls affects the magnitude of our coefficient of interest nor its significance. All specifications include bank and country-time effects, so the results are not driven by country-specific factors that might have affected credit demand differently in different countries.

The measure of interbank dependence IBD_{t-1}^{b} is the share of short-term wholesale funding of bank b. Our conjectured mechanism implies that interbank dependent banks see a particularly large decline in short-term funding during the crisis, which is exactly what is observed in the data. Appendix Table A.2 reports on the regression (5) for domestic banks, but with short-term funding as the dependent variable. The coefficient on the interaction $\text{IBD}_{t-1}^{b} \times \text{GBS}_t$ remains positively significant in all specifications.

During the eurozone crisis, cross-border interbank lending decreased by 18 percent, so $\text{GBS} = 0.18$. The α estimate of around 0.5 in Table 1 implies that the sensitivity of a bank's lending to changes in IBD is $\alpha \times \text{GBS} = 0.5 \times 0.18 = 0.09$. The interbank dependence of the average bank in our sample is 0.2, which is virtually identical to the standard deviation of IBD across banks. Hence, the average bank would have seen a decline in lending of 1.8 percent due to the collapse in interbank markets. Increasing the interbank dependence of the average bank by one standard deviation would have decreased its lending by another 1.8 percent, which implies considerable heterogeneity in the responses to the global banking shock.

[3]Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, and Spain and NACE rev. 2 sectors: Manufacturing (C); Electricity, Gas, Steam and Air Conditioning Supply (D); Water Supply; Sewerage, Waste Management and Remediation Activities (E); Construction (F); Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles (G); Transportation and Storage (H); Accommodation and Food Service Activities (I); Information and Communication (J); Real Estate Activities (L); Professional, Scientific and Technical Activities (M); and Administrative and Support Service Activities (N).

To appreciate the economic significance of the α estimate, we compare to earlier estimates in the literature. A specification that is close to ours is given in Table 7 of Baskaya et al. (2017), which focuses on the role of 'other' capital inflows (which includes interbank flows) relative to GDP. Their Figure 2 shows that this measure decreased by 2 percentage points during the global financial crisis which, together with their point estimate of 4.6, implies a sensitivity to variation in bank-level exposures of 0.09, virtually identical to our estimate.

The results in Tables 1 and A.2 capture an essential cog in our argument by showing that the collapse in cross-border interbank lending during the eurozone crisis disproportionately affected domestic banks that were dependent on wholesale funding. We would expect the impact of the collapse in interbank lending to be less pronounced for foreign banks and we provide evidence for this in Tables A.3 and A.4 in the online appendix, where we re-run the analysis in Tables 1 and A.2, using the sample of foreign banks. The coefficient of interest is much smaller in absolute value than the corresponding coefficient for domestic banks in Tables 1 and A.2 and never significant. This finding lends further support to our conjecture that domestic banks were particularly exposed to the freeze in cross-border interbank lending during the eurozone crisis, and that those that were more dependent on interbank funding had to reduce their lending more.

Country-sector-level results Tables 2 and 3 explore the aggregate implications of the interbank shock on sectoral output growth in the eleven EMU countries in our sample.

The two top panels of Table 2 present country-sector-level regressions (7) using $\text{SME}^{c,s} \times \mathcal{G}_t^c$ as instrument for $\text{SME}^{c,s} \times \text{CreditGrowth}_t^c$, with the second and first stages of the IV estimation shown in the upper and middle panel, respectively.

Column (1) presents our baseline specification. The coefficient of interest is that of the interaction $\text{SME}^{c,s} \widehat{\times \text{CreditGrowth}_t^c}$; its estimate is positive and significant in line with our conjectured mechanism, and the first-stage F-statistics far exceeds the conventional critical value of 10 (Stock and Yogo (2005)), suggesting that the instrument is relevant. In column (2), we report a specification, where we include the interaction, $\text{SME}^{c,s} \times \widehat{f}_t^c$, of the estimated country-time effects from Table 1, column 4 with sectoral SME shares. The estimate of our coefficient of interest and the relevance of the instrument in the first stage remain unchanged. In column (3), we let the coefficient on $\widehat{f}_t^c$ vary by sector, allowing for the confounding factors to affect sectors differentially. The estimate of α is quite stable at around 0.55. The cross-sectional standard deviation of $\text{SME}^{c,s}$ is 0.22, while its mean is 0.64, which implies that after a one percent decline in lending, a sector with a one standard deviation higher SME share will have output growth that is $0.55 \times 0.22 = 0.12$ percent lower than that of the average sector.

The lower panel of Table 2 presents estimates of equation (7) in reduced form; i.e., we directly substitute CreditGrowth_t^c with $\mathcal{G}_t^c$ and estimate

$$\Delta \log \text{GVA}_t^{c,s} = \gamma \times \text{SME}^{c,s} \times \mathcal{G}_t^c + \text{CONTROLS}_t^{c,s} + \eta_t^{c,s}\,. \tag{8}$$

There results confirm the general conclusion that the collapse in interbank funding affected high-SME sectors (that are more dependent on domestic banks) more strongly.

To provide a simpler quantitative interpretation of our results, we classify a country-sector as generally domestic-bank dependent ('high SME') or not ('low SME'). Table 3 presents IV and reduced form estimates, where the variable $\text{HiSME}^{c,s}$ is coded as a dummy variable that is unity whenever the SME share of a country-sector is above the European median and zero otherwise. Our results remain qualitatively unchanged from Table 2. Also, the first stage in the middle and the reduced-form estimates in the lower panels confirm the relevance of our instrument. The coefficient of interest is significant, positive, and stable across all four specifications, and the first-stages remain strong. The estimate of 0.34 in the regressions implies that a one percent decline in lending reduces output growth in high-SME sectors by 0.34 percentage points more than in low-SME sectors. We target these IV estimates in our quantitative-theoretical model below.

Graphical evidence Figure A.2 considers the role of sectoral variation in SME shares for the transmission of the global banking shock. Here, we plot the 2008 sectoral SME share in sectoral value added against estimates of the country-sector specific coefficients $\gamma^{c,s}$ obtained from the regression

$$\Delta \log \text{GVA}_t^{c,s} = \gamma^{c,s} \times \mathbf{1}^{c,s} \times \mathcal{G}_t^c + \text{fixed effects} + \eta_t^{c,s}, \tag{9}$$

estimated country-sector by country-sector, where $\mathbf{1}^{c,s}$ is an indicator variable for country-sector c, s. The figure shows that the impact of country-level lending growth is larger in higher-SME sectors.

6 A theoretical model

To explain the empirical patterns documented, we propose a tractable model of a small open economy with two sectors—SMEs and large firms—as well as a final goods producer. The model features a domestic ('local') bank, which lends to small firms and a foreign ('global') bank, which lends cross-border to large firms and domestic banks. In this section, we provide the model setup and details of the calibration, while the full set of model equations is given in the online appendix. Figure 5 provides a synopsis of the model structure.

Firms Firms in sectors $s = \{\text{BF}, \text{SME}\}$ (BF refers to large ('big') firms and SME to SMEs) produce output according to the production function:

$$Y_t^s = \theta_t^s (K_{t-1}^s)^{\alpha} (N_t^s)^{1-\alpha} \,, \tag{10}$$

where Y_t^s, θ_t^s, K_{t-1}^s, N_t^s denote output, total factor productivity, capital (at the end of the previous period), and labor in sector s, while α denotes capital intensity.

Firms operate in perfectly competitive environments and maximize the present discounted value of dividends (DIV_t^s) for their owners. Both large and small firms are owned by domestic households, so that firms discount future dividends using the households' discount factor. With these assumptions, firms' maximization problem becomes

$$\max_{\{K_t^s,\, N_t^s,\, L_t^s\}_{t=0}^{\infty}} \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \Lambda_{0:t} \text{DIV}_t^s \right] . \tag{11}$$

where $\Lambda_{0:t}$ is the household stochastic discount factor at horizon t. Firms do not retain any earnings, so dividends are given by

$$\text{DIV}_t^s = P_t^s Y_t^s - W_t N_t^s - I_t^s - \varphi_t^{I,s} + L_t^s - R_{t-1}^s L_{t-1}^s \,, \tag{12}$$

where P_t^s denotes the price of output in sector s, I_t^s denotes investment in sector s, and W_t is the wage rate which is equal across sectors because labor is perfectly mobile within the country. L_t^s denotes total sector s bank borrowing at the (gross) interest rate R_t^s. Both capital and investment are produced out of the final good subject to a sector-specific capital adjustment cost, $\varphi_t^{I,s} = f\left(I_t^s,\, K_{t-1}^s\right)$, and the law of motion for capital, given depreciation rate δ, is given by

$$K_t^s = (1-\delta) K_{t-1}^s + I_t^s \,. \tag{13}$$

The key financial friction in the model is that firms need to borrow in order to finance their wage bill:

$$L_t^s = W_t N_t^s \,. \tag{14}$$

This setup builds on Neumeyer and Perri (2005) and Uribe and Yue (2006), who rationalize this assumption by the timing structure of wage contracts and firm production. An alternative rationalization is that of Mendoza and Yue (2012), who assume intra-period loans are needed to pay for a fraction of intermediate inputs. In our model, workers need to be paid before output is sold. Specifically, we assume that firms borrow after shocks for the current period are realized, but before production takes place, and repay loans from the last period (plus interest) out of their cash flow after output has been sold. The resulting optimality conditions with respect to capital, labor, and loans are given by

$$Q_t^s = \mathbb{E}_t \left[\Lambda_{t:t+1} \left(P_{t+1}^s \alpha \frac{Y_{t+1}^s}{K_t^s} + (1-\delta) Q_{t+1}^s - \frac{\partial \varphi_{t+1}^{I,s}}{\partial K_t} \right) \right] , \tag{15}$$

$$W_t(1+\Xi_t^s) = P_t^s(1-\alpha)\frac{Y_t^s}{N_t^s}\,, \tag{16}$$

$$1+\Xi_t^s = \mathbb{E}_t\left[\Lambda_{t:t+1}R_t^s\right]\,, \tag{17}$$

where $Q_t^s = 1 + \frac{\partial \varphi_t^{I,s}}{\partial I_t^s}$ is Tobin's Q, the marginal cost of newly installed capital, and Ξ_t^s is the Lagrange multiplier associated with the borrowing constraint 14.

Final goods producer The goods produced by SMEs and large firms are utilized as intermediate inputs for a final good used for consumption, investment, and net exports. The final good is internationally tradeable at a price normalized to one and thus acts as numeraire. This good is produced in perfectly competitive markets according to the following technology:

$$Y_t = \left(\omega^{\frac{1}{\epsilon}} {Y_t^{\mathrm{BF}}}^{\frac{\epsilon-1}{\epsilon}} + (1-\omega)^{\frac{1}{\epsilon}} {Y_t^{\mathrm{SME}}}^{\frac{\epsilon-1}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}}, \tag{18}$$

where ω is the share of large firm goods in the final good production—the relative size of the large firms sector in GDP—and ϵ is the intratemporal elasticity of substitution between the SME and large firm goods.

The final goods producer maximizes the value of output, which yields the following demand functions for the output of large and small firms:

$$Y_t^{\mathrm{BF}} = \omega\left(P_t^{\mathrm{BF}}\right)^{-\epsilon} Y_t \quad \text{and} \quad Y_t^{\mathrm{SME}} = (1-\omega)\left(P_t^{\mathrm{SME}}\right)^{-\epsilon} Y_t\,. \tag{19}$$

Households Households consume C_t of the final good, supply labor N_t to firms and receive dividends and profits from the firms and banks they own. They maximize the lifetime utility

$$\max_{\{C_t,\, N_t\}} \mathbb{E}_0\left[\sum_{t=0}^{\infty}\beta^t\left(\frac{{C_t}^{1-\sigma}-1}{1-\sigma} - \Psi\frac{N_t^{1+\psi}}{1+\psi}\right)\right]\,, \tag{20}$$

where β is the discount factor, σ is the coefficient of risk aversion, ψ is the inverse Frisch elasticity, and Ψ is the weight of labor disutility.

Each period, households receive wage income W_tN_t, dividends $\mathrm{DIV}_t^{\mathrm{BF}}$ and $\mathrm{DIV}_t^{\mathrm{SME}}$ from firms, profits Π_t from the domestic banks, and hold deposits D_t that earn (gross) interest R_t^d. Households' flow budget constraint is thus given by

$$C_t + D_t = W_tN_t + R_{t-1}^d D_{t-1} + \mathrm{DIV}_t^{\mathrm{BF}} + \mathrm{DIV}_t^{\mathrm{SME}} + \Pi_t\,. \tag{21}$$

The resulting set of optimality conditions for consumption and labor is given by

$$\mathbb{E}_t\left[\Lambda_{t:t+1}R_t^d\right] = 1\,. \tag{22}$$

$$W_t = \Psi N_t^{\psi} C_t^{\sigma}\,, \tag{23}$$

where $\Lambda_{t:t+1} = \beta\left(\frac{C_{t+1}}{C_t}\right)^{-\sigma}$ is the stochastic discount factor of the household.

The banking sector The banking sector features a global bank which borrows funds in the global wholesale market and lends cross-border to large firms and to a domestic bank which lends to small firms and finances itself by raising deposits from domestic households and by borrowing from the global bank. This setup captures the double-decker nature of banking integration in the eurozone documented by Bruno and Shin (2015) and Hale and Obstfeld (2016).

The domestic bank is more efficient in intermediating funds to small firms, while the global bank is more efficient in lending to large firms. We formalize this idea by assuming that the global bank fully concentrates its cross-border real-sector lending on large firms, while the local bank concentrates on small firms. Cross-border lending is subject to convex intermediation costs. These assumptions are consistent with empirical research showing that distance is a major determinant of the strength of a banking relationship (Petersen and Rajan (1994) and Degryse and Ongena (2005)), and that local banks have a comparative advantage in screening small, relatively opaque, borrowers.

To pin down the global bank's choice of direct and interbank cross-border lending, we assume that intermediation costs for direct cross-border lending are higher than for interbank lending. This effectively implies a pecking order of the mode of international bank lending in which the global bank trades off direct lending to firms at high screening costs (and high margins) against low-margin interbank lending, and makes the latter more elastic than the former.

Local bank The local bank maximizes profits from lending to small firms

$$\max_{L_t^{\text{SME}},\, M_t,\, D_t} \quad \Pi_{t+1}\,. \tag{24}$$

subject to the balance sheet constraint which is given by

$$L_t^{\text{SME}} = M_t + D_t\,, \tag{25}$$

where M_t is cross-border interbank borrowing, D_t is domestic deposits, and L_t^{SME} is local bank lending to small firms. We assume that local-bank profits are fully disbursed to households in period $t+1$, after loans made in period t have been repaid, so that

$$\Pi_{t+1} = R_t^{\text{SME}} \times (1-\iota)\, L_t^{\text{SME}} - R_t^{m} \times M_t - \left(R_t^{d} + \zeta_t^{lbs}\right) \times D_t - \varphi^{d}\left(D_t\right), \tag{26}$$

where R_t^{SME} , R_t^{m}, and R_t^{d} are the (gross) interest rates on small firm lending, interbank borrowing, and deposits, respectively, ι is a fixed intermediation margin for lending to the real sector, ζ_t^{lbs} is a mean-zero local-bank deposit liquidity shock, and $\varphi^{d}\left(D_t\right)$ is a convex cost of raising deposits.

We assume that the local bank operates in a perfectly competitive environment, taking interest rates as given, and that the cost of raising deposits is a function only of the current level of deposits, D_t. This implies that the bank optimizes period-by-period. The fixed intermediation margin $\iota > 0$ induces a constant positive spread between lending rates and banks' refinancing rates and ensures that firms' borrowing constraints bind (and also hold in steady state).

The optimality conditions of the local bank are as follows:

$$R_t^{\mathrm{SME}} = \frac{R_t^m}{1-\iota} \text{ and } R_t^d + \zeta_t^{lbs} + \varphi^{d\prime}(D_t) = R_t^m \,. \tag{27}$$

Global bank We build on Schmitt-Grohé and Uribe (2003) and Uribe and Yue (2006) and assume international borrowing takes place through a global bank, owned and funded by residents of the rest of the world. The global bank captures wholesale funds in the global money market and lends cross-border to large domestic firms and to domestic banks in the interbank market.

The global bank maximizes profits (disbursed to foreign owners in period $t+1$, after loans made in period t have been repaid)

$$\max_{L_t^{\mathrm{BF}},\, M_t,\, F_t} \quad \Pi_{t+1}^{\mathrm{GB}} \,, \tag{28}$$

subject to the balance sheet constraint

$$L_t^{\mathrm{BF}} + M_t = F_t, \tag{29}$$

where L_t^{BF} is cross-border lending to large firms, M_t is interbank lending, and F_t is wholesale funding. As for the local bank, the global bank takes interest rates as given and adjustment costs only depend on current levels. Therefore, the bank maximizes profits period-by-period, where profits are given by

$$\Pi_{t+1}^{\mathrm{GB}} = R_t^{\mathrm{BF}} \times \left((1-\iota)\, L_t^{\mathrm{BF}} - \varphi(L_t^{\mathrm{BF}})\right) + R_t^m \times (M_t - \kappa\varphi\,(M_t)) - R_t^w \times F_t \,, \tag{30}$$

where R_t^w is the world interest rate and R_t^{BF} is the (gross) interest rate on large firm lending. $\varphi\,(.)$ is a convex function increasing in the amount of category cross-border lending, and the constant $0 < \kappa < 1$ captures relatively lower intermediation costs of interbank lending.

We assume that the global banking shock takes the form of an interest rate wedge λ_t such that

$$R_t^{\mathrm{BF}} = \frac{R_t^w + \lambda_t}{1 - \iota - \varphi'\,(L_t^{\mathrm{BF}})} \text{ and } R_t^m = \frac{R_t^w + \lambda_t}{1 - \kappa\varphi'\,(M_t)} \,. \tag{31}$$

λ_t may reflect a shadow price of balance sheet capacity for the global bank which impacts all countries in the same way but that is exogenous from the point of view of the small open economy.[4]

[4]For example, λ_t could be a Lagrange multiplier on an exogenous limit $\overline{F_t}$ on the aggregate liabilities of

Market clearing The market for the final good clears according to:

$$Y_t = C_t + I_t + \Gamma_t + NX_t \,, \tag{32}$$

where Γ_t is total domestic net costs (which can be thought of as part of gross investment):

$$\Gamma_t = \iota \times L^{\text{SME}}_{t-1} + \zeta^{lbs}_{t-1} \times D_{t-1} + \varphi^d \left(D_{t-1}\right) + \varphi^I_t \,, \tag{33}$$

and where net exports are given by

$$NX_t = R^m_{t-1} M_{t-1} - M_t + R^{\text{BF}}_{t-1} L^{\text{BF}}_{t-1} - L^{\text{BF}}_t \,. \tag{34}$$

Market clearing conditions for the factor markets are given by

$$I_t = I^{\text{BF}}_t + I^{\text{SME}}_t \text{ and } N_t = N^{\text{BF}}_t + N^{\text{SME}}_t \,. \tag{35}$$

Forcing variables There are four sources of shocks in the model: shocks to total factor productivity θ^s_t for SMEs and large firms, shocks to the global bank λ_t, and shocks to the local bank ζ^{lbs}_t.

The TFP processes (one for each sector s) are given by

$$\log \theta^s_t = \rho^\theta \log \theta^s_{t-1} - \sigma^\theta \eta^s_t \,, \tag{36}$$

the stochastic process for the global banking shock is given by

$$\lambda_t = \left(1 - \rho^{gbs}\right) \lambda + \rho^{gbs} \lambda_{t-1} + \sigma^{gbs} \eta^{gbs}_t \,, \tag{37}$$

and the local banking shock process is given by

$$\zeta^{lbs}_t = \rho^{lbs} \zeta^{lbs}_{t-1} + \sigma^{lbs} \eta^{lbs}_t \,, \tag{38}$$

where the innovations η^s_t, η^{gbs}_t, ζ^{lbs}_t to idiosyncratic country sectoral TFP, global banking, and local banking shocks, respectively, are independent draws from a standard normal distribution. In the baseline specification, TFP and local banking shocks are uncorrelated across countries. The world interest rate is exogenous and constant:

$$R^w_t = R^w \,. \tag{39}$$

Equilibrium The equilibrium is a set of quantities Y^s_t, K^s_t, I^s_t, N^s_t, L^s_t, DIV^s_t, Y_t, K_t, I_t, N_t, C_t, D_t, M_t, F_t, Π_t, Π^{GB}_t, NX_t, Γ_t, and prices P^s_t, Q^s_t, Ξ^s_t, R^s_t, W_t, $\Lambda_{t:t+1}$, R^d_t, R^m_t for $s = \{\text{BF}, \text{ SME}\}$ satisfying the first-order conditions of SMEs and large firms in (15), of (16)

the global banks in all countries c such that $\sum_c F^c_t \leq \overline{F_t}$. In this case, λ_t could be interpreted as a global deleveraging shock.

and (17), of the final good producer in (19), of households in (22) and (23), of the local bank in (27), of the global bank in (31); technology in (10) and (18); constraints in (12), (14), (21), (25), (26), (29), and (30); the law of motion for capital in (13); the market clearing conditions in (32) and (35); definitions in (33) and (34); exogenous processes for θ_t^s, λ_t, and ζ_t^{lbs} in (36), (37), and (38); non-stochastic R_t^w in (39); and exogenous shock variables η_t^s, η_t^{gbs}, and η_t^{lbs}.

The model is solved by log-linearizing around the deterministic steady-state, given the functional forms and parameters discussed in the calibration section.

A simplified version of the model for interpretation In a simplified version of the model, we assume consumers make no decisions but accept a fixed wage rate and deposit a fixed amount in the local bank. Further, firms only use labor as input and pre-finance wage payments through loans at the beginning of the period and repay principal plus interest at the end of the period. Then we can write the profit function of the firm in sector s as

$$\theta^s \left(\frac{L^s}{W}\right)^{1-\alpha} - R^s L^s \,, \tag{40}$$

for $s = \{\text{SME}, \text{BF}\}$, which implies a sector-level loan demand function of the form

$$L^s = \bar{c}\,(R^s)^{-\frac{1}{\alpha}} \,, \tag{41}$$

where $\bar{c}$ is a constant. At the end of the period, after firms have repaid their loans and produced, consumers receive income, withdraw deposits, and consume.

The global bank's marginal intermediation costs for each category of cross-border lending are linear in percentage deviations from initial values (here indicated by bars) so that $\varphi'(X) = \overline{\varphi} \times \left(\frac{X-\overline{X}}{\overline{X}}\right)$ for $X = \{L, M\}$, where $\overline{\varphi}$ is some positive constant, and we normalize the intermediation margin to the real sector, ι, to zero. The global bank's supply functions for cross-border interbank and direct lending are determined by the first-order conditions

$$R^m = \frac{R^w + \lambda}{1 - \kappa\overline{\varphi} \times \left(\frac{M-\overline{M}}{\overline{M}}\right)} \quad \text{and} \quad R^{\text{BF}} = \frac{R^w + \lambda}{1 - \overline{\varphi} \times \left(\frac{L^{\text{BF}}-\overline{L^{\text{BF}}}}{\overline{L^{\text{BF}}}}\right)} \,. \tag{42}$$

Because deposits in the simplified model are fixed at $\overline{D}$, the growth in local bank lending is directly proportional to growth in interbank lending:

$$\frac{L^{\text{SME}} - \overline{L^{\text{SME}}}}{\overline{L^{\text{SME}}}} = \underbrace{\left[\frac{\overline{M}}{\overline{M} + \overline{D}}\right]}_{=\overline{\text{IBD}}} \times \frac{M - \overline{M}}{\overline{M}} \,, \tag{43}$$

where the elasticity here corresponds to the initial value of interbank dependence, $\overline{\text{IBD}}$. The local bank's marginal costs of funding is given by the interbank rate R^m, which must equal the lending rate, so that $R^{\text{SME}} = R^m$.

Figure 6 illustrates this stylized model graphically. Assume first that there are no deposits, so that all small firm lending is financed by interbank borrowing, $\overline{\text{IBD}} = 1$. Large and small firms have identical demand functions and, initially, both banks supply funds at the world interest rate R^w, where we normalize the initial value of the spread λ to zero. Firms initially borrow $\overline{L^{\text{BF}}}$ and $\overline{L^{\text{SME}}} = \overline{M} + \overline{D}$ such that intermediation costs are zero for both banks. A spread shock λ shifts both banks' supply curves upwards. Because the local bank's supply of funds is fully exposed to the stress in interbank markets ($\overline{\text{IBD}} = 1$), lending supply to small firms 'inherits' the elasticity of the supply of interbank funds by the global banks, which by assumption ($0 < \kappa < 1$) is higher than that of direct bank lending. Thus, given identical demand curves of large and small firms, local bank lending to SMEs will fall more than cross-border lending to big firms.

To see how $\overline{\text{IBD}}$ scales the transmission of the shock, note from (43) that $\overline{\text{IBD}}$ is the elasticity of local bank lending to interbank funding. Lower levels of $\overline{\text{IBD}}$ therefore mitigate the impact of the spread shock λ on the the local bank's lending supply. This makes the local bank's lending supply curve steeper in Figure 6, dampening the impact of the shock on lending to small firms and thus on output.[5]

The results in the simplified model depend on the assumption that deposits are fixed; however, the basic intuition carries over to the full model as long as deposit supply is relatively inelastic compared to wholesale funding supply.

Mapping the model to the data

Definitions Aggregate real GDP in the model is given by Y_t. Total credit corresponds to the sum of loans to both sectors: $L_t^{\text{BF}} + L_t^{\text{SME}}$, and the growth rate of this variable corresponds to the variable CreditGrowth_t^c in our empirical specifications.

Domestic bank dependence is defined in the model as the ratio of locally originated loans to total credit in the economy:

$$\text{DBD}_t = \frac{L_t^{\text{SME}}}{L_t^{\text{SME}} + L_t^{\text{BF}}} \,. \tag{44}$$

Interbank dependence is defined in the model as the ratio of cross-border interbank borrowing to the total funding of the local banks:

$$\text{IBD}_t = \frac{M_t}{M_t + D_t} \,. \tag{45}$$

[5]It is straightforward to show that the elasticity of the local bank's supply curve is given by $\overline{\text{IBD}}/(\kappa\overline{\varphi})$, while that of the global bank to large firms has elasticity $1/\overline{\varphi}$. Hence, our results regarding the relative impact of the shock on large and small firms would reverse if $\overline{\text{IBD}} < \kappa$. However, as long as interbank markets are sufficiently frictionless, so that κ is sufficiently low, this case is unlikely to be empirically relevant. Even then it would be true that higher levels of $\overline{\text{IBD}}$ increase the exposure of small firms to the shock.

Letting letters without time subscript denote steady-state values of the respective variable, the steady-state values of domestic and interbank dependence are given by $\text{DBD} = \frac{L^{\text{SME}}}{L^{\text{SME}}+L^{\text{BF}}} \approx 1-\omega$ and $\text{IBD} = \frac{M}{M+D}$, and we calibrate these values separately for each country.

The model counterpart to the global banking shock in our regressions, GBS_t, is constructed as follows. We simulate the model for all eleven countries in our sample to obtain artificial data on cross-border bank-to-bank lending, M_t^c, where c indexes a country, and we aggregate the country-specific interbank lending values to get the EMU-wide variable $M_t^{\text{EMU}} = \sum_{c=1}^{11} M_t^c$. The global banking shock is the growth rate of this variable:

$$\text{GBS}_t = \Delta \log M_t^{\text{EMU}} \,. \tag{46}$$

Calibration We calibrate the baseline model at the quarterly frequency using parameter values displayed in Table A.5. In our calibration, we target steady-state nominal GDP (GDP), domestic bank dependence (DBD), and interbank dependence (IBD) for the countries in our sample as shown in Table 4. Most of the parameters are calibrated to standard values common in the literature.

Households' discount factor β is set to 0.99, to match the steady-state quarterly net deposit rate of 1 percent, and households' coefficient of relative risk aversion σ is set to 1. The inverse of the Frisch elasticity, ψ, equals 2, while the scale parameter, Ψ, is determined by the steady-state restrictions. The elasticity of intratemporal substitution between the SME and large-firm goods, ϵ, is 0.4, which is close to the average value estimated in Siena (2021) for the European periphery countries. The household preference parameter, ω, is pinned down by the domestic bank dependence, DBD, in a given economy.

The capital intensity parameter, α, equals 0.35 for large and small firms. Capital depreciation, δ, equals 0.025, and we define the investment cost adjustment function as $\varphi_t^{I,s} = \frac{1}{2}\varphi^I K_{t-1}^s \left(\frac{I_t^s}{K_{t-1}^s} - \delta\right)^2$, with the parameter φ^I set to 22 in order to match the volatility of investment growth rate.

We assume the following functional forms for the adjustment costs of global bank direct and interbank lending and local bank deposits: $\varphi\left(L_t^{\text{BF}}\right) = \frac{1}{2}\bar{\varphi}L^{\text{BF}}\left(\frac{L_t^{\text{BF}}-L^{\text{BF}}}{L^{\text{BF}}}\right)^2$, $\varphi\left(M_t\right) = \frac{1}{2}\bar{\varphi}M\left(\frac{M_t-M}{M}\right)^2$, and $\varphi^d\left(D_t\right) = \frac{1}{2}\varphi^d D\left(\frac{D_t-D}{D}\right)^2$. We set $\varphi^d = \bar{\varphi} = 2$ and the scaling parameter of intermediation cost of interbank lending to $\kappa = 0.025$. Using these values, we match the relative volatilities of the growth rates of total firm loans, interbank loans, and deposits in the model to those in the data. The fixed loan intermediation cost, ι, is set to 0.02, which is the average interest rate spread in the model, and we normalize the world interest rate R_t^w to 1 at all times.

The exogenous shock processes are AR(1) with persistence parameters $\rho^\theta = \rho^{gbs} = \rho^{lbs} = 0.95$. We set the standard deviation of the global banking shock, σ^{gbs}, to 0.025 and that of the local deposit shock, σ^{lbs}, to 0.04, matching the volatility of the interbank lending, loan, and deposit growth rates. The standard deviation of the TFP shocks σ^{θ} is 0.0091, which helps match the standard deviation of the growth rates of real GDP.

Business cycle properties The business cycle properties of the calibrated model are given in Table 5. The first two columns present statistics for model simulations calibrated to 'Austria,' which is typical for the countries in our sample in terms of IBD and DBD, while the last two columns contain the respective data-counterparts, calculated as an average over the countries in the sample using data from Eurostat and BIS. We present the statistics for the following variables: GDP, consumption, investment, employment, deposits, total firm loans, interbank loans, and net exports-to-lagged-GDP ratio. Empirical moments are obtained from the pre-crisis sample 1997Q1–2007Q4.

7 Quantitative results

Impulse responses Figure 7 displays model impulse responses to the global banking shock. We provide impulse responses to (negative) sectoral TFP and to the local banking shocks in the online appendix, Figures A.3, A.4, and A.5.

Each figure provides impulse responses for three different calibrations of the model: the baseline calibration—which we take to be Austria, as described in the previous section—a low-interbank-dependence scenario in which IBD in steady state is set to 50 percent of the baseline level, and a scenario in which domestic bank dependence (effectively: the size of the SME sector) in steady state is set to 50 percent of the baseline level, while all other parametrizations are as in the baseline case.

The impulse responses in the first row of Figure 7 show that a global banking shock leads to a protracted decline of GDP, wages, and employment. There is also a marked decline in consumption (see the panel in the third row). Consistent with our central hypothesis, all these real effects are attenuated when local banks are less dependent on interbank funding, and when domestic bank dependence is lower. The panels in the second row show that a global banking shock leads to a reduction in aggregate global bank lending and, consistent with our basic mechanism, this reduction falls mainly on cross-border interbank lending, while direct lending to large firms (second panel in the fifth row) declines much less. The sudden stop in cross-border lending leads to an increase in net exports. Because cross-border interbank lending falls markedly, local banks try to make up for this funding shortfall by attracting additional deposits (see the third row of Figure 7).

Lower interbank dependence mutes the response of deposits, but leads to a larger (percentage) decline in cross-border interbank lending. Turning to the responses of sector-level variables (rows 4 and 5), we find that both sectors see marked declines in lending (by global banks to large firms and by local banks to SMEs) and an increase in the associated interest rates, but the drop in lending and the increase in interest rates is stronger for the SME sector. Output also declines more in the SME sector.

Higher levels of interbank dependence attenuate the differences between sectors. Low IBD benefits SME output, but deteriorates the output response to a global banking shock for large firms. The explanation for this can be found from inspecting the responses of sectoral lending to a global banking shock: consistent with Figure 6, lending to small firms reacts more to the global banking shock than lending to large firms, but while the elasticity of lending to large firms is unaffected, lending to small firms becomes less elastic with respect to the global banking shock as IBD declines.

To understand the impact of lowering domestic bank dependence, recall that domestic bank dependence in our model corresponds to the size of the SME sector and reducing the size of this sector therefore attenuates the impact of a global banking shock on aggregate variables such as GDP and wages via compositional effects. By contrast, lower domestic bank dependence has virtually no effect on sector-level outcomes nor on how the shock affects local bank funding.

Matching the IV regressions We further evaluate the model by asking whether it can replicate the country-sector-level IV regressions presented in Table 3. Having verified this, we use the model to assess to what extent alternative configurations of shocks could explain our empirical findings. We calibrate the model to our sample, for each country matching GDP, domestic bank dependence and interbank dependence as described in the subsection on calibration above. For each country, we simulate the data for 60 quarters by drawing a realization of the global banking shock and by drawing separate realizations for each country of the local banking shock and the sectoral TFP shocks. From these model-generated data, we calculate annual growth rates of real output by sector and country, $(\Delta \log \text{GVA}_t^{c,s})$ and country-level bank lending (CreditGrowth_t^c), and we construct the counterpart of GBS by computing the growth rate of aggregate (across countries) model-simulated interbank lending. Our model does not feature heterogeneous domestic banks and the analog of the granular instrumental variable in the model-generated data is $\mathcal{G}_t^c = \text{DBD}_{t-1}^c \times \text{IBD}_{t-1}^c \times \text{GBS}_t^c$. We then run the IV regression (7), and the reduced form (8), on the artificial panel of 22 country-sectors (eleven countries with one SME and one large firm sector each), including country-sector and country-time fixed effects.

Table 6 presents results, obtained from averaging regression coefficients and constructing t-statistics from the distribution of 1000 simulations as described in the previous paragraph, for various model scenarios that we describe shortly. The first row of the table presents the IV estimate on which we focus here, because it is our main coefficient of interest, capturing the causal link between loan supply and sectoral outputs. To show the relevance of the instrument $\mathcal{G}_t^c$ in the model-simulated data, we also report first-stage and reduced form results in the second and third rows.

The average model-simulated IV regression coefficient in the baseline scenario reported in the first row of column (1) is 0.33, which almost exactly matches our IV estimate of 0.34 from Table 3 above. The first stage and reduced-form estimates are significant, albeit smaller than those found for the empirical data.

In column (2), we examine whether our results can be ascribed to global banking sector shocks. In column (2), we switch off all shocks other than the global banking shock when simulating the data and re-run our regression. The estimates of the coefficient of interest remain virtually unchanged from the baseline specification in column (1), where all shocks were switched on. We draw two conclusions from column (2). First, the global banking shock on its own seems sufficient to quantitatively account for the size of the IV coefficient in the real data. Second, the comparison between columns (1) and (2) reveals that the IV regression correctly identifies the magnitudes of the coefficient, even in the presence of a range of other structural shocks—at least if these shocks are uncorrelated with the global banking sector shock, as is the case in the baseline scenario.

Columns (3) and (4) examine whether other plausible shock-scenarios might confound these conclusions. For example, it is conceivable that the European sovereign debt crisis was a run on domestic banks by domestic depositors that was synchronized across countries; e.g., because of contagion. We simulate such a scenario in column (3), by switching off the global banking shock and by allowing local banking shocks to be correlated across countries. Estimating our main regression on model-simulated data reveals that this scenario cannot account for the effect of GBS on high-SME sectors: the IV coefficient is clearly insignificant, as are the first stage and the reduced form estimates.

The eurozone crisis could also have reflected a sudden and synchronized deterioration of fundamentals (and a drop in credit demand) that particularly affected small-firm intensive sectors. In column (4), we therefore consider a scenario in which we allow TFP shocks in the SME sector to be correlated across countries while switching off the global banking shock. Again, the IV coefficient is clearly insignificant, along with the first-stage and reduced-form estimates.

Taken together, the results in columns (1)–(4) show that plausible alternative shock scenarios alone cannot account for the patterns we observe in our IV regressions, and that a global banking shock is required to explain them. However, it is still conceivable that our conclusions regarding the quantitative importance of the global banking shock could be confounded by the simultaneous occurrence of local banking crises or by a sudden drop in local credit demand that happened at the same time as global banks started to retrench from cross-border interbank lending to eurozone countries.

To account for these possibilities, in columns (5) and (6), we reconsider the scenarios from columns (3) and (4), but now by switching the global banking shock back on, and allowing it to be correlated with the local banking shocks or the country-specific TFP shocks in the SME sector, respectively. Column (5), with correlated local and global banking shocks, shows that our main coefficient of interest remains unaffected, while the first-stage and the reduced-form estimates now are closer to the empirical estimates. This suggests that local banking sector shocks—which are likely to have occurred during the crisis—could have affected our first stage, but that they do not bias the IV estimate. By contrast, in column (6), where the global banking shock is correlated with local TFP shocks in the SME sector, the IV coefficient doubles relative to the baseline while the first stages remain almost unchanged. This makes the coefficient of interest implausibly large when compared to the estimates obtained from real data, allowing us to effectively rule out this scenario. We therefore conclude that a shock to the global banking sector is required for the model to explain the growth differential between SME-intensive and other sectors.

8 Conclusion

After the inception of the euro, the real economy in most member countries remained dependent on the provision of credit by domestic banks, which increasingly funded themselves through cross-border interbank borrowing. This pattern of 'double-decker' banking integration exposed economies and sectors that were reliant on domestic banks to the sharp declines in cross-border interbank lending during the eurozone crisis. We show that domestic banks that were more reliant on interbank finance reduced lending more in response to this sudden stop in European interbank markets, and that sectors with many SMEs (that are particularly dependent on domestic banks for finance) saw the biggest declines in output as a result. To explain these patterns in the data, we propose a quantitative small open economy model that allows us to explore whether alternative shock scenarios such as local banking crises or synchronized negative credit demand shocks could explain our empirical findings. The upshot from the model is that they cannot, and that a global deleveraging shock leading to a sudden stop in cross-border interbank lending in the eurozone is required to quantitatively account for the protracted decline in economic output in the sectors most dependent on domestic banks.

Our findings have some interesting policy implications. Banking integration in the eurozone in the years before 2008 was of the 'wrong' kind, in the sense that it was driven by lending from international banks to domestic banks, rather than by lending from international banks to the real economy. This left firms highly exposed to global banking shocks without shielding them from shocks to the domestic banking sector. Banking integration in Europe may require a 'reset' that involves cross-border mergers between banks and consolidation of branch networks by retail banks across country-borders in the eurozone, as happened in the United States after the liberalization of state-level banking in the 1980s. This would enable international banks to operate genuine internal capital markets, allowing them to respond to the financing needs of small firms by reallocating credit across borders.

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Table 1: Bank-level regressions: domestic bank lending and interbank dependence

	(1)	(2)	(3)	(4)
$\text{GBS}_t \times \text{IBD}^b_{t-1}$	0.44***	0.44***	0.55***	0.55***
	(5.48)	(8.27)	(13.26)	(22.93)
IBD^b_{t-1}	-0.05**	0.02	-0.22***	-0.17***
	(-2.43)	(0.58)	(-5.82)	(-4.71)
$\log \text{ASSETS}^b_{t-1}$		-0.24***		-0.15***
		(-10.20)		(-7.15)
$\Delta \log \text{DEPOSITS}^b_t$			0.29***	0.27***
			(7.19)	(6.73)
Num.Obs.	32935	32935	32802	32802
R2 Adj.	0.07	0.11	0.19	0.21
$FE : bank$	X	X	X	X
$FE : country \times date$	X	X	X	X

NOTES: The table shows estimates of the bank-level regression (5)

$$\text{LendingGrowth}^b_t = \alpha \times \text{IBD}^b_{t-1} \times \text{GBS}_t + \mu^b + f^c_t + \text{CONTROLS}^b_t + \zeta^b_t \ ,$$

where the dependent variable is bank lending growth, IBD^b_{t-1} is interbank dependence (the share of short-term wholesale funding in total funding), and GBS_t is the global banking shock (see text for precise definitions). μ^b denotes bank fixed effects and f^c_t denotes country-year fixed effects. The vector CONTROLS^b_t includes bank-level log assets, ASSETS^b_{t-1}, and and deposit growth, $\Delta \log \text{DEPOSITS}^b_t$. The sample includes domestic banks from the eleven EMU countries in our sample over the years 1999–2013. Standard errors are two-way clustered by country and year. Statistical significance at the 1, 5, and 10 percent level is denoted by ***, **, and *.

Table 2: Country-sector level regressions (continuous $\text{SME}^{c,s}$)

	(1)	(2)	(3)	(4)
IV results				
$(\text{fit})\text{CreditGrowth}_t^c \times \text{SME}^{c,s}$	0.50**	0.50**	0.55**	0.50**
	(2.37)	(2.74)	(2.97)	(2.37)
$\widehat{f}_t^c \times \text{SME}^{c,s}$		-0.01		
		(-0.12)		
1st stage results				
$\mathcal{G}_t^c \times \text{SME}^{c,s}$	2.57***	2.48***	2.54***	2.57***
	(5.09)	(4.82)	(4.97)	(5.08)
$\widehat{f}_t^c \times \text{SME}^{c,s}$		0.07		
		(1.49)		
Num.Obs.	1672	1672	1672	1672
R2 Adj.	0.28	0.28	0.28	0.27
Weak inst. test	25.93 (0.00)	23.20 (0.00)	24.67 (0.00)	25.76 (0.00)
Reduced form				
$\mathcal{G}_t^c \times \text{SME}^{c,s}$	1.31*	1.27*	1.43*	1.31*
	(1.82)	(1.93)	(2.09)	(1.81)
$\widehat{f}_t^c \times \text{SME}^{c,s}$		0.03		
		(0.45)		
Num.Obs.	1694	1694	1694	1694
R2 Adj.	0.28	0.28	0.28	0.27
$FE : date \times sector$	X	X	X	X
$FE : date \times country$	X	X	X	X
$FE : country \times sector$	X	X	X	X
$Slopes : sector \times \widehat{f}_t^c$			X	
$Slopes : country \times \widehat{f}_t^c$				X

NOTES: The upper and middle panels of the table show IV and first-stage estimates of the country-sector panel IV regression (7)

$$\Delta \log \text{GVA}_t^{c,s} = \gamma \times \text{SME}^{c,s} \times \text{CreditGrowth}_t^c + \text{CONTROLS}_t^{c,s} + \eta_t^{c,s} ,$$

using $\text{SME}^{c,s} \times \mathcal{G}_t^c$ as an instrument for $\text{SME}^{c,s} \times \text{CreditGrowth}_t^c$, where $\text{SME}^{c,s}$ is the SME share in value added in country-sector c, s in 2008 and $\mathcal{G}_t^c$ is an aggregate of the exposures of individual banks in country c to the global banking shock, see main text for details. The lower panel reports estimates of the corresponding reduced-form regression (8)

$$\Delta \log \text{GVA}_t^{c,s} = \gamma \times \text{SME}^{c,s} \times \mathcal{G}_t^c + \text{CONTROLS}_t^{c,s} + \eta_t^{c,s}.$$

$\text{CONTROLS}_t^{c,s}$ includes the interactions of $\text{HiSME}^{c,s}$ with the country-time shocks $\widehat{f}_t^c$ (estimated from the domestic bank-level regression presented in Table 1, column (4)) and the various fixed effects as indicated at the bottom of the table. In columns (3) and (4), we allow for sector- and country-specific slopes on the estimates of the country-time shocks $\widehat{f}_t^c$. The sample covers eleven EMU countries and eleven NACE rev. 2 one-digit sectors over the period 1999–2013. Standard errors are two-way clustered by country and year. Statistical significance at the 1, 5, and 10 percent level is denoted by ***, **, and *.

Table 3: Country-sector level regressions (discrete $\text{SME}^{c,s}$)

	(1)	(2)	(3)	(4)
IV results				
$(\text{fit})\text{CreditGrowth}_t^c \times \text{HiSME}^{c,s}$	0.34**	0.34**	0.35**	0.34**
	(2.25)	(2.23)	(2.23)	(2.24)
$\widehat{f}_t^c \times \text{HiSME}^{c,s}$		-0.01		
		(-0.39)		
1st stage results				
$\mathcal{G}_t^c \times \text{HiSME}^{c,s}$	2.11***	2.11***	2.10***	2.11***
	(4.48)	(4.64)	(4.47)	(4.47)
$\widehat{f}_t^c \times \text{HiSME}^{c,s}$		0.04		
		(0.91)		
Num.Obs.	1672	1672	1672	1672
R2 Adj.	0.27	0.27	0.27	0.27
Weak inst. test	20.09 (0.00)	21.49 (0.00)	20.00 (0.00)	19.96 (0.00)
Reduced form				
$\mathcal{G}_t^c \times \text{HiSME}^{c,s}$	0.75*	0.75*	0.76*	0.75*
	(2.10)	(2.13)	(2.12)	(2.09)
$\widehat{f}_t^c \times \text{HiSME}^{c,s}$		0.01		
		(0.91)		
Num.Obs.	1694	1694	1694	1694
R2 Adj.	0.28	0.28	0.28	0.28
$FE : date \times sector$	X	X	X	X
$FE : date \times country$	X	X	X	X
$FE : country \times sector$	X	X	X	X
$Slopes : sector \times \widehat{f}_t^c$			X	
$Slopes : country \times \widehat{f}_t^c$				X

NOTES: The upper and middle panels of the table show IV and first-stage estimates of the country-sector panel IV regression (7)

$$\Delta \log \text{GVA}_t^{c,s} = \gamma \times \text{HiSME}^{c,s} \times \text{CreditGrowth}_t^c + \text{CONTROLS}_t^{c,s} + \eta_t^{c,s} ,$$

using $\text{HiSME}^{c,s c,s} \times \mathcal{G}_t^c$ as an instrument for $\text{HiSME}^{c,s} \times \text{CreditGrowth}_t^c$ where $\text{HiSME}^{c,s}$ is an indicator variable that is unity (zero) if country-sector c, s has a 2008 SME-share in value added above (below) the median of all country-sectors. $\mathcal{G}_t^c$ is an aggregate of the exposures of individual banks in country c to the global banking shock, see main text for details. The lower panel reports estimates of the corresponding reduced-form regression (8)

$$\Delta \log \text{GVA}_t^{c,s} = \gamma \times \text{HiSME}^{c,s} \times \mathcal{G}_t^c + \text{CONTROLS}_t^{c,s} + \eta_t^{c,s} ,$$

$\text{CONTROLS}_t^{c,s}$ includes the interactions of $\text{HiSME}^{c,s}$ with the country-time shocks $\widehat{f}_t^c$ (estimated from the domestic bank-level regression presented in Table 1, column (4)) and the various fixed effects as indicated at the bottom of the table. In columns (3) and (4), we allow for sector- and country-specific slopes on the estimates of the country-time shocks $\widehat{f}_t^c$. The sample covers eleven EMU countries and eleven NACE rev. 2 one-digit sectors over the period 1999–2013. Standard errors are two-way clustered by country and year. Statistical significance at the 1, 5, and 10 percent level is denoted by ***, **, and *.

Table 4: Calibration targets for GDP, IBD and DBD by country

	GDP	IBD	DBD
Austria	0.57	0.26	0.68
Belgium	0.70	0.26	0.46
Finland	0.37	0.28	0.44
France	3.98	0.39	0.54
Germany	5.51	0.28	0.78
Greece	0.43	0.18	0.85
Ireland	0.33	0.22	0.62
Italy	3.36	0.25	0.73
Netherlands	1.23	0.21	0.51
Portugal	0.35	0.21	0.68
Spain	1.92	0.27	0.75

NOTES: This table reports values of GDP, interbank dependence (IBD), and domestic bank dependence (DBD) for the eleven EMU countries in our sample that we match for each country in our calibration of the model. The values for GDP and DBD are constructed as pre-2008 within-country averages. Nominal GDP is measured at a quarterly frequency and in 100 billion euros. The values for IBD are constructed as pre-2008 country averages of bank-level measures, IBD_t^b, which we aggregate to the country level using lagged bank-level net loans as weights.

Table 5: Business cycle properties of the model

	Austria		Data	
	Std. Dev.	Corr.	Std. Dev.	Corr.
GDP	0.69		0.69	
Consumption	2.15	0.21	0.88	0.47
Investment	3.76	0.17	3.89	0.48
Employment	0.70	0.21	0.67	0.34
Deposits	2.70	0.09	2.62	-0.03
Loans	2.26	0.40	2.26	0.30
B2B lending	13.15	0.24	13.05	0.06
Net exports	1.53	-0.35	2.97	0.06

NOTES: The table reports theoretical (simulated) and empirical standard deviations ('St.Dev.') and correlations ('Corr.') of the main variables in the model (where B2B_t^c is cross-border interbank ('bank-to-bank') lending to domestic banks in each country). The theoretical moments are shown for Austria, which is the 'representative' country in our sample. The empirical moments are calculated as an average over eleven EMU countries in our sample using data from Eurostat and BIS. All variables refer to the respective growth rates (log-differences), except for net exports, which are in proportion to previous-year nominal GDP. For each variable in the table, we present the standard deviations relative to the standard deviation of GDP and correlation with domestic GDP. The standard deviation of GDP, marked with an asterisk, is an absolute value. All model statistics are obtained from 1000 model simulations of the baseline scenario over 250 quarters (with the first 50 quarters dropped). Empirical moments are obtained from the pre-crisis sample 1997Q1–2007Q4.

Table 6: Model simulation results under counterfactuals

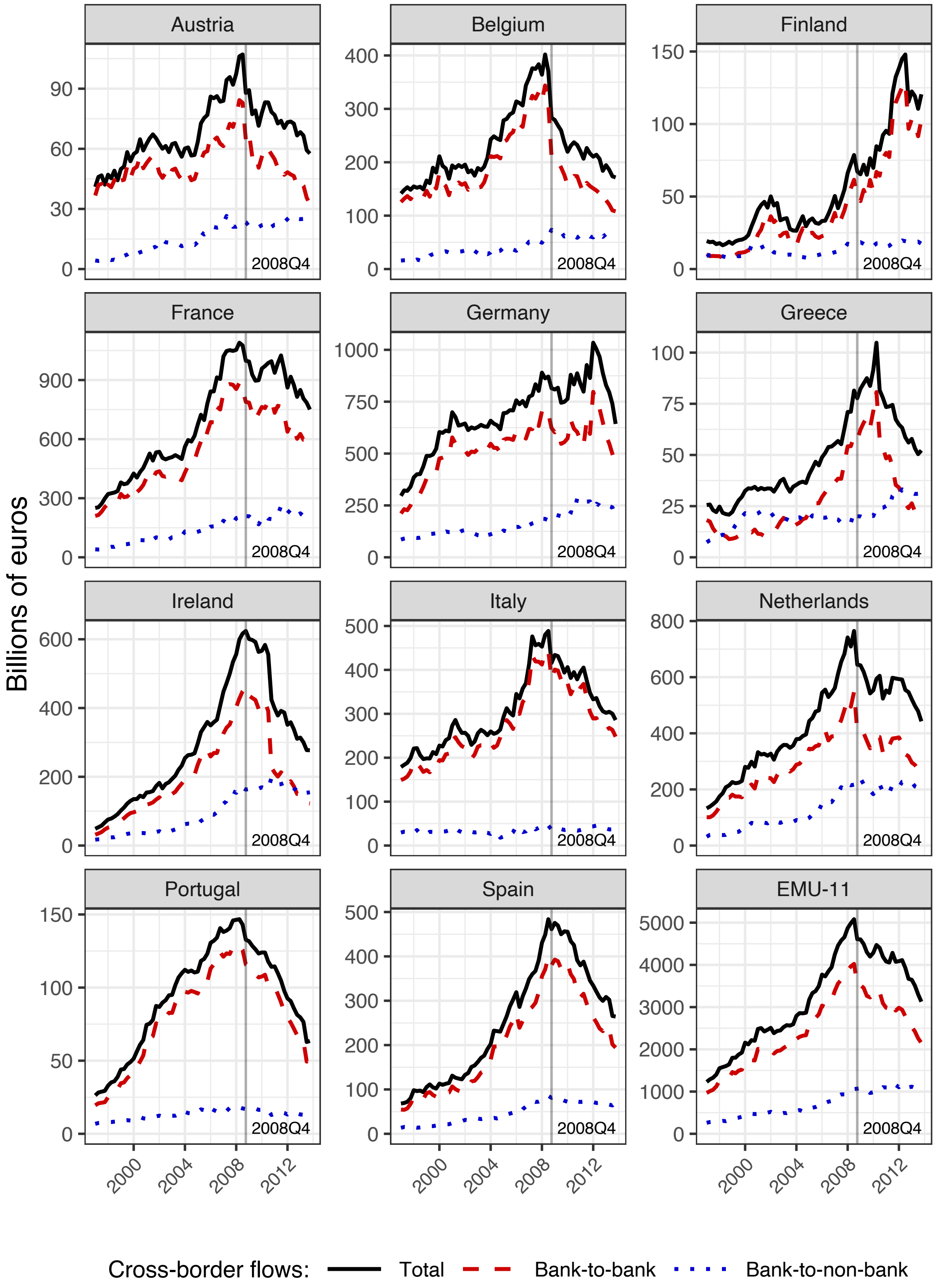
	(1)	(2)	(3)	(4)	(5)	(6)
			Synchronised, no GBS		Correlated with GBS	
	Baseline	Only GBS	LBS	SME	LBS	SME
IV	0.33***	0.33***	-1.52	0.57	0.36***	0.65***
	(5.52)	(154.26)	(-0.04)	(0.03)	(6.61)	(14.16)
IV 1st stage	0.88***	0.96***	0.06	0.24	1.70***	0.95***
	(4.40)	(4.77)	(0.58)	(1.23)	(8.39)	(4.11)
Reduced form	0.29***	0.32***	-0.06	0.29	0.61***	0.62***
	(3.38)	(4.71)	(-0.44)	(0.55)	(5.07)	(3.89)
Num. Obs.	308	308	308	308	308	308

NOTES: The table reports estimates from the regression:

$$\Delta \log \mathrm{GVA}_t^{c,s} = \gamma \times \mathrm{SME}^s \times \mathrm{CreditGrowth}_t^c + \tau_t^c + \mu^{c,s} + \varepsilon_t^{c,s}.$$

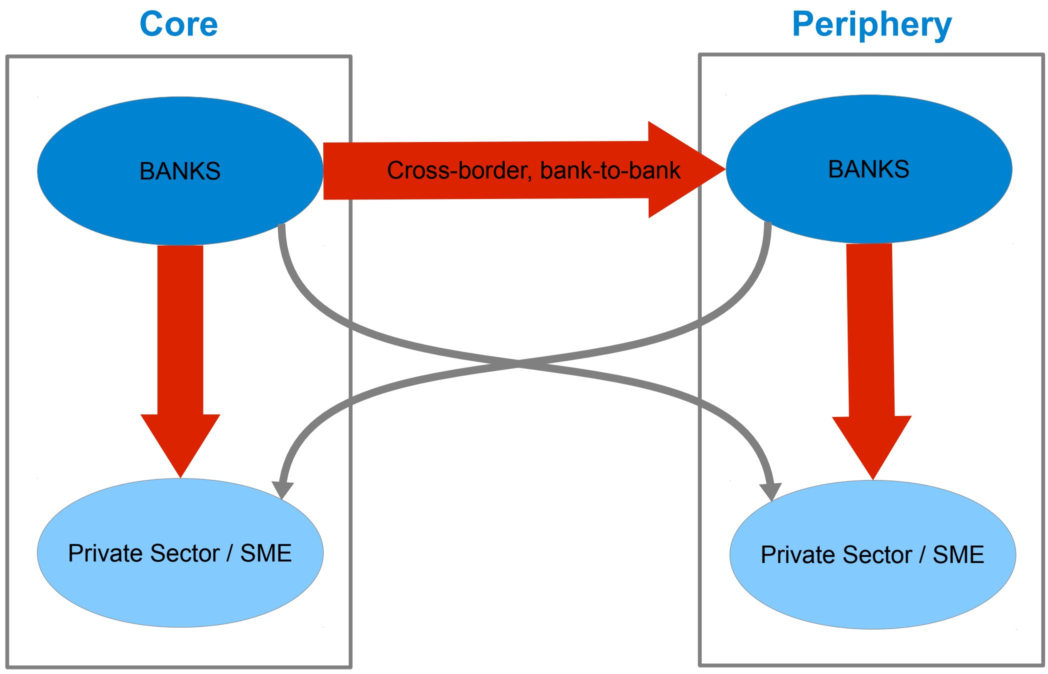
The rows correspond to different estimation approaches: row (1) shows IV estimates, in which the term $\mathrm{SME}^s \times \mathrm{CreditGrowth}_t^c$ is instrumented with $\mathrm{SME}^s \times \left(\mathrm{GBS}_t \times \mathrm{IBD}_{t-1}^c \times \mathrm{DBD}_{t-1}^c\right)$; row (2) shows the IV 1st stage; and row (3) shows the reduced form. c denotes country, s denotes sector, SME is SME share, GBS is the model equivalent of the global banking shock, IBD is the model equivalent of interbank dependence, and DBD is the model equivalent of domestic banking dependence; see main text for precise definitions. Estimated coefficients and t-stats (in parentheses) are derived from sample means and standard deviations of simulated regression coefficients. For each simulation, we run the regressions, save the estimated coefficients, and use their distribution to construct the reported values. The data has been obtained and annualized for 1000 model simulations over 60 quarters, using 40 quarters of additional 'pre-sample' observations, such that the final sample spans 15 years representing the 1999–2013 period, for eleven model EMU countries: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, and Spain. Statistical significance at the 1, 5, and 10 percent level is denoted by ***, **, and *.
The scenarios are as follows: 'Baseline:' all shocks—global banking shock (GBS), local banking shock (LBS), productivity shocks for SMEs and large firms (SME TFP and BF TFP, respectively) are 'on' and random (GBS is the same for all countries, but different across simulations); 'Only GBS:' only GBS is 'on,' other shocks are 'off;' 'Synchronized LBS shocks, no GBS': all shocks are 'on' but GBS is 'off,' LBS shocks are synchronized across countries; 'Synchronized SME shocks, no GBS': all shocks are 'on,' but GBS is 'off,' SME TFP shocks are synchronized across countries; 'LBS shocks, correlated with GBS:' all shocks are 'on,' LBS shocks are correlated with GBS (and thus also synchronized across countries); 'SME shocks, correlated with GBS:' all shocks are 'on,' SME TFP shocks are correlated with GBS (and thus also synchronized across countries). In the correlated-shocks scenarios, the cross-country pairwise correlation of the respective shocks equals 0.8.

Figure 1: Cross-border bank lending in the eurozone



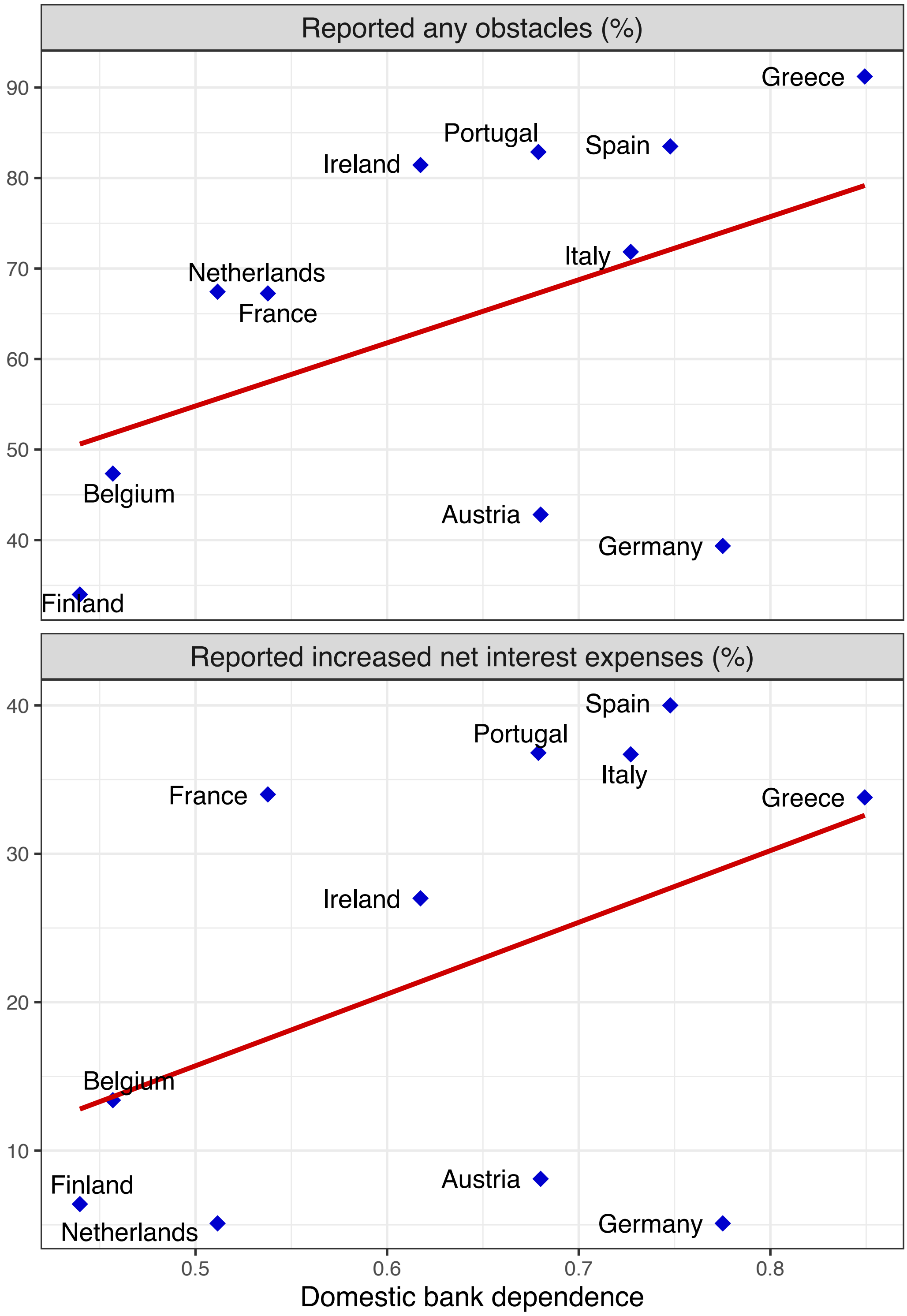
NOTES: The figure plots cross-border lending by foreign banks to each country. The last panel plots cross-border flows aggregated over the eleven countries in our sample. The black solid line shows total lending, the red dashed line shows lending by foreign banks to domestic banks, and the blue dotted line shows lending by foreign banks to the domestic non-bank sector (including governments). Source: BIS locational banking statistics database.

Figure 2: Bank-to-bank integration vs. bank-to-real sector integration



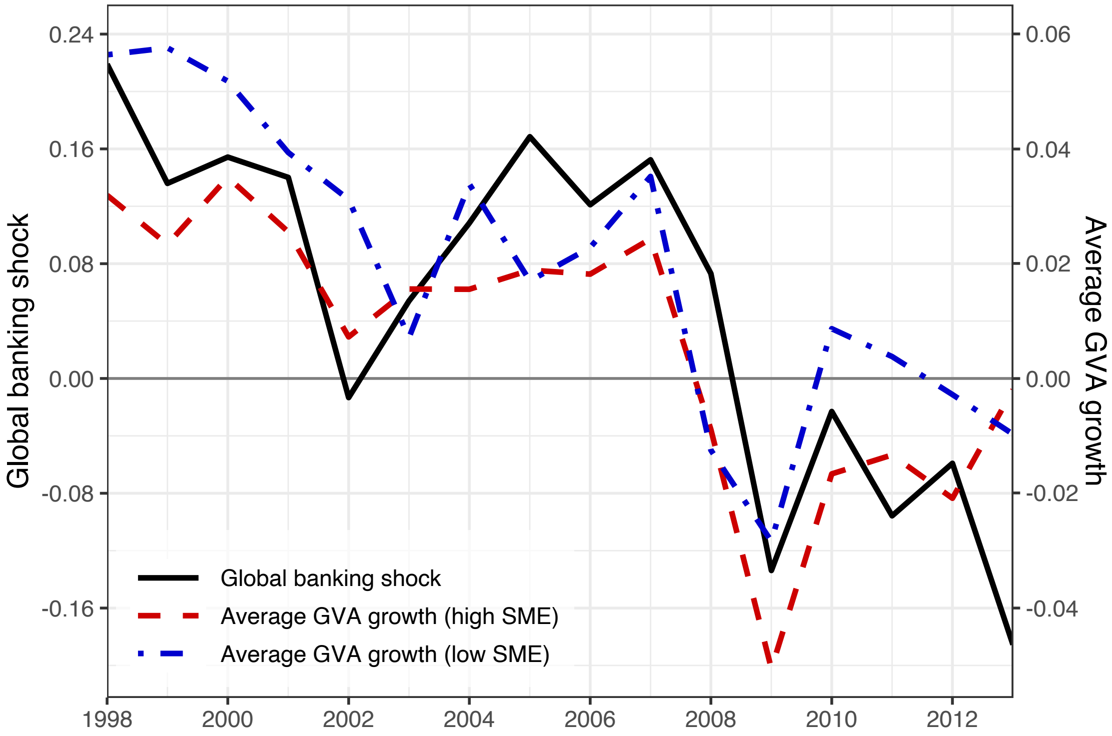
NOTES: The figure conceptualizes the structure of banking integration in the eurozone in the years before the financial crisis. Cross-border integration mainly took place between banks (bank-to-bank integration) with net flows largely in the direction of the periphery country (big red arrow in the middle). Cross-border flows from banks to the real sector remained very limited (thin gray arrows). This left periphery economies vulnerable to sudden stops in banking flows (due to the global crisis), while keeping the domestic banking sector exposed to country-specific shocks due to its domestically concentrated loan portfolio.

Figure 3: Domestic bank dependence and SME financial conditions



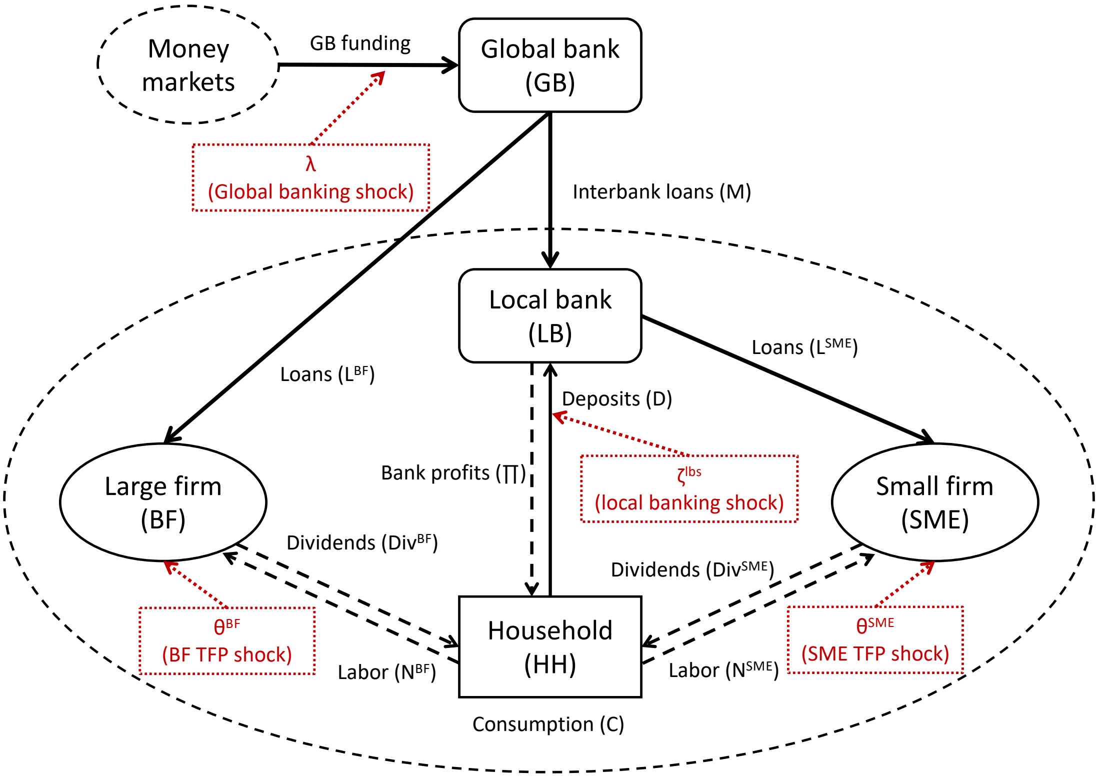
NOTES: The top panel plots the fraction of firms that reported any obstacles in obtaining finance in the ECB-EU Commission's Survey of Access to Finance of Enterprises (SAFE) 2011 against the pre-crisis average value of domestic bank dependence (the share of lending done by domestic banks) by country, DBD. The bottom panel plots the the fraction of firms that reported increased net interest expenses in SAFE 2011 against DBD. For the two regression lines, the slope (robust t-stat) $[R^2]$ in the top panel is 69.93 (1.72) [0.22], and in the bottom panel is 48.32 (1.79) [0.20].

Figure 4: Global banking shock and sectoral output growth



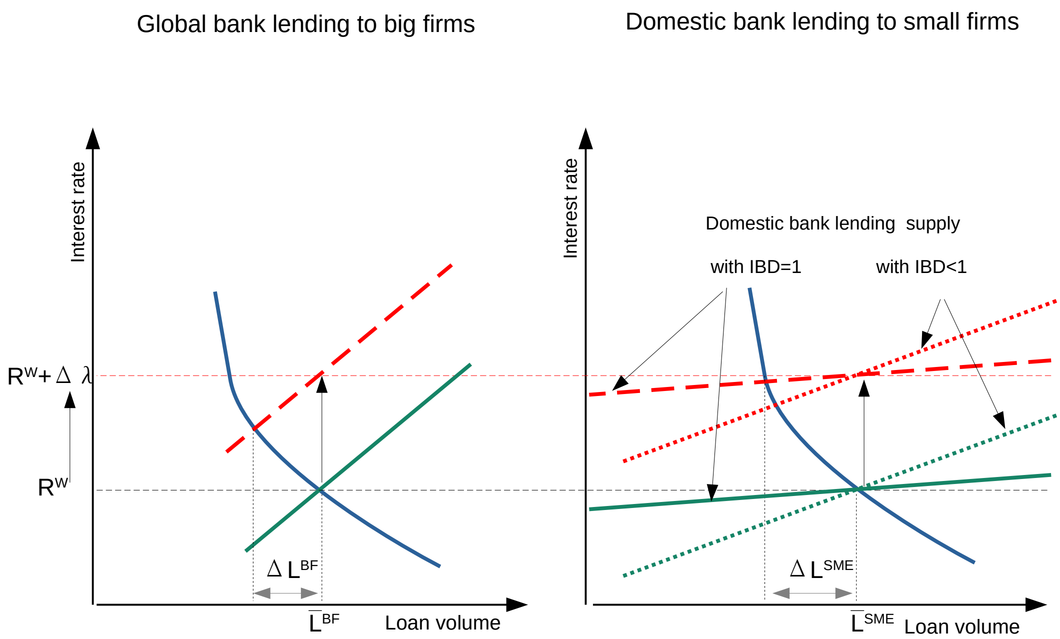
NOTES: The figure plots the global banking shock (black solid line, left y-axis), average growth rates of high (top tercile) SME country-sectors (red dashed line, right y-axis) and average growth rates of low (bottom tercile) SME country-sectors (blue dot-dashed line, right y-axis). The global banking shock is defined as the growth rate 1998–2013 of total yearly cross-border lending by foreign banks to the eleven EMU countries in our sample, $\text{GBS}_t = \Delta \log \sum_c \text{B2B}_t^c$, where B2B_t^c is cross-border interbank lending to domestic banks and c indexes Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, and Spain. Sources: BIS locational banking statistics database and Eurostat.

Figure 5: Model economy



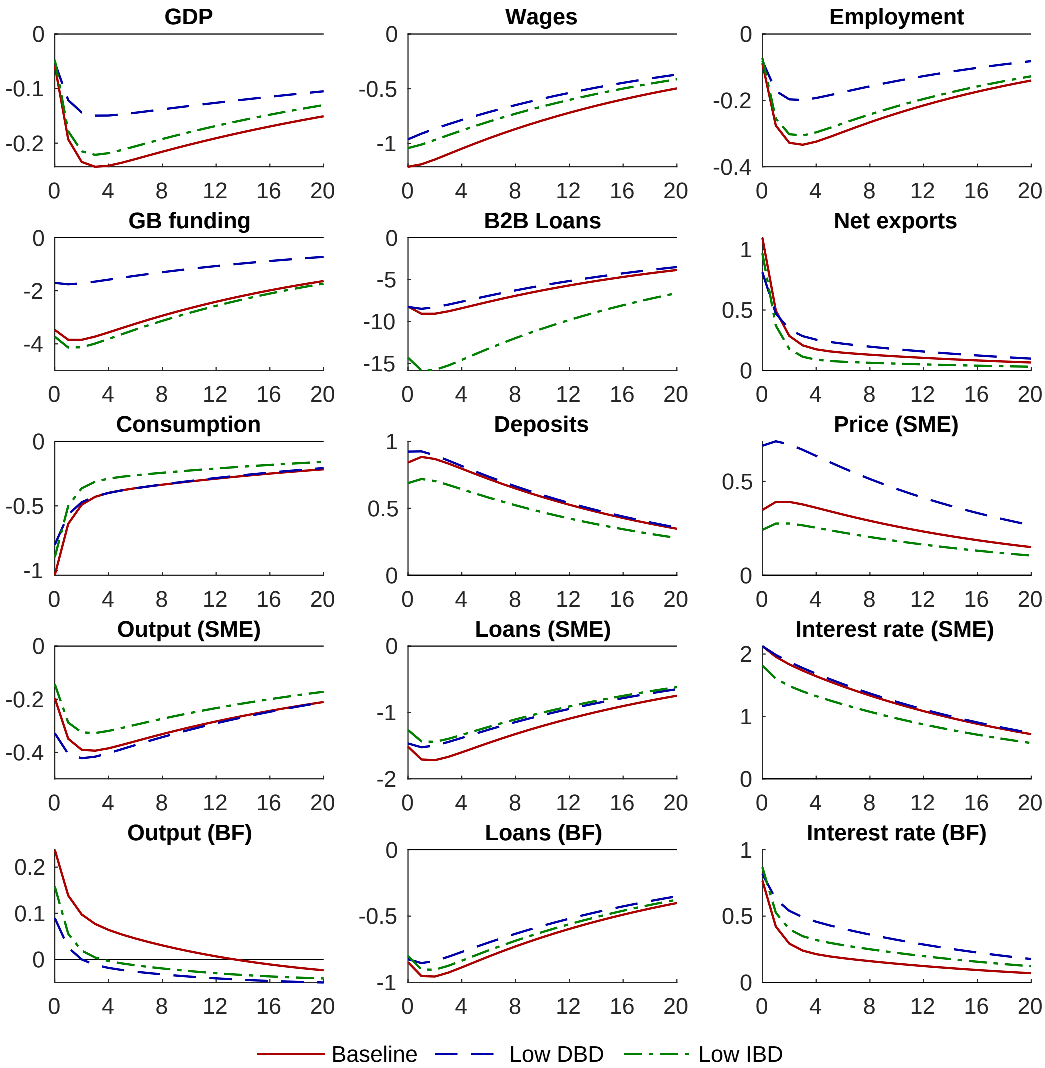
NOTES: The figure conceptualizes the structure of the model in Section 6. The model features a foreign ('global') and a domestic ('local') bank, and two sectors producing intermediate goods—one which is populated by 'large' firms, that borrow cross-border directly from global banks, and another one which is populated by 'small' firms, that borrow from local banks. The large dashed oval denotes the boundaries of the small open economy. The local bank lends to small firms and finances itself by raising deposits from domestic households and by borrowing from the global bank. The global bank borrows funds in the global wholesale market and lends cross-border to large firms and to the domestic bank. Solid lines denote flows of loans and funding. Dashed lines denote flows of dividends, profits, and labor. Red dashed boxes include the description of exogenous shocks in the economy—the global banking shock, the local banking shock, and TFP shocks to large firms and SMEs—with arrows pointing at the origin of the shock in the model. For expositional clarity, we do not show graphically the flows of goods and the final goods producer. The latter combines intermediate output by large firms and SMEs into a final good, which is used for consumption, investment, and net exports.

Figure 6: Model intuition



NOTES: The figure illustrates the differential impact of a deleveraging shock to the global bank on cross-border lending to large ('big') and small firms. Interbank depencence (IBD) is the local (i.e. domestic) bank's dependence on short-time wholesale funds as a share of total funding. The global bank's lending supply to large firms (solid green line in the left panel) is assumed to be less elastic than interbank lending supply to domestic banks. When the domestic bank is fully interbank dependent (IBD $= 1$) its lending supply to small firms is identical to the global bank's interbank lending supply (solid green line in the right panel). The deleveraging shock shifts lending supply for both firms upwards by $\Delta\lambda$ (dashed red lines) and the lower elasticity of lending supply to large firms implies that the reduction of lending to large firms (ΔL^{BF}) is smaller than that to small firms (ΔL^{SME}). Lowering interbank dependence, IBD, makes the supply of lending to small firms less elastic by rotating the domestic bank's supply curves counterclockwise (dotted lines in the right panel). This dampens the impact of the shock on ΔL^{SME}.

Figure 7: Model impulse responses to a global banking shock



NOTES: The graph plots the model impulse response functions of various variables for 'Baseline' (red solid lines), 'Low DBD' (blue dashed lines), and 'Low IBD' (green dot-dashed lines) scenarios to a one standard deviation global banking shock. DBD is the model equivalent of the share of lending done by domestic banks and IBD is the model equivalent of the share of banks' short-time wholesale funding in total funding, see main text for details. The 'Baseline' impulse responses are generated from a model simulated for 'Austria,' using parameter values from Table 4. The 'Low DBD' scenario illustrates the counterfactual in which DBD is reduced by 50% compared to the 'Baseline' scenario, while the 'Low IBD' scenario illustrates the counterfactual in which IBD is reduced by 50% compared to the 'Baseline' scenario. All impulse responses are percentage deviations from steady state, except for interest rates which are in percentage points, and net exports which are in proportion to the steady-state value of nominal GDP. Number of quarters following the shock is on the x-axis.

A. Appendix: Supplementary tables and figures

Table A.1: Summary stats

	Mean	Std. Dev.	25 Pct.	Median	75 Pct.	Obs
Domestic banks						
IBD_t^b	0.21	0.21	0.08	0.15	0.26	34671
LendingGrowth_t^b	0.05	0.30	0.00	0.03	0.09	32130
ASSETS_t^b	12.78	90.71	0.20	0.57	1.95	23127
$\Delta \log \text{DEPOSITS}_t^b$	0.05	0.34	0.00	0.03	0.08	31675
Foreign banks						
IBD_t^b	0.43	0.34	0.14	0.34	0.73	1002
LendingGrowth_t^b	0.06	0.50	-0.06	0.05	0.17	1003
ASSETS_t^b	21.97	67.63	0.82	2.66	12.68	1128
$\Delta \log \text{DEPOSITS}_t^b$	0.05	0.66	-0.09	0.04	0.20	893

NOTES: The table shows descriptive statistics for the variables in our main bank lending growth regression. IBD_t^b is interbank dependence (the share of short-term wholesale funding in total funding), LendingGrowth_t^b is growth of net loans, ASSETS_t^b is assets in billions of euros, and $\Delta \log \text{DEPOSITS}_t^b$ is the growth rate of total customer deposits. The sample includes domestic banks from the eleven EMU countries in our sample for the years 1999–2013. See main text for precise definitions.

Table A.2: Bank-level regressions: Short-term funding of domestic banks and interbank dependence

	(1)	(2)	(3)	(4)
$\text{GBS}_t \times \text{IBD}^b_{t-1}$	2.00*	2.03*	2.02*	2.04*
	(2.06)	(2.19)	(2.03)	(2.12)
IBD^b_{t-1}	-2.10***	-2.04***	-2.20***	-2.13***
	(-3.82)	(-3.60)	(-4.02)	(-3.83)
$\log \text{ASSETS}^b_{t-1}$		-0.25***		-0.20***
		(-8.77)		(-5.78)
$\Delta \log \text{DEPOSITS}^b_t$			0.20**	0.16*
			(2.42)	(2.05)
Num.Obs.	31289	31289	31214	31214
R2 Adj.	0.24	0.24	0.24	0.25
$FE : bank$	X	X	X	X
$FE : country \times date$	X	X	X	X

NOTES: The table shows estimates of the bank-level regression

$$\text{FundingGrowth}^b_t = \alpha \times \text{IBD}^b_{t-1} \times \text{GBS}_t + \mu^b + f^c_t + \text{CONTROLS}^b_t + \zeta^b_t \ ,$$

where the dependent variable is bank short-term funding growth, IBD^b_{t-1} is interbank dependence (the share of short-term wholesale funding in total funding), and GBS_t is the global banking shock (see text for precise definitions). μ^b denotes bank fixed effects and f^c_t denotes country-year fixed effects. The vector CONTROLS^b_t includes bank-level log assets, ASSETS^b_{t-1}, and and deposit growth, $\Delta \log \text{DEPOSITS}^b_t$. The sample includes domestic banks from the eleven EMU countries in our sample over the years 1999–2013. Standard errors are two-way clustered by country and year. Statistical significance at the 1, 5, and 10 percent level is denoted by ***, **, and *.

Table A.3: Bank-level regressions: foreign bank lending and interbank dependence

	(1)	(2)	(3)	(4)
$\text{GBS}_t \times \text{IBD}^b_{t-1}$	0.26	0.05	0.48	0.27
	(0.45)	(0.09)	(0.86)	(0.48)
IBD^b_{t-1}	-0.23*	-0.14	-0.36**	-0.26*
	(-2.03)	(-1.34)	(-2.60)	(-2.29)
$\log \text{ASSETS}^b_{t-1}$		-0.21***		-0.20***
		(-3.68)		(-3.77)
$\Delta \log \text{DEPOSITS}^b_t$			0.10*	0.10*
			(2.01)	(2.00)
Num.Obs.	918	918	904	904
R2 Adj.	0.07	0.10	0.08	0.11
$FE : bank$	X	X	X	X
$FE : country \times date$	X	X	X	X

NOTES: The table shows estimates of the bank-level regression (5), i.e.

$$\text{LendingGrowth}^b_t = \alpha \times \text{IBD}^b_{t-1} \times \text{GBS}_t + \mu^b + f^c_t + \text{CONTROLS}^b_t + \zeta^b_t \ ,$$

where the dependent variable is bank lending growth, IBD^b_{t-1} is interbank dependence (the share of short-term wholesale funding in total funding), and GBS_t is the global banking shock (see text for precise definitions). μ^b denotes bank fixed effects and f^c_t denotes country-year fixed effects. The vector CONTROLS^b_t includes bank-level log assets, ASSETS^b_{t-1}, and and deposit growth, $\Delta \log \text{DEPOSITS}^b_t$. The sample includes foreign banks from the eleven EMU countries in our sample for the years 1999–2013. Standard errors are two-way clustered by country and year. Statistical significance at the 1, 5, and 10 percent level is denoted by ***, **, and *.

Table A.4: Bank-level regressions: Short-term funding of foreign banks and interbank dependence

	(1)	(2)	(3)	(4)
$\text{GBS}_t \times \text{IBD}^b_{t-1}$	0.20	-0.04	0.19	-0.03
	(0.30)	(-0.05)	(0.28)	(-0.05)
IBD^b_{t-1}	-0.94***	-0.89***	-0.98***	-0.92***
	(-8.12)	(-9.63)	(-7.57)	(-8.27)
$\log \text{ASSETS}^b_{t-1}$		-0.15		-0.14
		(-1.52)		(-1.52)
$\Delta \log \text{DEPOSITS}^b_t$			-0.01	-0.01
			(-0.16)	(-0.22)
Num.Obs.	882	882	875	875
R2 Adj.	0.00	0.01	0.00	0.01
$FE : bank$	X	X	X	X
$FE : country \times date$	X	X	X	X

NOTES: The table shows estimates of the bank-level regression

$$\text{FundingGrowth}^b_t = \alpha \times \text{IBD}^b_{t-1} \times \text{GBS}_t + \mu^b + f^c_t + \text{CONTROLS}^b_t + \zeta^b_t \ ,$$

where the dependent variable is bank short-term funding growth, IBD^b_{t-1} is interbank dependence (the share of short-term wholesale funding in total funding), and GBS_t is the global banking shock (see text for precise definitions). μ^b denotes bank fixed effects and f^c_t denotes country-year fixed effects. The vector CONTROLS^b_t includes bank-level log assets, ASSETS^b_{t-1}, and and deposit growth, $\Delta \log \text{DEPOSITS}^b_t$. The sample includes foreign banks from the eleven EMU countries in our sample for the years 1999–2013. Standard errors are two-way clustered by country and year. Statistical significance at the 1, 5, and 10 percent level is denoted by ***, **, and *.

Table A.5: Model calibration

Parameter	Value	Description
Households		
β	0.99	Households' discount factor
ψ	2	Inverse of Frisch elasticity
σ	1	Households' risk aversion
ϵ	0.4	Elasticity of substitution between consumption goods
Firms		
α	0.35	Capital intensity
φ^I	22	Investment adjustment cost parameter
δ	0.025	Capital depreciation
Banks		
φ^d	2	Deposits adjustment cost parameter
$\bar{\varphi}$	2	Global bank lending to firms intermediation cost parameter
κ	0.025	Global bank interbank lending intermediation scale parameter
ι	0.02	Average firm loans intermediation margin
R^w	1	Gross world interest rate
Shocks		
σ^θ	0.0091	Standard deviation of SME and BF TFP shocks
σ^{gbs}	0.025	Standard deviation of the global banking shock
σ^{lbs}	0.04	Standard deviation of the local banking shock
ρ^θ	0.95	Autocorrelation of SME and BF TFP shocks
ρ^{gbs}	0.95	Autocorrelation of the global banking shock
ρ^{lbs}	0.95	Autocorrelation of the local banking shock

NOTES: This table reports calibrated parameters, common for all the eleven EMU countries in our sample. The country-specific values of GDP, IBD, and DBD shares are reported in Table 4. The values of model parameters ω, Ψ, and λ are determined from steady-state restrictions.

Table A.6: Model counterfactuals with additional controls

	(1)	(2)	(3)	(4)	(5)	(6)
			Synchronised, no GBS		Correlated with GBS	
	Baseline	Only GBS	LBS	SME	LBS	SME
IV	0.33***	0.33***	0.23	-1.90	0.30**	0.30***
	(5.52)	(154.26)	(0.37)	(-0.08)	(2.32)	(3.19)
IV 1st stage	0.88***	0.96***	0.44***	0.13	1.24***	0.62***
	(4.40)	(4.77)	(3.26)	(1.11)	(7.92)	(3.84)
Reduced form	0.29***	0.32***	0.12	-0.11	0.38**	0.19**
	(3.38)	(4.71)	(0.61)	(-0.76)	(2.17)	(2.47)
Num. Obs.	308	308	308	308	308	308

NOTES: The table reports the estimates of the regression:

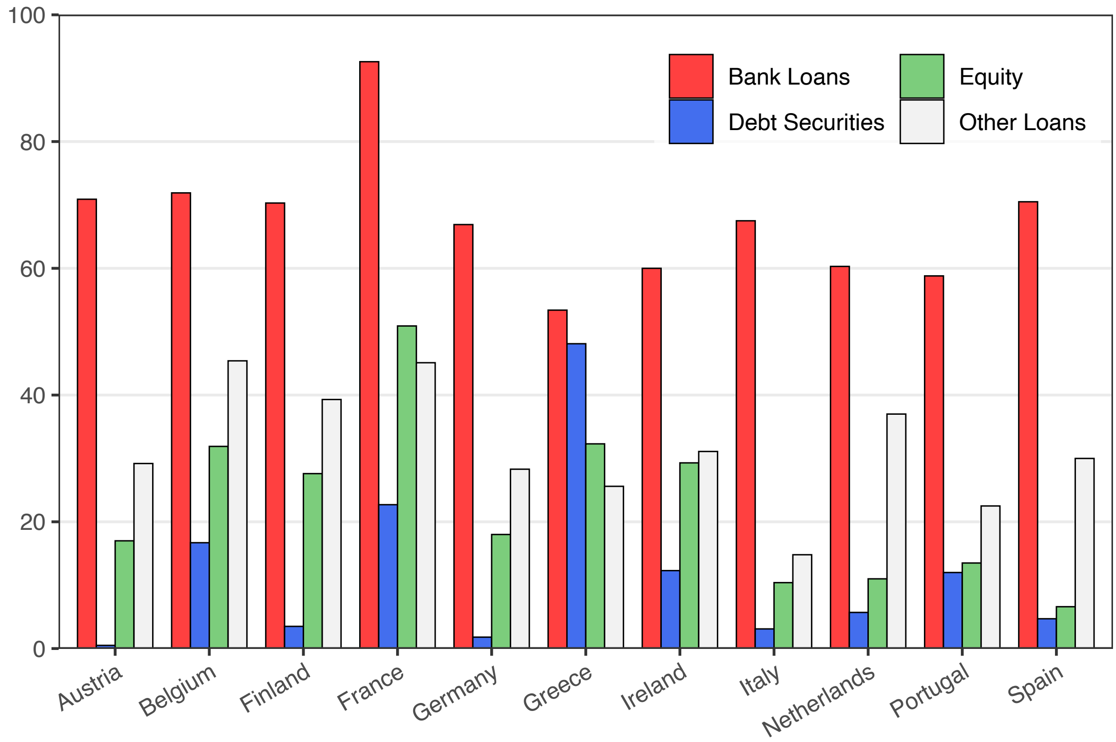
$$\Delta \log \text{GVA}_t^{c,s} = \gamma \times \text{SME}^s \times \text{CreditGrowth}_t^c + \text{CONTROLS} + \tau_t^c + \mu^{c,s} + \varepsilon_t^{c,s} \, .$$

The rows correspond to different estimation approaches: row (1) shows IV estimates, in which the term $\text{SME}^s \times \text{CreditGrowth}_t^c$ is instrumented with $\text{SME}^s \times \left(\text{GBS}_t \times \text{IBD}_{t-1}^c \times \text{DBD}_{t-1}^c\right)$; row (2) shows the IV 1st stage; and row (3) shows the reduced form. Columns (1)–(2) feature country-sector and country-time fixed effects only, the same as in Table 6. Columns (4)-(6), feature additional controls; the change of country-specific local banking shocks, $\Delta\zeta_t^{lbs,c}$, interacted with sectoral SME share ($\text{CONTROLS} = \text{SME}^s \times \Delta\zeta_t^{lbs,c}$) in columns (3) and (5), and the growth rate of county-specific SME TFP shocks, interacted with sectoral SME share ($\text{CONTROLS} = \text{SME}^s \times \Delta \log \theta_t^{\text{SME},c}$) in columns (4) and (6).

Estimated coefficients and t-stats (in parentheses) are derived from sample means and standard deviations of the simulated regression coefficients. In particular, for every of 1000 simulations, we run the regressions, save the estimated coefficients, and use their distribution to construct the reported values. The data has been obtained and annualized for 1000 model simulations over 60 quarters, using 40 quarters of additional 'pre-sample' observations, such that the final sample spans 15 years representing the 1999–2013 period, for eleven model EMU countries: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, and Spain. Statistical significance at the 1, 5, and 10 percent level is denoted by ***, **, and *.

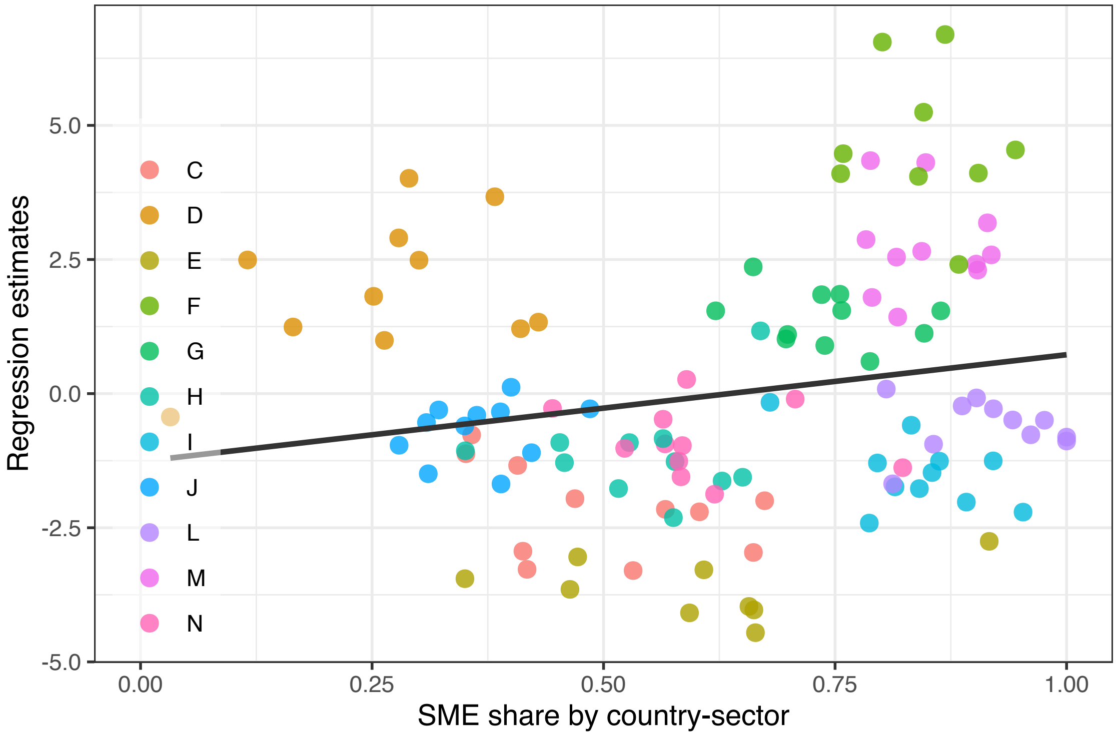
The scenarios are as follows: 'Baseline:' all shocks—global banking shock (GBS), local banking shock (LBS), productivity shocks for SMEs and large firms (SME TFP and BF TFP, respectively) are 'on' and random (GBS is the same for all countries, but different across simulations); 'Only GBS:' only GBS is 'on,' other shocks are 'off;' 'Synchronized LBS shocks, no GBS': all shocks are 'on' but GBS is 'off,' LBS shocks are synchronized across countries; 'Synchronized SME shocks, no GBS': all shocks are 'on,' but GBS is 'off,' SME TFP shocks are synchronized across countries; 'LBS shocks, correlated with GBS:' all shocks are 'on,' LBS shocks are correlated with GBS (and thus also synchronized across countries); 'SME shocks, correlated with GBS:' all shocks are 'on,' SME TFP shocks are correlated with GBS (and thus also synchronized across countries)—the pairwise correlation coefficients are equal to 0.8.

Figure A.1: Bank dependence of SMEs in the eurozone



NOTES: The figure reports the fraction of SMEs reporting to have used or to be currently using the respective source of external finance. The definition of SMEs follows the official EU approach, i.e., firms with less than 250 employees, and turnover less than 50 million euros or balance sheet total less than 43 million euros. The data source is the European Central Bank's and EU Commission's Survey of Access to Finance by Enterprises (SAFE) 2011 for eleven eurozone countries.

Figure A.2: Exposures to global banking shock and SME shares by country-sector

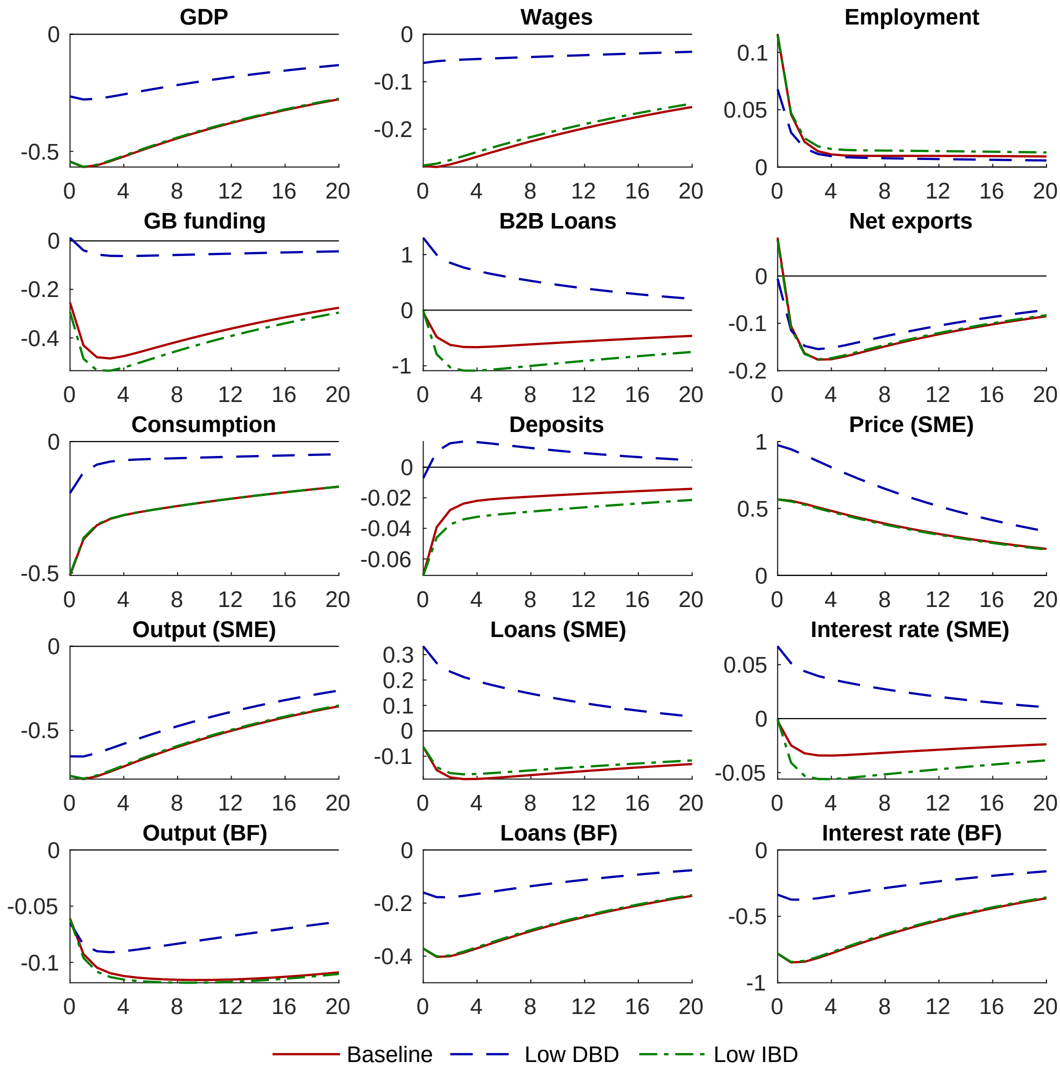


NOTES: The figure plots the estimates of $\gamma^{c,s}$ from the panel regression

$$\Delta \log \text{GVA}_t^{c,s} = \gamma^{c,s} \times \mathbf{1}^{c,s} \times \mathcal{G}_t^c + \text{fixed effects} + \eta_t^{c,s},$$

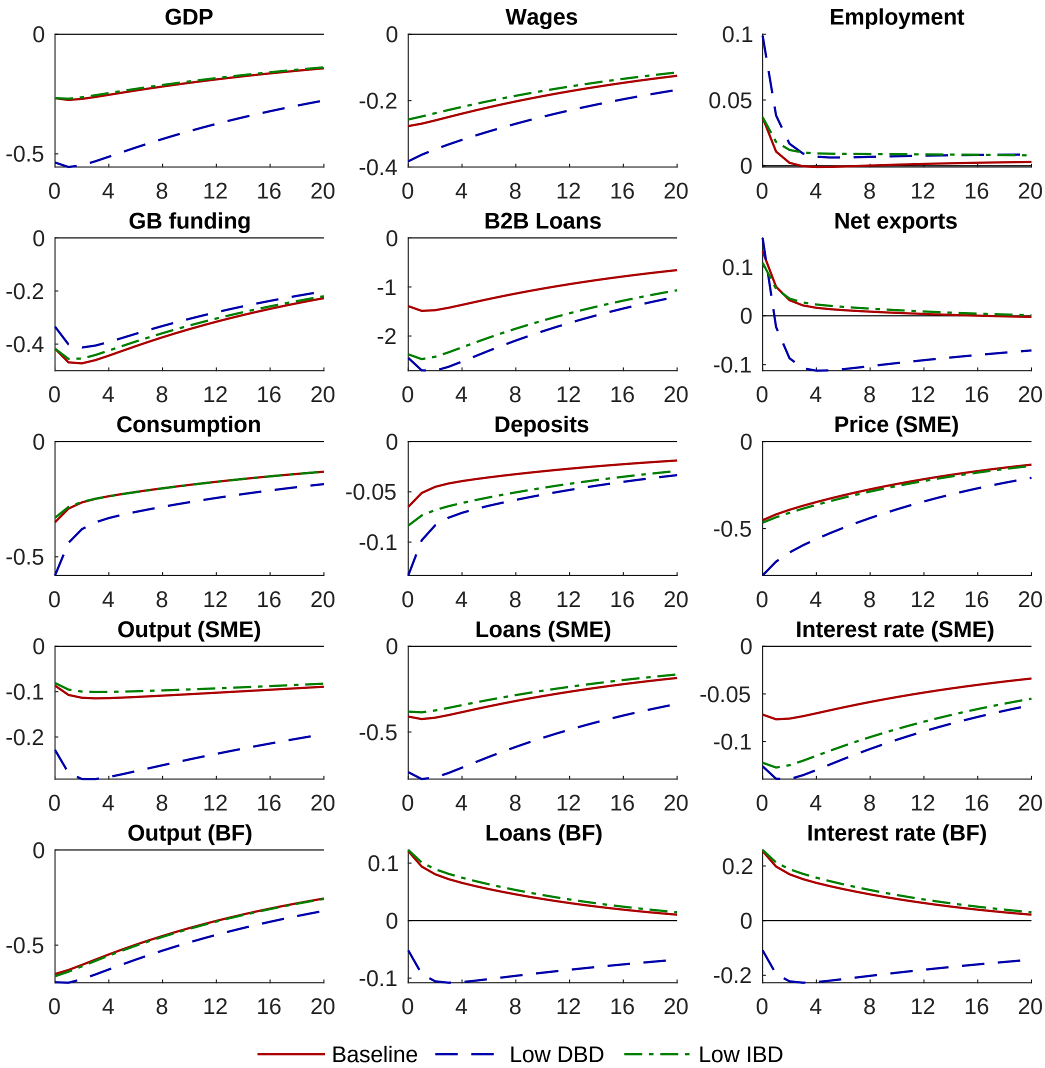
against the 2008 sectoral SME share. The regression contains a saturated set of fixed effecs (country-sector, country-time, and sector-time). The cross-sectional regression of $\gamma^{c,s}$ on $\text{SME}^{c,s}$ is significant with coefficient 2.02 and t-statistic 2.13. The sectors are as follows: Manufacturing (C); Electricity, Gas, Steam and Air Conditioning Supply (D); Water Supply; Sewerage, Waste Management and Remediation Activities (E); Construction (F); Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles (G); Transportation and Storage (H); Accommodation and Food Service Activities (I); Information and Communication (J); Real Estate Activities (L); Professional, Scientific and Technical Activities (M); and Administrative and Support Service Activities (N). The observation period is 1999–2013 for the countries Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, and Spain.

Figure A.3: Model impulse responses to an SME TFP shock



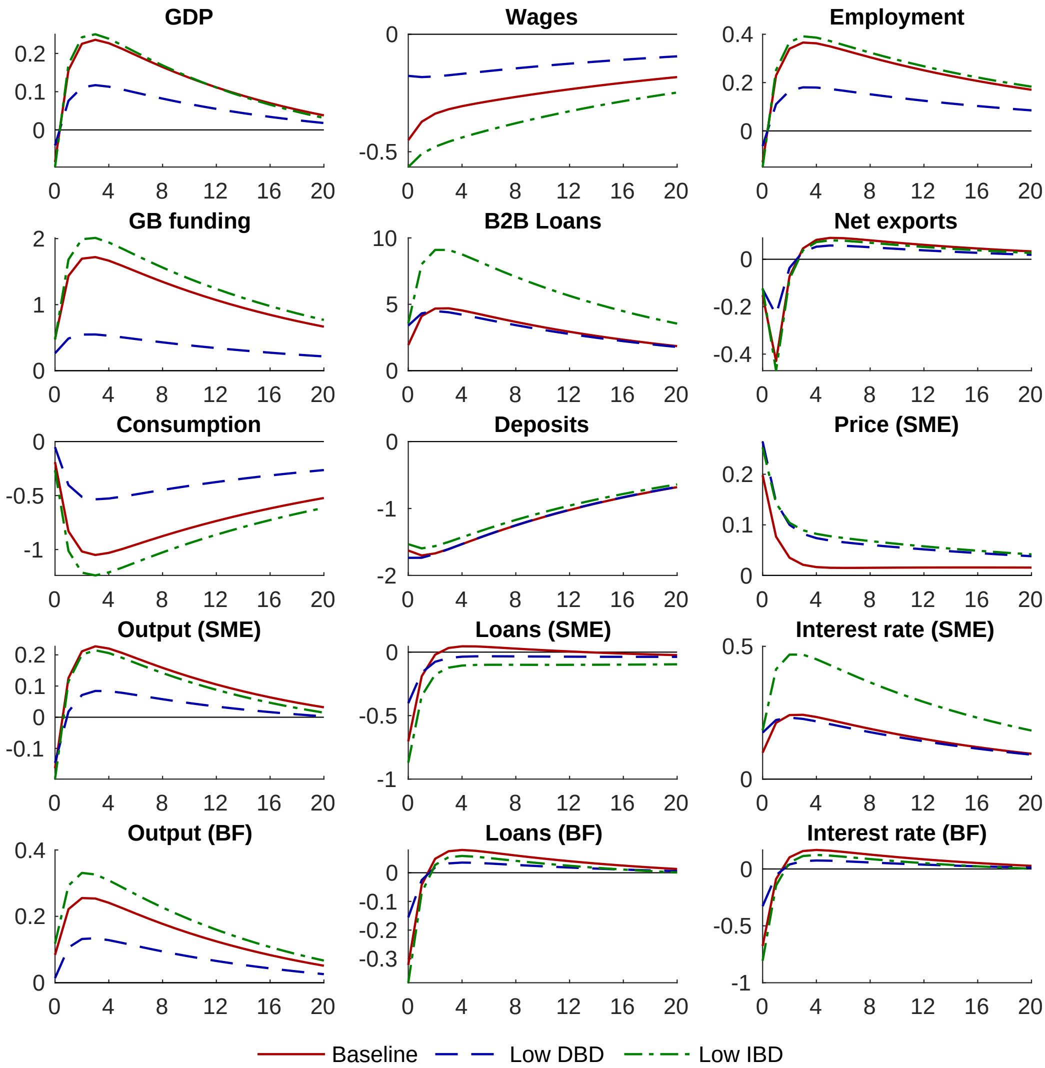
NOTES: The graph plots the model impulse response functions of various variables for 'Baseline' (red solid lines), 'Low DBD' (blue dashed lines), and 'Low IBD' (purple dot-dashed lines) scenarios to a one standard deviation TFP shock to the SME sector. The 'Baseline' impulse responses are generated from a model simulated for 'Austria,' using parameter values from Table 4. The 'Low DBD' scenario illustrates the counterfactual in which DBD is reduced by 50% compared to the 'Baseline' scenario, while the 'Low IBD' scenario illustrates the counterfactual in which IBD is reduced by 50% compared to the 'Baseline' scenario. All impulse responses are percentage deviations from steady state, except for the interest rates which are in percentage points, and net exports which are in proportion to the steady-state value of nominal GDP. Number of quarters following the shock is on the x-axis.

Figure A.4: Model impulse responses to a large-firm TFP shock



NOTES: The graph plots the model impulse response functions of various variables for 'Baseline' (red solid lines), 'Low DBD' (blue dashed lines), and 'Low IBD' (purple dot-dashed lines) scenarios to a one standard deviation TFP shock to the large firms sector. The 'Baseline' impulse responses are generated from a model simulated for 'Austria,' using parameter values from Table 4. The 'Low DBD' scenario illustrates the counterfactual in which DBD is reduced by 50% compared to the 'Baseline' scenario, while the 'Low IBD' scenario illustrates the counterfactual in which IBD is reduced by 50% compared to the 'Baseline' scenario. All impulse responses are percentage deviations from steady state, except for the interest rates which are in percentage points, and net exports which are in proportion to the steady-state value of nominal GDP. Number of quarters following the shock is on the x-axis.

Figure A.5: Model impulse responses to a local banking shock



NOTES: The graph plots the model impulse response functions of various variables for 'Baseline' (red solid lines), 'Low DBD' (blue dashed lines), and 'Low IBD' (purple dot-dashed lines) scenarios to a one standard deviation local banking shock. The 'Baseline' impulse responses are generated from a model simulated for 'Austria,' using parameter values from Table 4. The 'Low DBD' scenario illustrates the counterfactual in which DBD is reduced by 50% compared to the 'Baseline' scenario, while the 'Low IBD' scenario illustrates the counterfactual in which IBD is reduced by 50% compared to the 'Baseline' scenario. All impulse responses are percentage deviations from steady state, except for the interest rates which are in percentage points, and net exports which are in proportion to the steady-state value of nominal GDP. Number of quarters following the shock is on the x-axis.

B. Appendix: Model equations

Firms

Objective:

$$\max_{\{K_t^s,\, I_t^s,\, N_t^s,\, L_t^s\}_{t=0}^{\infty}} \quad \mathbb{E}_0\left[\sum_{t=0}^{\infty} \Lambda_{0:t}\text{DIV}_t^s\right]. \tag{B.1}$$

Dividends:

$$\text{DIV}_t^s = P_t^s Y_t^s - W_t N_t^s - I_t^s - \frac{1}{2}\varphi^I K_{t-1}^s \left(\frac{I_t^s}{K_{t-1}^s} - \delta\right)^2 + L_t^s - R_{t-1}^s L_{t-1}^s\,. \tag{B.2}$$

Production function:

$$Y_t^s = \theta_t^s (K_{t-1}^s)^{\alpha} (N_t^s)^{1-\alpha}\,. \tag{B.3}$$

Capital law of motion (with Q_t^s as Lagrange multiplier):

$$K_t^s = (1-\delta)K_{t-1}^s + I_t^s\,. \tag{B.4}$$

Wage pre-financing constraint (with Ξ_t^s as Lagrange multiplier):

$$L_t^s = W_t N_t^s\,. \tag{B.5}$$

FOC w.r.t. K_t:

$$Q_t^s = \mathbb{E}_t\left[\Lambda_{t:t+1}\left(P_{t+1}^s \alpha \frac{Y_{t+1}^s}{K_t^s} + (1-\delta)Q_{t+1}^s - \frac{1}{2}\varphi^I\left(\frac{I_{t+1}^s}{K_t^s} - \delta\right)^2 + \varphi^I \frac{I_{t+1}^s}{K_t^s}\left(\frac{I_{t+1}^s}{K_t^s} - \delta\right)\right)\right]. \tag{B.6}$$

FOC w.r.t. I_t:

$$Q_t^s = 1 + \varphi^I\left(\frac{I_t^s}{K_{t-1}^s} - \delta\right). \tag{B.7}$$

FOC w.r.t. N_t:

$$W_t(1+\Xi_t^s) = P_t^s(1-\alpha)\frac{Y_t^s}{N_t^s}\,. \tag{B.8}$$

FOC w.r.t. L_t^s:

$$1 + \Xi_t^s = \mathbb{E}_t\left[\Lambda_{t:t+1} R_t^s\right]. \tag{B.9}$$

Final goods producer

Objective:

$$\min_{\{Y_t^{\text{BF}},\, Y_t^{\text{SME}}\}} \quad Y_t = P_t^{\text{SME}} Y_t^{\text{SME}} + P_t^{\text{BF}} Y_t^{\text{BF}}\,. \tag{B.10}$$

CES technology:

$$Y_t = \left(\omega^{\frac{1}{\epsilon}} {Y_t^{\text{BF}}}^{\frac{\epsilon-1}{\epsilon}} + (1-\omega)^{\frac{1}{\epsilon}} {Y_t^{\text{SME}}}^{\frac{\epsilon-1}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}}. \tag{B.11}$$

Cost minimization w.r.t. Y_t^{BF}:

$$Y_t^{\mathrm{BF}} = \omega \left(P_t^{\mathrm{BF}}\right)^{-\epsilon} Y_t \,. \tag{B.12}$$

Cost minimization w.r.t. Y_t^{SME}:

$$Y_t^{\mathrm{SME}} = (1-\omega) \left(P_t^{\mathrm{SME}}\right)^{-\epsilon} Y_t \,. \tag{B.13}$$

Household

Objective:

$$\max_{\{C_t,\, N_t,\, D_t\}_{t=0}^{\infty}} \quad \mathbb{E}_0 \left[\sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma} - 1}{1-\sigma} - \Psi \frac{N_t^{1+\psi}}{1+\psi} \right) \right] \,. \tag{B.14}$$

Intertemporal budget constraint:

$$C_t + D_t = W_t N_t + R_{t-1}^d D_{t-1} + \textsc{div}_t^{\mathrm{BF}} + \textsc{div}_t^{\mathrm{SME}} + \Pi_t \,. \tag{B.15}$$

SDF (FOC w.r.t. C_t):

$$\Lambda_{t:t+1} = \mathbb{E}_t \left[\beta \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \right] \,. \tag{B.16}$$

FOC w.r.t. N_t:

$$W_t = \Psi N_t^{\psi} C_t^{\sigma} \,. \tag{B.17}$$

FOC w.r.t. D_t:

$$\mathbb{E}_t \left[\Lambda_{t:t+1} R_t^d \right] = 1 \,. \tag{B.18}$$

Local Bank

Objective:

$$\max_{L_t^{\mathrm{SME}},\, M_t,\, D_t} \quad \Pi_{t+1} \,. \tag{B.19}$$

Profits (accruing in the beginning of next period):

$$\Pi_{t+1} = R_t^{\mathrm{SME}} \times (1-\iota)\, L_t^{\mathrm{SME}} - R_t^m \times M_t - \left(R_t^d + \zeta_t^{lbs}\right) \times D_t - \varphi^d \left(D_t\right) \,.$$

Balance sheet:

$$L_t^{\mathrm{SME}} = M_t + D_t \,. \tag{B.20}$$

FOC w.r.t. D_t (comb. with FOC w.r.t. M_t):

$$R_t^d + \zeta_t^{lbs} + \varphi^d \frac{D_t - D}{D} = R_t^m \,. \tag{B.21}$$

FOC w.r.t. L_t^{SME} (comb. with FOC w.r.t. M_t):

$$R_t^{\text{SME}} = \frac{R_t^m}{1-\iota}\,. \tag{B.22}$$

Global Bank

Objective:

$$\max_{L_t^{\text{BF}},\, M_t,\, F_t} \quad \Pi_{t+1}^{\text{GB}}\,. \tag{B.23}$$

Profits (accruing in the beginning of next period):

$$\begin{aligned}\Pi_{t+1}^{\text{GB}} = R_t^{\text{BF}} \times \left((1-\iota)\, L_t^{\text{BF}} - \frac{1}{2}\bar{\varphi} L^{\text{BF}} \left(\frac{L_t^{\text{BF}} - L^{\text{BF}}}{L^{\text{BF}}} \right)^2 \right)\,. \\ + R_t^m \times \left(M_t - \frac{1}{2}\kappa\bar{\varphi} M \left(\frac{M_t - M}{M} \right)^2 \right) - R_t^w \times F_t\,.\end{aligned} \tag{B.24}$$

Balance sheet:

$$L_t^{\text{BF}} + M_t = F_t\,. \tag{B.25}$$

FOC w.r.t. L_t^{BF} (comb. with FOC w.r.t. F_t and interest rate wedge λ_t):

$$R_t^{\text{BF}} = \frac{R_t^w + \lambda_t}{1-\iota-\bar{\varphi}\frac{L_t^{\text{BF}} - L^{\text{BF}}}{L^{\text{BF}}}}\,. \tag{B.26}$$

FOC w.r.t. M_t (comb. with FOC w.r.t. F_t and interest rate wedge λ_t):

$$R_t^m = \frac{R_t^w + \lambda_t}{1-\iota-\kappa\bar{\varphi}\frac{M_t - M}{M}}\,. \tag{B.27}$$

Market Clearing and additional definitions

Final good market clearing:

$$Y_t = C_t + I_t + \Gamma_t + NX_t\,. \tag{B.28}$$

Labor market clearing:

$$N_t = N_t^{\text{BF}} + N_t^{\text{SME}}\,. \tag{B.29}$$

Investment market clearing:

$$I_t = I_t^{\text{BF}} + I_t^{\text{SME}}\,. \tag{B.30}$$

Capital market clearing:

$$K_t = K_t^{\text{BF}} + K_t^{\text{SME}}\,. \tag{B.31}$$

Net exports:

$$NX_t = R^m_{t-1} M_{t-1} - M_t + R^{\mathrm{BF}}_{t-1} L^{\mathrm{BF}}_{t-1} - L^{\mathrm{BF}}_t \,. \tag{B.32}$$

Total net costs:

$$\begin{aligned}\Gamma_t = \iota \times R^{\mathrm{SME}}_{t-1} L^{\mathrm{SME}}_{t-1} + \zeta^{lbs}_{t-1} \times D_{t-1} \\ + \frac{1}{2}\varphi^d D \left(\frac{D_{t-1} - D}{D}\right)^2 + \frac{1}{2}\varphi^I K^s_{t-1} \left(\frac{I^s_t}{K^s_{t-1}} - \delta\right)^2 \,.\end{aligned} \tag{B.33}$$

Domestic bank dependence:

$$\mathrm{DBD}_t = \frac{L^{\mathrm{SME}}_t}{L^{\mathrm{SME}}_t + L^{\mathrm{BF}}_t} \,. \tag{B.34}$$

International bank dependence:

$$\mathrm{IBD}_t = \frac{M_t}{M_t + D_t} \,. \tag{B.35}$$

Exogenous Processes

TFP shocks (one for each sector s):

$$\log \theta^s_t = \rho^\theta \log \theta^s_{t-1} - \sigma^\theta \eta^s_t \,. \tag{B.36}$$

Global banking shock:

$$\lambda_t = \left(1 - \rho^{gbs}\right) \lambda + \rho^{gbs} \lambda_{t-1} + \sigma^{gbs} \eta^{gbs}_t \,. \tag{B.37}$$

Local bank shocks:

$$\zeta^{lbs}_t = \rho^{lbs} \zeta^{lbs}_{t-1} + \sigma^{lbs} \eta^{lbs}_t \,, \tag{B.38}$$

where $\eta^s_{ct},\ \eta^{gbs}_t,\ \zeta^{lbs}_{ct} \overset{i.i.d.}{\sim} \mathcal{N}\left(0,\ 1\right)$.

World interest rate:

$$R^w_t = R^w \,. \tag{B.39}$$