Sovereign Risk and Economic Activity: The Role of Firm Entry and Exit*

Gaston Chaumont
University of Rochester
gaston.chaumont@rochester.edu

Givi Melkadze
Georgia State University
gmelkadze@gsu.edu

Ia Vardishvili
Auburn University
izv0013@auburn.edu

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Abstract

We quantify the role of firm entry and exit in shaping the output costs of sovereign debt crises. Empirically, higher sovereign risk correlates with less firm entry and more exits. We find evidence of a credit supply channel explaining the sovereign risk-entry relationship but not for the sovereign risk-exit relationship. We develop a model with sovereign risk, financial frictions and endogenous firm dynamics. Calibrated with data around the Portuguese debt crisis, the model predicts that sovereign risk explains 60% of the fall in entry and most of the exit dynamics. The extensive margin explains 80% of the output fall in the long-run.

Keywords: Sovereign Debt Crises, Financial Frictions, Firm Dynamics.
JEL classifications: E32; E44; F34; G15.

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1 Introduction

The 2011-2012 European sovereign debt crisis was characterized by rising government bond yields and a substantial economic downturn in the Eurozone periphery. More recently, the COVID-19 pandemic and associated surge in public debt levels worldwide have again intensified concerns about sovereign debt sustainability. A large body of empirical and theoretical literature documents that a higher sovereign default risk can depress economic activity via disruptions in bank credit supply to non-financial firms (Gennaioli et al. (2014), Bocola (2016), Acharya et al. (2018), Becker and Ivashina (2018), Arellano et al. (2020), among others). This literature focuses on the *intensive* margin of adjustment in firms' investment and output during a sovereign debt crisis. In this paper, we focus on the *extensive* margin of firm dynamics. Specifically, we ask: Does sovereign default risk affect firm entry and exit? What is the role of the extensive (entry and exit) margin in shaping the effects of a sovereign debt crisis on the economy?

To answer these questions, first, we empirically analyze the relationship between sovereign default risk and firm entry and exit. We use annual country-industry level data on firm entry and exit from Eurostat's Business Demography Statistics over the period 2004-2018. Controlling for country, industry and year fixed effects, and relevant aggregate variables, we find that a one percentage point increase in sovereign spreads is associated with a 2.4% decline in the number of entrants and a 2% increase in the number of exiting firms.[1] We then explore the role of the bank credit channel in driving these relationships by exploiting the variation in entry and exit dynamics across industries with different degrees of external finance dependence, and across countries with different levels of banks' sovereign exposures.[2] We find strong support for the credit supply channel in explaining the observed negative relationship between sovereign risk and firm entry. Specifically, the negative association between sovereign risk and the number of startups is strongest in high external finance-

[1]We use sovereign spreads, i.e., the difference between yields on long-term domestic government bonds and German bonds, as our main proxy of sovereign risk.

[2]We rely on Rajan and Zingales (1998) measure of external financial dependence (EFD) and various leverage-based measures to characterize an industry's needs for external funds. We consider the Eurozone periphery as a group of countries whose banking systems are more exposed to their own governments' default risk through holdings of domestic sovereign debt.

dependent industries in the Eurozone periphery countries. However, the effect of sovereign risk on firm exit seems to be driven by other factors instead of changes in credit supply.

Next, we develop a heterogeneous firm dynamics model with endogenous entry and exit, sovereign default risk, and financial frictions. In the model, heterogeneous firms - incumbents and entrants - rely on bank credit to finance a fraction of their investment and wage bill. The firms operate in two types of sectors which differ in terms of the degree of external finance dependence (EFD), with the high-EFD sector facing greater working capital needs. The interest rate on bank loans to the corporate sector is affected by sovereign risk. An increase in exogenous sovereign default probability drives up the required rate of interest on corporate loans and affects firms' decisions at the intensive and extensive margins – the credit supply channel of sovereign risk. In addition, to capture the documented empirical relationship between sovereign risk and firm exit, we assume that sovereign risk also directly affects the incumbent firms' exit decisions beyond the credit supply channel.[3]

We calibrate the model to the Portuguese economy. The parameterized model successfully matches relevant (targeted and non-targeted) moments of firm dynamics at intensive and extensive margins, such as firms' average size, employment share, survival rates, and exit hazard rates at entry and over time. The model also matches relevant characteristics of high- and low-EFD sectors in the data. Moreover, it generates data-consistent dynamics in firms' borrowing needs over the life cycle – an important feature to correctly quantify the sovereign-credit supply channel. Specifically, in the model and data, firms' leverage increases with firm size and decreases with age. Finally, the calibrated model successfully reproduces the empirical associations of firm entry and exit with sovereign spreads.

We use the calibrated model to quantify the output costs of the Portuguese sovereign debt crisis. To do so, we feed the model with the sequences of shocks to sovereign default probability and aggregate productivity so that the model-implied dynamics of sovereign spreads and output matches the data counterparts in Portugal over the 2008-2015 period. The model successfully reproduces the observed non-targeted dynamics of firm entry, exit, and the total number of firms throughout the event window. We find that sovereign risk

[3] This direct effect captures various other channels that might be relevant for a firm's exit decision during a sovereign debt crisis, such as expectations about higher taxes, disruptions in international trade, or increased uncertainty about future policies.

accounts for about 60% of the observed drop in output in 2012 and still represents 57% of the drop by 2015. Importantly, the negative effect persists long after the sovereign crisis.

Sovereign default risk plays an important role in driving the observed dynamics of firm entry, exit, and the total number of operating firms. In particular, sovereign risk is responsible for 14.6% drop in firm entry out of a total 25.1% observed in 2012 (relative to 2008). The default shocks account for most of the firm exit dynamics in 2011-2012. Overall, the model predicts that sovereign risk is responsible for around 76% and 60% drop in the total number of firms in 2012 and 2015, respectively. Consistent with our empirical results, we find that the credit supply channel fully explains the dynamics of firm entry but not firm exits. The intuition is that the higher borrowing rate, due to the elevated sovereign risk, increases the cost of entry and lowers expected profits, which directly discourages firm entry. However, for incumbent firms, changes in the interest rate do not have a quantitatively strong effect on their value function even in the high-EFD sector. As a result, the response of exit to sovereign risk shocks is small in both sectors.

Next, we show that the dynamics of firms at the extensive margin accounts for most of the persistent effects of the sovereign debt crisis. In particular, firm entry and exit account for 27% of the observed fall in output in Portugal over the 2011-2012 period, which represents 47% of the total output cost of the debt crisis. The contribution of the extensive margin increases over time and by 2017 it is responsible for 80% of the persistent decline in output due to the debt crisis. The strength of the propagation from the extensive margin hinges on the effect of the sovereign debt crisis on the share of high productivity-high survival rate firms in the entrant and exiting firms. The mechanism is similar to the "missing generation" effect studied by Gourio et al. (2016) and Sedláček (2020) in the context of the United States during the Great Recession. We show that exit dynamics also generate a persistent negative "wasted generation" effect when the crisis drives high-productivity firms out of the market.

Finally, we also study the short- and long-run effects of the sovereign crisis on the dynamics of total factor productivity. We find that while the negative effect of default risk on the productivity is minor in the short run, its contribution increases over time and accounts for half of the productivity decline by 2015. Importantly, the extensive margin of firm dynamics accounts for almost all of the persistence in productivity losses related to high sovereign risk.

Related Literature This paper is related to three strands of the literature. First, our work contributes to the literature exploring transmission mechanisms of sovereign debt crises to real economic activity. Mendoza and Yue (2012) propose a model in which sovereign default reduces firms' access to external financing generating imperfect substitution of domestic to foreign inputs and a misallocation of labor across sectors. Bocola (2016), Sosa-Padilla (2018), Perez et al. (2018), Gennaioli et al. (2014) associate the costs of sovereign default risk to disruptions in financial intermediation (e.g., the domestic banking system) which is transmitted to the real economy. A common thread among these papers is that sovereign defaults hurt domestic banks' lending capacity, investment and output. We contribute to this literature by focusing on the propagation mechanism generated through the extensive margin of firm dynamics. Importantly, the endogenous firm entry and exit dynamics allow us to also explain the relatively persistent drop in output due to sovereign debt crisis, consistent with the empirical evidence (Kuvshinov and Zimmermann (2019), De Paoli et al. (2009) and Furceri and Zdzienicka (2012)).

Our paper is most closely related to a recent strand of the literature that emphasizes the role of firm heterogeneity in the transmission of sovereign risk to the real economy. Arellano et al. (2020) quantifies the output costs of sovereign risk using a combination of a quantitative model and detailed firm and bank level data from Italy. They find that sovereign default risk contributed significantly to the output decline during the Italian debt crisis. Buera and Karmakar (2021) use Portuguese firm and bank level data to document that highly leveraged firms, and especially those with a larger share of short-term debt, were hurt the most during the sovereign debt crisis. Using a quantitative heterogeneous-firms model, Rojas (2020) shows that smaller firms respond more to sovereign default risk, consistent with the empirical evidence from the Eurozone periphery countries. Moretti (2021) studies the role of non-financial firms' default risk during sovereign debt crisis and finds that the corporate risk channel significantly amplifies and propagates the effects sovereign crisis. Finally, Deng and Liu (2021) use Italian firm level data to document that an increase in sovereign risk resulted in a reallocation of firm investment from intangible assets to tangible assets. Then they propose a model in which a decrease in intangible investment has a negative effect on firms' productivity and output. Our main contribution to this literature is that we allow for endogenous firm entry and exit dynamics, absent margins in the above papers[4], and study their quantitative relevance for the effects of sovereign default risk.

In addition, our paper relates to the large existing literature on the role of firm entry and exit margins for aggregate economic dynamics (Lee and Mukoyama (2008), Bilbiie et al. (2012), Clementi and Palazzo (2016), Gourio et al. (2016), Siemer (2019), Sedláček and Sterk (2017), Sedláček (2020), Ayres and Raveendranathan (2023), among others). This literature finds that endogenous entry and exit significantly affects the dynamics of aggregate variables. Our paper contributes to this strand of the literature by quantifying the role of the extensive margin of firm dynamics in transmitting sovereign default risk to the aggregate economy.

Two recent papers are closely related to our work. Ates and Saffie (2021) studies the effects of a financial crisis in the form of a transitory sudden stop and focuses on the consequences on innovation and long-run growth. Asturias et al. (2022) conduct a Foster et al. (2001) decomposition and find that entry and exit of plants account for a large fraction of aggregate productivity growth during periods of fast GDP growth. Moreover, the changes in the contribution of entry and exit are accounted for by changes in the relative productivity of entering and exiting plants and not by their market shares. The focus of our paper is to understand how the loss of a generation of productive firms due to a debt crisis shapes the magnitude and persistence of the fall in economic activity.

2 Empirical Evidence

In this section we study the relationship between sovereign default risk and firm entry and exit dynamics using annual industry-level data from European countries. For our main analysis, we consider a sample of relatively large countries for which data on firm entry and exit is available at least since 2010. This group includes Italy, Portugal, Spain, Austria, Czech Republic, France, Hungary and Netherlands. In Appendix C we show that our main findings hold if we consider a sample that includes all countries in the Eurostat Employer Business Demography database.[5]

[4]In the models of Rojas (2020) and Moretti (2021) defaulting firms do exit the market but the mass of firms in every period remains constant because exiting firms are replaced by an equal number of new firms.

[5]See Appendix A for detailed information about the Eurostat Employer Business Demography database and Table A1 for a detailed description of our sample and data coverage.

We document that an increase in sovereign default risk is associated with a decline in firm entry and an increase in firm exits. We then explore the role of the credit supply channel in driving the above relationships. We find that the credit supply channel is important to explain the negative relationship between sovereign risk and firm entry dynamics, while this channel seems to play a minor role in the relationship between sovereign risk and firm exit. Finally, using the data from Portugal, we document the persistent effects of the sovereign debt crisis on exposed cohorts' life-cycle dynamics.

2.1 Sovereign Risk, Firm Entry and Exit

We start by investigating the relationship between sovereign default risk and the extensive margin of firm dynamics. Our empirical analysis uses a standard proxy for sovereign default risk - sovereign spreads - defined as the difference between the yields on domestic long-term sovereign bonds and German Bunds. We consider the following panel data regression:

$$log(Y_{i,c,t}) = \beta_0 + \beta_1 spread_{c,t} + \alpha_i + \gamma_c + \phi_{i,c} + \eta_t + \psi_{i,t} + X_{i,c,t} + \varepsilon_{i,c,t}, \qquad (1)$$

where $Y_{i,c,t}$ denotes an outcome variable, such as the number of entrants or exits in industry i, country c, at time t. $spread_{c,t}$ denotes sovereign spreads in country c at time t.[6] The terms α_i, γ_c and $\phi_{i,c}$ control for industry, country, and industry-by-country fixed effects. η_t and $\psi_{i,t}$ denote year and industry-specific year fixed effects. $X_{i,c,t}$ is a vector of controls, which depending on a specification, may include a real GDP growth, inflation, population, current account and country-specific linear time trends.

Table 1 reports the results from different specifications based on regression equation (1). Panel A shows the results when a dependent variable is entry, while Panel B has the results for exit, with both variables expressed in logs. The results illustrate that there is a robust, statistically significant, negative (positive) relationship between firm entry (exit) and sovereign spreads.

Column (1) of each panel shows the regression results from the specification which controls only for country-industry fixed effects. Column (2) then adds year fixed effects and an array of relevant macroeconomic variables, such as real GDP growth, inflation and current

[6] Sovereign spread is defined as a percentage point (p.p.) difference between yields on 10-year domestic government bonds and German bonds of the similar maturity

Table 1: Sovereign risk, firm entry and exit

	Panel A. Entry			Panel B. Exit		
	(1)	(2)	(3)	(1)	(2)	(3)
Sovereign spread	-0.026***	-0.024***	-0.024***	0.022***	0.021***	0.020***
	(0.005)	(0.007)	(0.006)	(0.005)	(0.006)	(0.006)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	–	✓	✓	–	✓	✓
Industry×Year FE	–	–	✓	–	–	✓
Controls	–	✓	✓	–	✓	✓
Observations	4,731	4,449	4,449	4,032	3,885	3,885
R^2	0.976	0.979	0.984	0.976	0.984	0.987

Note: Robust standard errors clustered at industry×country level are in parentheses. Sovereign spread is defined as a percentage point difference between yields on 10-year domestic government bonds and German bonds of the similar maturity. Controls include real GDP growth, y-o-y inflation rate, (log) population, the current account to GDP ratio, and country-specific linear time trends. When the outcome variable is (log) exit we also control for (log) entry. See Appendix A for a detailed description of our sample and data coverage. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

account-to-GDP ratio. The year fixed effects control for any common global or Europe-wide time-varying factors, while macro controls help account for macroeconomic conditions within a given country over time that could potentially drive entry and exit dynamics and sovereign spreads at the same time. Column (3) further includes industry-specific time fixed effects to control for industry-level time-varying observable and unobservable factors (that are common across countries) such as technological changes, industry concentration or demand-side effects within a given industry over time.

Several results stand out. There is a strong statistically significant negative (positive) relationship between firm entry (exit) and sovereign spreads. These estimated relationships between entry, exit and sovereign spreads are robust to an inclusion of various fixed effects and other relevant control variables. In the most demanding and our preferred specification (Column 3 of Panels A and B) a one percentage point increase in the sovereign spread decreases entry by about 2.4% and increases exit by about 2%. These coefficients are also economically significant once we consider the 2011-2012 European sovereign crisis, when sovereign spreads increased significantly for some countries. For example, in 2011-2012, Portugal - the country we study in more detail - saw an increase in sovereign spreads of about 7 percentage points.

In Appendix C.1 we perform an extensive set of robustness checks and confirm that our results still hold when we (i) restrict the sample to include only the post-Great Recession period 2010-2018 (Table C1); (ii) control for lagged sovereign spreads (Table C2); (iii) use all available data on firms' entry and exit for all countries in the Eurostat database (Table C3); (iv) use all available data on firms' entry and exit for all countries restricted to the post-Great Recession period 2010-2018 (Table C4).

Overall, our results provide strong evidence that an increase in sovereign default risk, proxied by sovereign spreads, is associated to a decline in firm entry and an increase in exits.

2.2 Evidence on the Credit Supply Channel

A large body of recent empirical and theoretical literature documents that high sovereign default risk can cause credit supply disruptions in economies where domestic banks are exposed to their own governments' debt.[7] However, the role of this channel in the transmission of sovereign default risk to firm entry and exit dynamics has not been explored before. We thus investigate the relevance of the credit channel for explaining the associations between sovereign default risk and entry and exit documented in the previous section.

We design the following identification strategy. First, to investigate the role of financial constraints and borrowing costs for the extensive margin, we compare entry and exit dynamics across sectors with differing degrees of external financial dependence in response to changes in sovereign risk. We characterize an industry's needs for external finance using Rajan and Zingales (1998) sectoral measure of external financial dependence (EFD). The EFD measure is defined as the difference between capital expenditures and cash flows relative to capital expenditures at an individual firm level. A positive EFD value implies that a firm raises external funds to finance a fraction of its investment. An industry-level EFD measure is then computed based on a median value across EFD measures of all listed mature firms within a given industry. By focusing on mature firms, the measure captures an industry's technological demand for external financing (Rajan and Zingales (1998)).[8] As is common

[7] See, for example, Gennaioli et al. (2014), Bocola (2016), Acharya et al. (2018), Arellano et al. (2020), among others.

[8] In our analysis we use Rajan-Zingales EFD measure recomputed by Duygan-Bump et al. (2015) for the United States for the period 1980-1996 using the Compustat data. Duygan-Bump et al. (2015) construct the

in the existing literature, we rely on the plausible assumption that the industry-level EFD indicator, computed for the United States using data on mature firms, captures an industry's technological demand for external finance that would carry over to other countries as well (Rajan and Zingales (1998), Cetorelli and Strahan (2006)).[9]

Second, we choose a specific group of countries - the Eurozone periphery[10] - for which the above-mentioned credit channel played a particularly important role during the European debt crisis due to domestic banks' high exposures to their own governments' debt.

We test the following hypothesis: If the bank-credit channel is indeed a relevant transmission channel of sovereign default risk to the extensive margin of firm dynamics, then we would expect entry (exit) to decline (rise) more in response to the increased sovereign risk in the periphery countries and in industries with stronger dependence on external finance. Thus, we estimate the following regression to evaluate the role of the credit channel:

$$\begin{aligned} log(Y_{i,c,t}) &= \beta_0 + \beta_1 spread_{c,t} + \beta_2 spread_{c,t} \times high\text{-}EFD_i \\ &\quad + \beta_3 spread_{c,t} \times periphery_c + \beta_4 spread_{c,t} \times high\text{-}EFD_i \times periphery_c \\ &\quad + \alpha_i + \gamma_c + \phi_{i,c} + \eta_t + \psi_{i,t} + \theta_{c,t} + X_{i,c,t} + \varepsilon_{i,c,t}, \end{aligned} \tag{2}$$

where $high\text{-}EFD_i$ is a dummy variable which is equal to one if a sector has an EFD value above the 70th percentile of the distribution of EFD values across industries. $periphery_c$ is a dummy equal to 1 for the group of periphery countries. In our most stringent specification we also include country×year fixed effects $\theta_{c,t}$.[11] $X_{i,c,t}$ is the same vector of controls as in regression (1). The main coefficient of interest is β_4: it measures the differential effect of sovereign spreads on the entry (or exit) margin in high external dependence industries in the periphery countries relative to non-periphery countries.

EFD indicators for a wider range of industries at the 2-digit SIC category than the original Rajan-Zingales article, and we match these SIC categories and associated EFD indicators to our Eurostat data at 2-digit NACE categories.

[9] Rajan and Zingales (1998) EFD measure has been widely used in various contexts including the literature studying the effects of banking crises on real economic activity (Claessens and Laeven (2003), Dell'Ariccia et al. (2008)), on small and young firms (Siemer (2019), Duygan-Bump et al. (2015)) or on international trade flows and export dynamics (Chor and Manova (2012)), among others.

[10] Since Eurostat does not have data on firm entry and exit for Ireland and Greece, our definition of periphery countries includes only Portugal, Italy and Spain.

[11] Note in this case we can no longer estimate the average effect of sovereign spreads.

Table 2 reports the regression results. The first column of each panel is the case when we do not control for country×year fixed effects, but include all other fixed effects and macro controls. Panel A shows that an increase in sovereign spread decreases the number of entrants in high-EFD industries of the periphery countries. This negative effect is almost 2 times larger than the average effect of sovereign spreads on entry indicating that the credit channel and financial constraints play an important role in the transmission of sovereign risk to firm entry. The result is robust when we additionally control for country×year fixed effects (the second column of Panel A) that account for any country-specific shocks that could simultaneously affect sovereign spreads and entry and exit dynamics within a country.

Panel B of Table 2 runs similar regressions for exit. The effect of the credit supply channel of sovereign default seems to be statistically and economically insignificant. The results indicate that factors other than disruptions in credit supply are more important for the transmission of sovereign risk to firm exit dynamics. Finally, Panel C shows the results for net entry - the difference between log entry and log exit - to confirm that the entry margin dominates and the net firm creation is negatively affected by sovereign risk via credit supply channel. In the most demanding specification, a 1 percent increase in sovereign spreads results in about 5.8 percent fall in net entry in the high-EFD industries in the periphery countries relative to the non-periphery countries.

Appendix C.2 has various robustness checks showing that these empirical results hold when we (i) restrict the sample to post-Great Recession period, 2010-2018 (Table C5); (ii) use all available data on exit and entry from all countries (Table C6); (iii) restrict the sample that includes all countries to the post-Great Recession period, 2010-2018 (Table C7); (iv) categorize industries into high, medium and low EFD groups (Table C8).

In addition, in Appendix B, we exploit the European sovereign debt crisis – an episode with high sovereign default risk among the Eurozone periphery countries, and a standard triple difference identification strategy to further evaluate the role of credit supply on the transmission of sovereign risk to firm entry and exit. The results confirm that the credit supply channel plays an important role in driving firm entry dynamics during the sovereign debt crisis, but again does not explain the exit dynamics. Finally, Appendix B.1 provides robustness checks to alternative, leverage-based measures, of external finance dependence.

Table 2: Sovereign risk, firm entry and exit: Credit supply channel

	Panel A. Entry		Panel B. Exit		Panel C. Net entry	
	(1)	(2)	(1)	(2)	(1)	(2)
Sovereign spread	-0.048***		-0.000		-0.035*	
	(0.017)		(0.013)		(0.019)	
Sovereign spread×periphery	0.033*		0.023**		0.006	
	(0.017)		(0.012)		(0.017)	
Sovereign spread×high-EFD	0.035	0.043	-0.013	-0.01	0.041	0.041
	(0.028)	(0.028)	(0.016)	(0.016)	(0.025)	(0.025)
Sovereign spread×high-EFD×periphery	-0.062**	-0.066**	0.009	0.005	-0.058**	-0.058**
	(0.028)	(0.028)	(0.017)	(0.017)	(0.025)	(0.025)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Industry×Year FE	✓	✓	✓	✓	✓	✓
Country×Year FE	–	✓	–	✓	–	✓
Controls	✓	–	✓	✓	✓	–
Observations	4,915	5,197	4,351	4,398	4,351	4,398
R^2	0.985	0.987	0.987	0.992	0.578	0.714

Note: Robust standard errors clustered at industry×country level are in parentheses. Sovereign spread is defined as a percentage point (p.p.) difference between yields on 10-year domestic government bonds and German bonds of the similar maturity. Controls include real GDP growth, y-o-y inflation rate, (log) population, the current account to GDP ratio, and country-specific linear time trends. When the outcome variables is (log) exit we also control for (log) entry. See Appendix A for a detailed description of our sample and data coverage. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Overall, our empirical results indicate that sovereign risk negatively affects firm entry through the tightening of credit conditions to the corporate sector. We do not find strong evidence in favor of this channel for exit dynamics, indicating that other transmission channels of sovereign risk played a more important role in the latter case. Our results are complementary to the well-established literature showing that the increased sovereign risk during the European sovereign debt crisis triggered an economic contraction via significant disruptions in bank lending. For example, using Italian credit registry data Bofondi et al. (2018) find that Italian firms faced tightening in credit conditions following the 2011 sovereign crisis. Similarly, Balduzzi et al. (2018) document that the Italian sovereign debt crisis was associated with sharp reductions in exposed banks' market valuations and resulting cut in credit to non-financial (especially, small and young) firms. Bottero et al. (2020) find that Italian banks with exposures to domestic sovereign debt cut lending to all types of firms when sovereign risk increased, with negative real economic consequences only for small firms.[12]

2.3 The Case of Portugal

In this section, we use the Portuguese economy to evaluate the potential importance of the entry and exit margins in propagating the increase in sovereign default risk. We document that the sovereign debt crisis had a persistent effect on the exposed cohorts' life-cycle dynamics. Specifically, cohorts of firms exposed to high sovereign default risk consist of fewer firms and employ persistently and significantly fewer workers over the life cycle.

We focus on Portugal for several reasons. Portugal is one of the most severely affected countries by the European sovereign debt crisis. Unlike Spain and Ireland, who also experienced a deep recession, Portugal did not suffer from a housing market boom and bust, neither was it subject to severe political turmoil, as was the case for Greece and Italy (Reis (2013)). In this sense, Portugal provides a 'cleaner' environment to study the effects of sovereign risk on the economy.

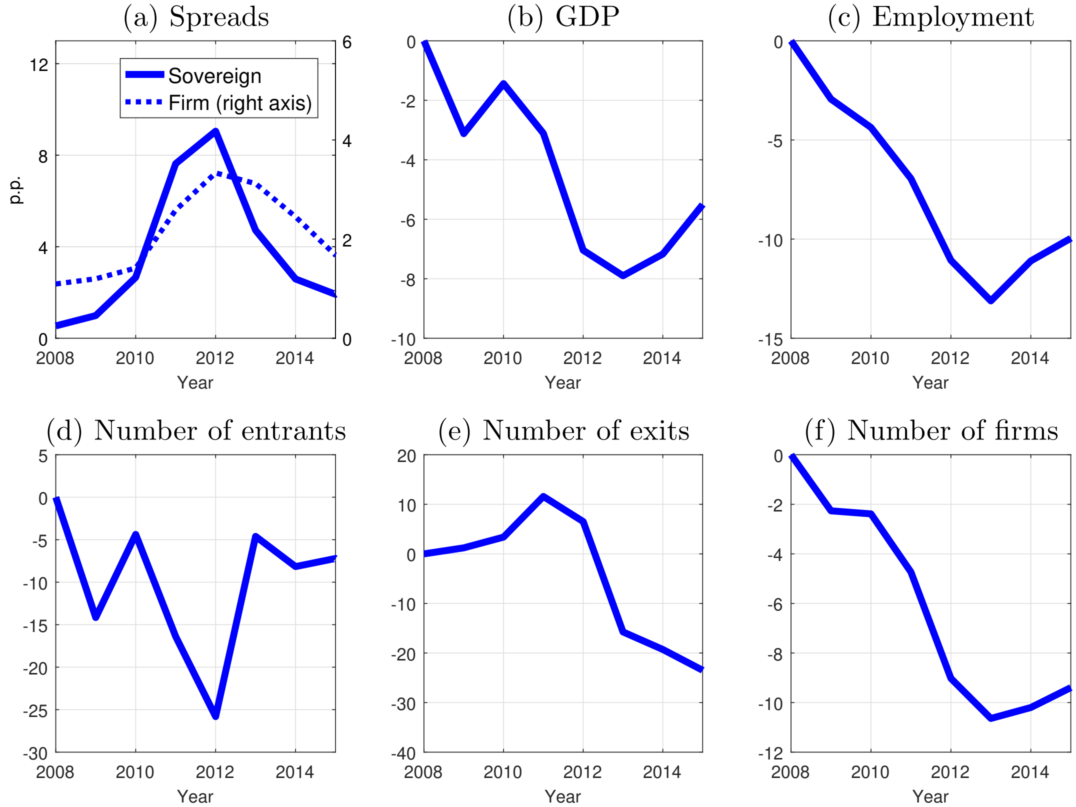
Figure 1 plots selected macroeconomic variables in Portugal for the period 2008-2015. Panels (a) to (c) show the familiar dynamics of sovereign and corporate spreads, real GDP and aggregate employment, while Panels (d) to (f) focus on the extensive margin of firm dynamics. Several facts stand out. First, the sharp rise in sovereign spreads during 2011-2012 was associated with a substantial fall in the number of entrants and a rise in exits. In 2012 there were about 20% fewer startups relative to 2010, and the number of firms exiting increased by about 10%. As a result, the total number of firms persistently declined during this period. Second, the fall in the number of operating firms strongly correlates with GDP and employment dynamics pointing to the potential relevance of the extensive margin for aggregate economic activity during and in the aftermath of the sovereign debt crisis.

2.3.1 Sovereign Crisis and Exposed Cohorts' Life Cycle Dynamics

Using Portuguese data, next we show that cohorts of firms exposed to high sovereign default risk consist of fewer firms and employ persistently and significantly fewer workers over the life

[12] See also Acharya et al. (2018), Arellano et al. (2020), and Buera and Karmakar (2021) for empirical evidence on sovereign crisis-driven credit contraction in the Eurozone periphery.

Figure 1: Interest rate spreads, GDP, employment and firm dynamics in Portugal

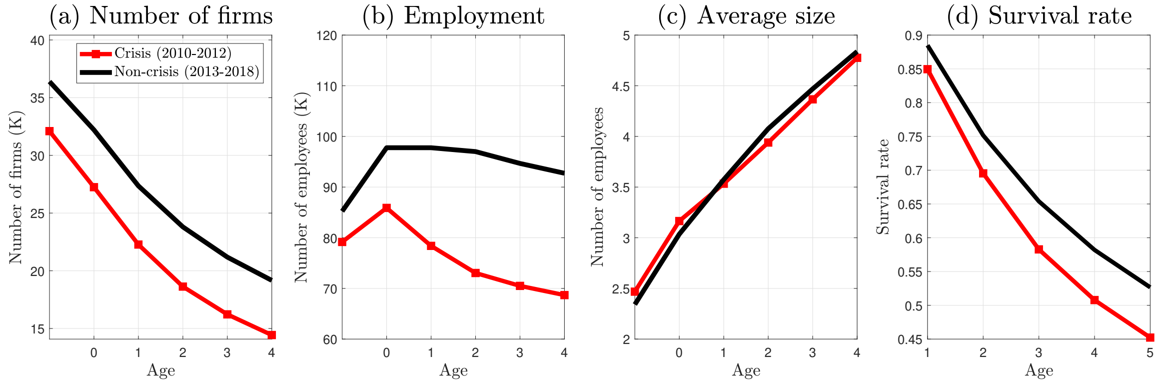


Note: Sovereign spread is a percentage point difference between yields on 10-year domestic government bonds and German bonds. The firms' spreads measure the percentage point difference between the annual (average) interest rates charged on bank loans to new businesses in Portugal and Germany. All other variables are shown in terms of percent deviations relative to 2008. Data sources: OECD, ECB, Eurostat.

cycle. Toward this end, we compare post-entry dynamics of cohorts with different degrees of exposure to the sovereign debt crisis. We consider cohorts born during 2010-2012 as a group of firms that were exposed to the sovereign stress, and call them 'crisis' cohorts. We treat cohorts that started operating after 2013 as a group of firms not exposed to high sovereign default risk and refer to them as 'non-crisis' cohorts.

Figure 2 plots the average life cycle characteristics of the crisis (2010-2012), and non-crisis (2013-2018) cohorts. Panel (a) displays the average employment (number of workers) in each cohort by age. It shows that the 'crisis' cohorts employ 12% fewer workers at entry compared to the 'non-crisis' cohorts; this difference in the cohort-level employment persists and further increases over time, reaching 25% by age 5. Panel (b) shows that the 'crisis' cohorts consist of about 17% fewer firms at entry compared to the 'non-crisis' cohorts, and

Figure 2: Cohorts' post-entry dynamics



Note: The figure displays average life-cycle dynamics of cohorts born over different periods of time. For example, '2010-2012' describes the average characteristics of cohorts born during 2010-2012. Panel (a) plots the average number of firms within each cohort by age. Panels (b), (c), and (d) show the average employment, firm size and survival rate of cohorts by age.

this difference further increases to 26% by age five. Panel (c) shows that the average number of workers employed by 'crisis' and 'non-crisis' cohorts are roughly similar, suggesting that the extensive margin of adjustment is primarily responsible for these differences in cohort-level employment. Finally, Panel (d) shows that the survival rate of firms exposed to the sovereign crisis is significantly and persistently lower compared to 'non-crisis' cohorts. In Appendix D, we use a simple accounting exercise to argue that these persistently different dynamics of the cohorts exposed to the increased sovereign default risk have a sizable and long-lasting effect on the aggregate economy.

Motivated by these findings, we next use a heterogeneous firm dynamics model with endogenous firm entry and exit to assess the quantitative importance of the extensive margin in propagating the effects of sovereign risk to aggregate output and productivity.

3 The Model

We consider an infinite horizon closed-economy model populated by households, firms, financial intermediaries (banks) and a government. The economy is subject to two types of exogenous aggregate shock processes: the aggregate productivity shocks and shocks to the sovereign default risk.

At the core of our model are heterogeneous firms: incumbents and potential entrants.

Firms operate in two sectors and rely on bank credit to finance their entry cost, investment, and production. The fraction of working capital that needs to be financed with external funds varies across the two sectors. In addition to the working capital requirement, firms are heterogeneous across productivity and capital. Every period, incumbent firms make decisions about investment, production, and continuation, and potential entrants make entry decisions.

The government borrows from banks by issuing long-term defaultable bonds. Default risk is determined by an exogenous shock, as in Bocola (2016). The price of the bonds is determined by a no-arbitrage condition equating the return of a safe asset to the expected returns of the sovereign bonds.

In the model, banks are a reduced form technology that determines the interest rate for corporate borrowing. When sovereign default risk increases, banks restrict credit supply and increase the lending rate to non-financial firms. This reduced-form technology, which passes through sovereign default risk to firms' cost of credit, captures micro-founded mechanisms widely discussed in the literature. The main channels emphasized by the literature are the banks' balance sheet channel, a fall in loanable funds and financial repression.[13]

Households have preferences over consumption, supply labor, and own firms. The remainder of this section describes each agent's problem in detail.

3.1 Firms

Firms consist of incumbents and new entrants, which operate in two different sectors. These sectors are identical, except that they differ in their needs for external finance. There are two aggregate state variables affecting firms. The level of aggregate productivity, A, and a default shock, d, to be described below. We denote the aggregate state of the economy as $s \equiv (A, d)$.

In each sector, a positive mass of price-taking firms produce a homogeneous good by

[13]The balance sheet channel operates through a deterioration of banks' net worth when sovereign risk increases. As banks hold sovereign bonds in their assets, a reduction in bond prices implies a loss of banks' net worth and a reduction in banks' lending capacity. For micro-founded models of the banks' balance sheet channel, see, for example, Bocola (2016) or Arellano et al. (2020). In Sosa-Padilla (2018) a default reduces banks' loanable funds and credit to the private sector. Financial repression occurs when governments force financial institutions to hold sovereign bonds, which crowds out credit to the corporate sector. For evidence of financial repression in the European debt crisis, see Becker and Ivashina (2018).

means of the same production technology, $y = zA(k^{\alpha}l^{1-\alpha})^{\theta}$ with $\alpha, \theta \in (0,1)$. Individual firms own physical capital, k, and hire labor, l, at the beginning of each period. Firms take the wage rate, w, as given and their idiosyncratic productivity, z, follows an AR(1) process given by

$$\log(z') = \rho_z \log(z) + \sigma_z \varepsilon_z \tag{3}$$

with $\varepsilon_z \sim \mathcal{N}(0,1)$ for all $t \geq 0$. The process is independent across firms and across sectors. Denote the conditional distribution of z by $F_I(z'|z)$. Aggregate productivity, A, follows a persistent AR(1) process given by

$$\log(A') = \rho_A \log(A) + \sigma_A \varepsilon_A \tag{4}$$

with $\varepsilon_A \sim \mathcal{N}(0,1)$ for all $t \geq 0$.

Every period, operating firms incur a fixed cost $c_f \geq 0$ drawn from the common time-invariant distribution F_{c_f}. The fixed operating cost c_f is distributed log-normally with parameters μ_f and σ_f. The process for the fixed operating cost is independent over time, across firms, and across sectors.

At the end of the period, each firm is hit by two types of exogenous exit shock: first, each firm may exit with a constant probability $\gamma \in (0,1)$; second, firms' exit probability also exogenously varies with the sovereign default risk, as described in detail below in equation 13. The latter assumption is motivated by our empirical finding that there is a strong positive association between sovereign risk and firm exits and that this relationship does not seem to be driven by the credit supply channel. This direct effect captures various other channels that might be relevant for a firm's exit decision during a sovereign debt crisis, such as expectations about higher taxes or lower subsidies, disruptions in international trade, or increased uncertainty about future policies.

In each sector, $j \in \{L, H\}$, firms have to pay in advance a fraction ϕ_j of their investment and labor cost before production takes place.[14] To do so, firms take intra-period working capital loans from banks. The two sectors in the economy only differ in their external finance dependence, determined by ϕ_H and ϕ_L, with $\phi_H > \phi_L$. We refer to sectors L and H as the

[14]Underlying the assumption of the cost is a working capital requirement. If firms want to invest and hire at the beginning of the period before they receive revenues they have to borrow to finance a share of their cost.

low-EFD and high-EFD sector, respectively.

3.1.1 Incumbent Firms

In the beginning of the period, a firm in sector j starts with predetermined capital stock, k, and idiosyncratic productivity z_{-1}. After observing an aggregate state s, and an idiosyncratic productivity shock, z, the firm makes hiring decision, undertakes production and chooses next period's capital stock, k'. Capital stock evolves according to $k^{'} = (1-\delta)k + i$, where i is investment and δ is the depreciation rate. Following the real business cycles literature, we assume that incumbents are subject to quadratic investment adjustment cost, $g(i,k) = c_k \left(\frac{i}{k}\right)^2 k$ where the parameter $c_k \geq 0$ controls the cost of adjusting capital. The firm borrows from financial intermediaries by issuing bonds b at an interest rate R.

While making exit decisions, the firm considers the fixed cost of production c_f. The firm optimally decides to exit the market if the expected continuation value after the observed fixed cost of production is less than the recovery value of capital. Upon exit, the value of an incumbent, $V_x(k)$, equals fraction η of undepreciated capital $V_x(k) = \eta(1-\delta)k$. Firms that exit cannot re-enter the market at a later stage.

We denote by $V_j^I(z,k,s)$ the value of an incumbent firm in sector $j \in \{L, H\}$ at the beginning of the period. Then the dynamic programming problem faced by an incumbent is:

$$\begin{aligned} V_j^I(z,k,s) = & \max_{l,i,b,k'} Az(k^\alpha l^{1-\alpha})^\theta - (1-\phi_j)\left[wl + i + g(i,k)\right] - R(s)b + \\ & + \int_{c_f} \max\left\{V_x(k), \beta d^\zeta (1-\gamma)\mathbb{E}\left[V_j^I(z',k',s')|z,s\right] - c_f\right\} dF_{c_f}(c_f), \end{aligned} \tag{5}$$

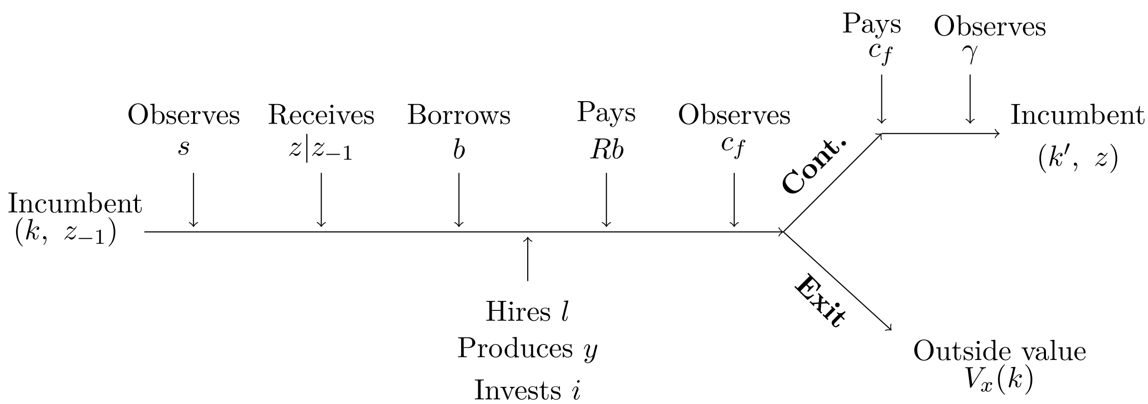
where $d > 0$ is the value of sovereign default shock process and $\zeta \geq 0$ is a parameter that shapes the effect of the sovereign risk on exit probability. Firms maximize the value function subject to the capital accumulation equation,

$$k' = (1-\delta)k + i, \tag{6}$$

and the working capital constraint,

$$b = \phi_j\left[wl + i + g(i,k)\right]. \tag{7}$$

Figure 3: **Incumbent firm's timing**



3.1.2 Potential Entrants

Every period, there is a limited and constant mass of heterogeneous business opportunities in high-EFD and low-EFD sectors that potential entrants use to enter the market. Each business opportunity is characterized by a signal p. The signal describes the expected initial productivity of a business opportunity after it is implemented in the market. The mass of business opportunities with signal p is given by Pareto distribution $F_p(p)$ with location parameter $\underline{p}$ and Pareto exponent $\xi > 0$. We use parameter μ_H to scale the available business opportunities in high- relative to low-EFD sectors so that the relative size of each sector is consistent with the data counterpart. Finally, the initial period productivity for a business opportunity with signal p is log-Normally distributed according to $log(z) = \rho_z log(p) + \sigma_z \epsilon_z$, with $\epsilon_z \sim N(0,1)$. We denote the conditional distribution by $F_E(z|p)$.

Every period, an infinite mass of aspiring start-ups compete for these business opportunities. Since the expected returns from each of these business opportunities are non-negative and there is no cost to participate in the competition, all the available business opportunities will be seized by some of these aspiring start-ups. The latter group of aspiring start-ups become potential entrants who make decisions about whether to implement the business opportunity in the market or not.

Each potential entrant with a business opportunity p in sector j, observes the aggregate state of the economy, s, and makes an entry decision. To enter the market entrepreneurs need to pay the fixed entry cost $c_e \geq 0$, that is equal across sectors. We assume that the entrant needs to externally finance the fraction ϕ_j of the fixed cost, which varies across high-and low-EFD sectors.

A firm that enters sector j today, starts its first period operation with idiosyncratic productivity drawn from $F_E(z|p)$ and an exogenously given initial stock of capital k_0. Thus, the firm becomes an incumbent with state variables (z, k_0, s). Therefore, the firm's expected gross value of entry, before paying the entry cost, equals the expected value of being an incumbent with state variables (z, k_0, s) in sector j given by

$$V_j^g(p,s) = \mathbb{E}\left[V_j^I(z,k_0,s)|p\right], \quad \text{where} \quad j = H, L \tag{8}$$

A firm enters the market if its expected gross value as an incumbent net of the entry cost is positive. Thus the value for an entrant with signal p is

$$V_j^E(p,s) = \max\left\{0, V_j^g(p,s) - (1-\phi_j)c_e - R\phi_j c_e\right\}, \quad \text{where} \quad j = H, L \tag{9}$$

3.1.3 The Mutual Fund

There is a mutual fund, fully owned by households, that collects profits from all active firms in both sectors and allocates these profits to the households in a lump-sum manner.

3.2 Households

There is a unit measure of identical households. Households receive labor income from working for non-financial firms and profits Π_t from the ownership of mutual funds owning all firms in the economy.

Households have linear preferences for consumption and labor supply. A representative household's problem is to choose the sequences of consumption C_t and labor hours L_t to maximize the discounted lifetime utility

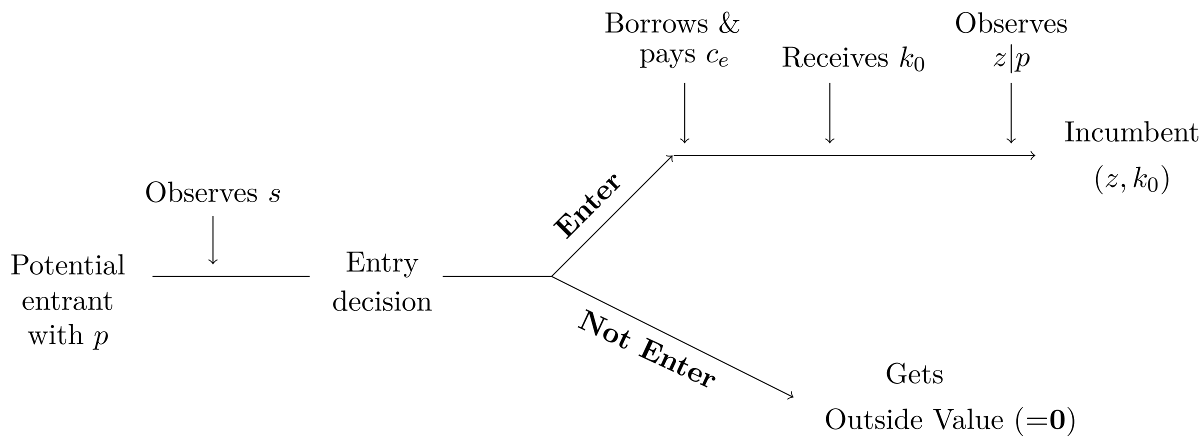
$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[C_t - \nu L_t\right], \tag{10}$$

subject to the budget constraint

$$C_t = \Pi_t + w_t L_t, \tag{11}$$

where $\beta \in (0,1)$ is the discount factor, $\nu > 0$ is the labor disutility parameter, and w_t denotes the hourly wage. Given the simplicity of the household's problem in the model, we assume

Figure 4: **Potential entrant's timing**



that households are hand-to-mouth. The infinitely elastic labor supply then implies that wages are fixed, $w_t = \nu$, $\forall t$. Therefore, equilibrium employment is fully demand-determined.

3.3 Government

As our focus is to investigate how sovereign default risk is transmitted to real economic activity, in particular through firms entry and exit, we model the government as a source of default risk. Let B_t be the stock of debt at the beginning of period t. Every period a fraction ϑ of outstanding debt matures. To simplify the analysis, we assume that maturing bonds are replaced by identical new bonds to keep the stock of debt constant at $B_t = \bar{B}$. We follow Bocola (2016) in assuming that over time sovereign risk evolves exogenously. In every period the economy is hit by a shock $\varepsilon_{D,t}$ drawn from a standard logistic distribution, and the default process, D_{t+1}, evolves according to

$$D_{t+1} = \begin{cases} 1 & \text{if } \ \varepsilon_{D,t+1} - d_t \geq 0 \\ 0 & \text{otherwise} \end{cases} \tag{12}$$

where d_t is an AR(1) process

$$d_{t+1} = (1 - \rho_d)\overline{d} + \rho_d d_t + \sigma_d \varepsilon_{d,t+1}, \qquad \varepsilon_{d,t+1} \sim \mathcal{N}(0,\, 1). \tag{13}$$

Then, the conditional probability that the sovereign is in default next period is given by

$$\pi_t^d \equiv \text{Prob}(D_{t+1} = 1) = \frac{e^{d_t}}{1 + e^{d_t}}. \tag{14}$$

3.4 Banks and Lending Rates

In this model, banks are a reduced form technology that determines firms' borrowing rate as a function of the state of the economy. In particular, firms pay to banks an interest rate that is a function of the sovereign bond price, and it is given by

$$R_t = \chi_1 R_{g,t}^{\chi_2} \tag{15}$$

where

$$R_{g,t} = 1 + \frac{\vartheta}{q_t} - \vartheta$$

is the gross yield to maturity of sovereign bonds, and the parameters $\{\chi_1, \chi_2\}$ measure the pass-through from sovereign yields for bank lending rates to the corporate sector. This relationship captures well-documented interactions between the aforementioned interest rates. The main two channels that explain why increases in sovereign risk result in higher rates paid by firms are the bank balance sheet channel and financial repression. For a micro-founded banking sector where firm's borrowing rates is determined endogenously, see Bocola (2016) or Arellano et al. (2020). In those models, banks hold sovereign bonds in their portfolio, and banks lending capacity is constrained by a function of their net worth. Thus, when default risk increases, the net worth of banks falls and it is more likely that the lending constraint binds in the present or future periods. As a result, banks charge higher interest rates to the corporate sector. For evidence on the financial repression during the European debt crisis, see Becker and Ivashina (2018), who finds that banks increase sovereign bond holdings during the debt crisis. Financial repression crowds out loanable funds from the private sector and increases firms' interest rate.

The price of bonds, q_t, is determined by a standard no-arbitrage condition,

$$q_t(d_t) = \mathbb{E}_t \left[\beta(1 - D_{t+1})(\vartheta + q_{t+1}(d_{t+1})(1 - \vartheta)) \right], \tag{16}$$

where the expectation is taken over the realizations of D_{t+1} and d_{t+1}.

4 Aggregate Shocks and Model Mechanisms

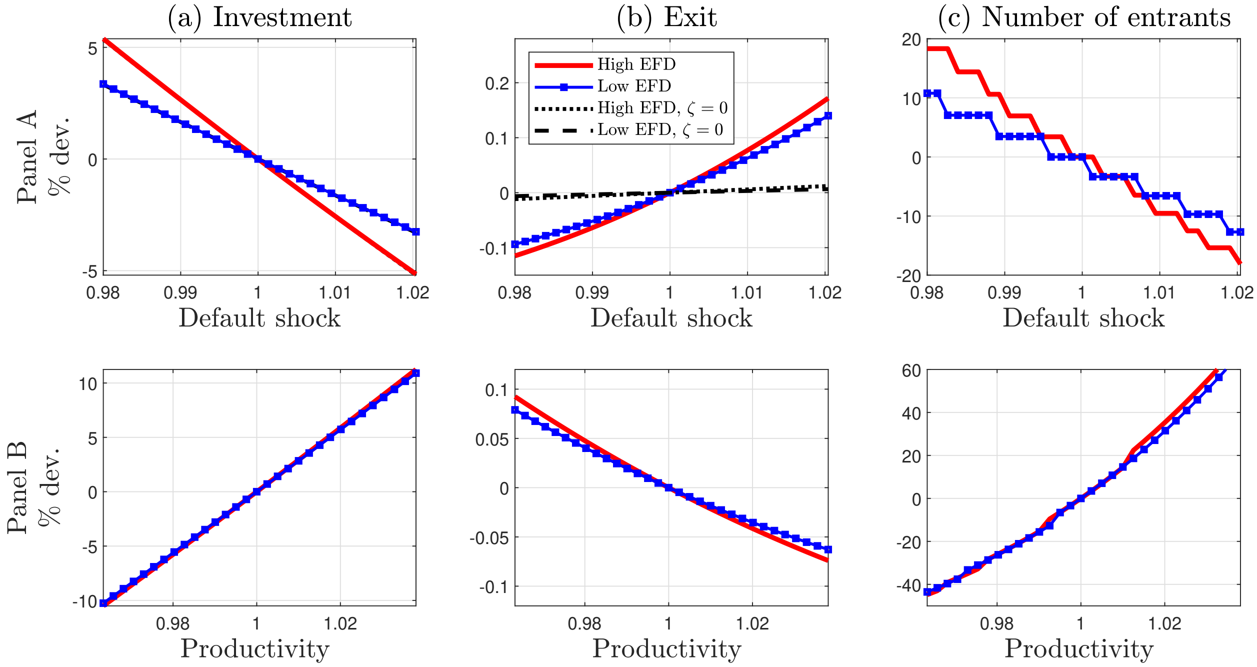
In this section, we illustrate how sovereign default and aggregate productivity shocks affect firm dynamics at intensive and extensive margins. Toward this end, Figure 5 displays changes in aggregate investment, exit, and entry across different levels of aggregate shocks. To assess the role of external financing needs for the transmission of shocks, we display average responses of each variable of interest in high and low-EFD sectors.[15] Finally, to isolate the credit-supply channel from the full effect of the sovereign default shocks, we illustrate how the aggregate investment, exit, and entry changes to with respect to aggregate shocks after eliminating the direct effect of default risk on the probability of exit by setting $\zeta = 0$.

Panel A of Figure 5 assesses the effect of the default shocks on the economy while setting the aggregate productivity shock at its mean value. Figure 5A(a) shows that an increase in the sovereign default probability lowers aggregate investment levels in both sectors, with the high-EFD sector responding more. The elasticity of investment does not change if we set $\zeta = 0$, implying that the sovereign default shocks affect firms' decisions at an intensive margin only through the credit supply channel: the increased interest rate makes working capital loans more expensive and firms optimally cut back on their investment and hiring. Due to the life cycle firm dynamics, the slower capital accumulation also dampens hiring decisions and lowers revenues and profits in the upcoming periods, further propagating the sovereign default shocks. Panel B of Figure 5 repeats the exercise for the aggregate productivity levels. Figure 5B(a) illustrates that the decrease in the aggregate productivity level lowers investment, with the impact being almost indistinguishable between high versus low-EFD sectors.

Figure 5A(b) compares the behavior of the number of firm exits across high- and low-EFD sectors in response to the default shocks. The exit increases with the default shocks in the high- and low-EFD sectors. Note that exit hardly changes with the sovereign default shocks without the direct effect of the sovereign risk on firms' continuation value ($\zeta = 0$ case). That is, the level of external finance dependence cannot account for the negative effect of the sovereign crisis on firm exits. The reason is that changes in the interest rate

[15] All model simulations presented in this section use the same parameter values as in our main calibration section. We describe the calibration strategy and model fit in detail in Section 5.

Figure 5: Aggregate investment, exit and entry: High- vs low-EFD sectors



do not have a quantitatively strong effect on the value function of firms and, therefore, the quantitative effect on exit is small even in the high-EFD sector. Thus, the major effect of sovereign risk on firm exit comes from its direct effect on firms' continuation value. The parameter ζ shapes the magnitude of this effect, which we later calibrate to directly match the elasticity of the exit with respect to sovereign spreads described in Table 1. This result is fully in line with our empirical finding from Section 2, showing that higher sovereign risk is associated with a significant increase in firm exits but that the degree of external finance dependence plays a minor role in explaining these relationships. Figure 5B(b) shows that the firm exit decreases with the aggregate productivity level.

Finally, Figure 5A(c) shows that an increase in the sovereign risk lowers the number of entrants at an aggregate and sector level. The effect only comes through the credit supply channel: first, the higher interest rate directly increases the total fixed cost of entry – the total value of internal and external funds needed to cover the fixed entry cost in high- and low-EFD sectors; second, the higher default shocks decrease the expected post-entry lifetime value, further discouraging entry. Note that the elasticity of the number of entrants to the interest rate is higher in high-EFD sectors than in low-EFD sectors – consistent with our empirical findings. Figure 5B(c) shows that the elasticity of the number of entrants to aggregate productivity shock is positive and does not vary across sectors.

5 Calibration and Model Performance

In this section, we calibrate the model to the Portuguese economy and evaluate the model's performance in various dimensions.

5.1 Calibration

A period in the model corresponds to one year. First we set some parameters to standard values in the literature. We then jointly calibrate the rest of the parameters to match important features of firm dynamics at the extensive and intensive margins in Portugal. Table 3 summarizes the parameter values.

We assign standard values to the discount factor, $\beta = 0.98$, the capital share in production, $\alpha = 0.34$, and the depreciation rate of capital, $\delta = 0.1$. We set the returns to scale parameter θ to 0.85.[16] The parameters describing the process for default risk are taken from Bocola (2016).

First, we calibrate the parameters that shape high- and low-EFD sectors. These parameters are the relative size of high- versus low-EFD sectors (μ_H), the fraction of working capital requirement in the high (ϕ_H) and low-EFD (ϕ_L) sectors. We set $\mu_H = 0.71$ which ensures that the share of the number of firms in the high-EFD sector (relative to total) is consistent with the empirical counterpart in Portugal over the period 2005-2008. Note that the choice of this parameter value also matches the share of entrants in the high- and low-EFD sectors, not directly targeted in the calibration. We use parameters ϕ_H and ϕ_L to match the distribution of leverage in high- and low-EFD sectors to the data. In the data, we define leverage as a firm's debt-to-assets ratio. We measure debt as the sum of short-term loans, long-term loans, and accounts receivable as in Arellano et al. (2020). We set $\phi_H = 0.8$ and $\phi_L = 0.5$, which matches the median (P50) leverage in high- and low-EFD sectors in the model and the data. Table 4 also shows the close match of P25 leverage in high- and low-EFD sectors.

[16] See, for example, Basu and Fernald (1997), Burnside et al. (1995) and Lee (2007) who estimate returns to scale in production in the US industries and at the plant level.

Table 3: Calibration

Symbol	**Description**	**Value**	**Calibration Targets/Source**
β	Discount rate	0.98	Standard value
δ	Depreciation rate	0.10	Standard value
α	Capital share	0.34	Standard value
θ	Span of control	0.85	Standard value
μ_h	Relative size of high EFD sector	0.71	Share of firms in high EFD sector
ϕ_ℓ	Financing needs: low EFD sector	0.50	Median leverage in low EFD sectors
ϕ_h	Financing needs: high EFD sector	0.80	Median leverage in high EFD sectors
ρ_z	Persistence of idiosyncratic shock	0.81	Firm size and empl. share by age
σ_z	SD of idiosyncratic shock	0.26	Firm size and empl. share by age
c_k	Investment adjustment cost	0.03	Firm size and leverage distribution
μ_f	Operating cost - mean parameter	0.62	Firm survival by age
σ_f	Operating cost - SD parameter	0.41	Firm survival by age
γ	Exit shock	0.07	Firm survival by age
$\underline{p}$	Pareto location	0.70	Relative size of entrants
ξ	Pareto exponent	4.00	Employment share of entrants
c_e	Entry cost	3.98	Entry rate
k_0	Initial level of capital	2.15	Firm size at entry
ζ	Firm exit elasticity to default shocks	-9.00	Exit elasticity to sovereign spreads
η	Capital recovery rate upon exit	0.00	Exit elasticity to sovereign spreads
ρ_A	Persistence of aggregate prod. shock	0.81	Arellano et al. (2020)
σ_A	SD of aggregate prod. shock	0.004	Arellano et al. (2020)
$\bar{d}$	Average default probability	0.0034	Bocola (2016)
ρ_d	Persistence of default shock	0.8145	Bocola (2016)
σ_d	SD of default shock	1.1705	Bocola (2016)
ϑ	Bond maturing probability	0.0560	Bocola (2016)
χ_1	Average corporate rate	1.0373	Regression of equation (15)
χ_2	Elasticity to sovereign yields	0.3450	Regression of equation (15)

Overall, these parameter values for sector-specific working capital constraints imply that median leverage in the overall economy equals 0.45, compared to a 0.54 in the data.

Next, we describe the calibration of the parameters that govern firm dynamics in the model. To fully quantify the propagation of sovereign default risk through entry and exit margins, it is crucial that the model replicates the dynamics of firms at entry and over time. For example, Haltiwanger et al. (2013) show that young firms are inherently different from their mature counterparts and emphasize the importance of accounting for firms' life cycle dynamics in understanding the role of entry. We use Eurostat's annual employer enterprise data over the period 2004-2017 to compute relevant statistics on firm dynamics in the Portuguese economy. We then jointly calibrate parameters governing firms' life cycle dynamics in the model to match the data counterparts of average firms' characteristics at entry and over time. These parameters are $\{c_e, \underline{p}, \xi, k_0, \mu_f, \sigma_f, \gamma, \sigma_z, \rho_z, c_k, \phi\}$. To capture

Table 4: Calibration targets and model-implied moments: High- vs low-EFD sectors

Moments	**Data**	**Model**
Share of firms (%)	**71**	**71**
Share of entrants (%)	71	71
High-EFD: P50 leverage	**0.44**	**0.48**
High-EFD: P25 leverage	0.17	0.18
Low-EFD: P50 leverage	**0.34**	**0.31**
Low-EFD: P25 leverage	0.90	0.11
Overall: P50 leverage	0.54	0.45

Note: Statistics in the data are calculated using the Eurostat dataset covering employer enterprises in Portugal over the period 2004-2018. Model-implied moments are from the stationary distribution. High- and low-EFD sectors are defined based on the RZ-EFD indicator defined in Section 2. Statistics in bold are directly targeted in the calibration. The rest of the moments are untargeted.

Table 5: Calibration targets and model-implied moments: Overall economy

Targeted moments	**Data**	**Model**
Average entry rate (%)	10.0	10.0
Survival rate up to age 1	0.84	0.80
Survival rate up to age 5	0.49	0.42
Average size of all enterprises	8.1	6.5
Average size of entrants	2.6	2.2
Average size of firms at age 4	4.7	4.7
Entrants' employment share (%)	3.0	3.3
Exit elasticity to sovereign spreads	0.020	0.028

Note: Statistics in the data are calculated using the Eurostat dataset covering employer enterprises in Portugal over the period 2004-2018. Model-implied moments, except for the exit elasticity, are from the stationary distribution. To calculate the exit elasticity, we simulate the model with aggregate shocks for 5000 periods and use the last 4000 periods of the simulated data to estimate regression (1).

cohorts' characteristics at entry (age zero) we target the entry rate, relative size of entrants and share of entrants' employment in total employment. With regard to cohorts' post-entry characteristics, we target the information about the life cycle survival, exit, average size, and share of employment for up to five years of operation. Table 5 lists the specific targeted moments. Even though the above parameters are jointly calibrated, below we discuss which specific moment helps us identify which parameter value.

The entry cost (c_e) pins down the threshold signal level and, therefore, the steady-state mass of entrants. To calibrate this parameter, we use the entry rate in Portugal. We discipline the initial level of capital (k_0) and parameters that shape potential entrants' distribution ($\underline{p}$ and ξ) to match the average size, relative size, and employment share of entrants. The mean (μ_f) and standard deviation (σ_f) of the fixed operating cost, together with the exogenous exit probability (γ) shape the cohort's life cycle survival and exit rates. We, therefore, calibrate these parameters to match average enterprise survival rates at age 1, age 3, and age 5.[17]

The persistence (ρ_z) and standard deviation (σ_z) of the idiosyncratic productivity shock process and investment adjustment cost parameter (c_k) shape the cohorts' employment, growth, and investment dynamics over the life cycle. To calibrate these parameters, we target the average size of cohorts at age 0 and age 4, and the share of age 0 firms' employment in total employment.

The parameter ζ shapes the direct effect of the sovereign risk on firm exit. We choose the parameter to match the elasticity of firm exit to sovereign spreads in the model and the data. To find the elasticity of exit with respect to sovereign spreads in the model, we simulate the economy over 5000 periods. Using the simulated data from the last 4000 periods we estimate the regression equation (1). In the model, a one percentage point increase in the sovereign spreads increases exit by 2.8%; in the data, this number equals to 2% (see Table 1). The model also closely gets the elasticity of entry with respect to sovereign spreads, which has not been targeted in the model. Specifically, a one percentage point increase in sovereign spreads decreases entry by 2.7% in the model and by 2.4% in the data. In addition, the model's predictions about the elasticity of entry and exit across high- and low-EFD sectors are also qualitatively similar to the data.

Finally, to estimate the pass-through of sovereign bond rates to corporate rates we use the exogenous default shocks computed by Bahaj (2020) for Portugal at a monthly frequency from July 2009 to March 2013.[18] In particular, we run the following first stage regression

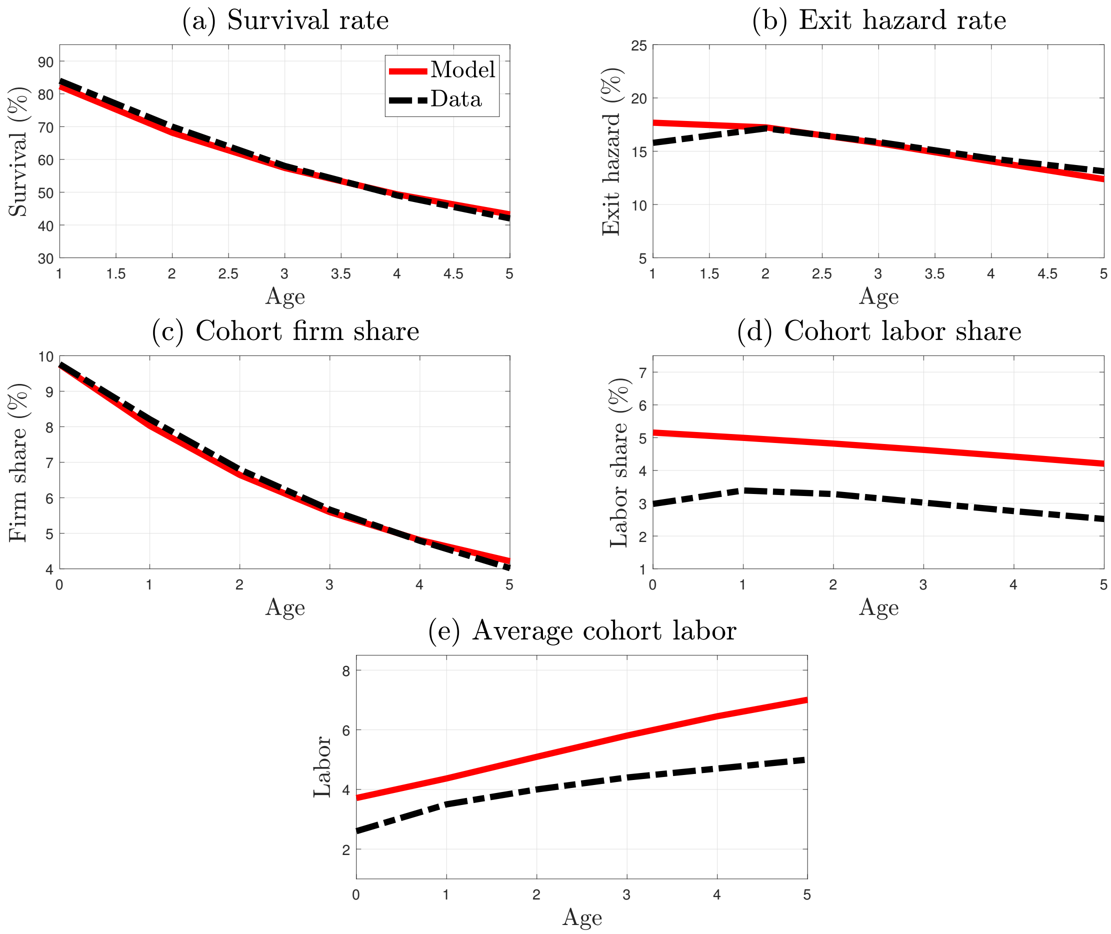
$$\log(R_t^g) = \alpha_b + \beta_b \varepsilon_{b,t} + \epsilon_{1,t},$$

where $\varepsilon_{b,t}$ are the exogenous default shocks and $\epsilon_{1,t}$ is a white noise. Next, we compute the predicted value for the gross yield of sovereign bonds, $\hat{R}_t^g$, and estimate the pass-through

[17]The Eurostat dataset does not provide information about firms with age six and more.

[18]See Bahaj (2020) for further details on the construction of the shocks.

Figure 6: Cohorts average life cycle characteristics



Note: The empirical moments are calculated from the Eurostat dataset covering employer enterprises in Portugal over the period 2004-2018. The model-implied moments are simulated using the stationary distribution of firms.

equation (15), in logs, running the following regression:

$$\log(R_t) = log(\chi_1) + \chi_2 \log(\hat{R}_t^g) + \epsilon_{2,t},$$

where $\epsilon_{2,t}$ is a white noise.

5.2 Firm Dynamics: Model vs. Data

Table 5 reports the calibration results comparing the model-implied moments with their empirical counterparts. The model does a good job at replicating the main characteristics of the Portuguese firm dynamics. The model-implied firm entry rate is 10%, the same as in Portugal. The model is also successful at reproducing firm survival rates in the data. On average, around 20 percent of the entrants exit in the first year of operation, and by age five, only 42 percent of the original entrants remain in the market. The average firm employs 6.5 workers in the model, which is two workers less than in the data. The average entrant employs 2.2 workers and grows up to 5 workers by the end of age 4. Overall, entrants contribute only around 3 percent to aggregate employment in the model and the data.

Figure 6 shows the full age profile of the selected variables. Panel (a) illustrates that the model closely replicates the survival rates of firms up to age 5. Moreover, Panel (b) shows that the model successfully matches the dynamics of exit by age. Panels (c) and (d) further compare the employment margin of firm dynamics in the model and the data. Specifically, it reports the growth of cohorts measured by average size and the share of cohorts' employment in aggregate employment by age. Overall, our model reproduces the well-known *up or out* dynamics of entrants.

5.3 Leverage Dynamics by Firm Age and Size: Model vs. Data

Finally, we show that the model endogenously leads to the documented rich heterogeneous dynamics in firms' borrowing needs over the life cycle – an important feature to correctly quantify the sovereign-credit supply channel. Particularly, we show that in the model, as in the data, firms' leverage increases with firm size and decreases with age.

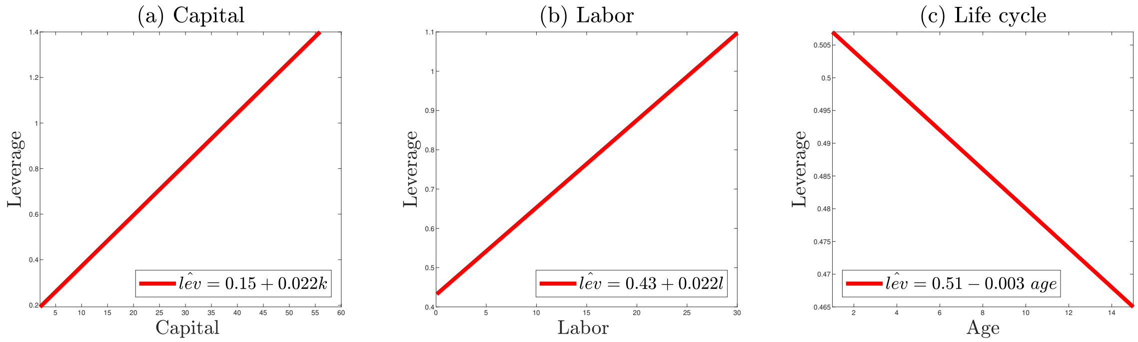
To document the dynamics of leverage by age and size for the Portuguese economy, we use the ORBIS dataset and follow Dinlersoz et al. (2019) to estimate the following standard leverage regression:

$$lev_{i,s,t} = \alpha + \omega_{s,t} + \underset{(0.000)}{0.019} \cdot log(emp_{i,s,t}) - \underset{(0.000)}{0.002} \cdot age_{i,s,t} + controls + \hat{\varepsilon}_{i,s,t} \quad (17)$$

where i is a firm, s is an industry that firm operates, and t is time, measured in years. $\omega_{s,t}$ is an industry×year fixed effects, where industry is at 2-digit level. $log(emp_{i,s,t})$ and $age_{i,s,t}$ measures the log number of employees and age of a firm i. *Controls* include firms' collateral and profitability.[19] The dependent variable is defined as firm's debt-to-assets

[19] Following Dinlersoz et al. (2019), we measure collateral as tangible fixed assets over total assets and profitability as net income over total assets. To control firms' growth potential, we use productivity measured by TFP following Wooldridge (2009).

Figure 7: Leverage and firm size and age: Cross-sectional relationships



ratio, where we choose our baseline specification to measure debt as the sum of short-term loans, long-term loans, and accounts receivable. Regression equation (17) reports the estimated coefficients for size and age. We report robust standard errors in parentheses under the estimated coefficients. In Portugal, firms' leverage significantly increases with size and decreases with age. The results are consistent across different leverage measures and regression specifications. The results are also consistent with Dinlersoz et al. (2019), who find that large firms are more leveraged and firm's leverage declines with age in the cross-section of private firms in the United States.

Figure 7 illustrates the relationship between firm leverage with the firm size and age in the model using the cross-sectional distribution of firms in the stationary steady state. Figures 7(a) and 7(b) illustrate that there is a positive association between firm leverage and size measured by either labor or capital. Panel (c) of Figure 7 further shows that there is a negative association between firm leverage and age in the cross-section of firms. The following features of the model are responsible for the heterogeneous leverage dynamics over the firm life cycle: First, heterogeneity in firm-level productivity and decreasing returns to scale production technology imply that firms have an optimal size. Second, working capital constraints and investment adjustment costs prevent firms from immediately getting to their optimal size of production. As a result, on average older firms are closer to the optimal scale and need to borrow less, while younger firms, who usually start small, tend to borrow more to scale up their production, pushing up their leverage. This generates an unconditional negative dependence between firm leverage and age.

6 Quantitative Evaluation

In this section, we use the calibrated model to evaluate the output and productivity losses in Portugal during sovereign debt crisis and quantify the role of the extensive margin in determining these costs.

6.1 The Output Costs of the Portuguese Sovereign Crisis

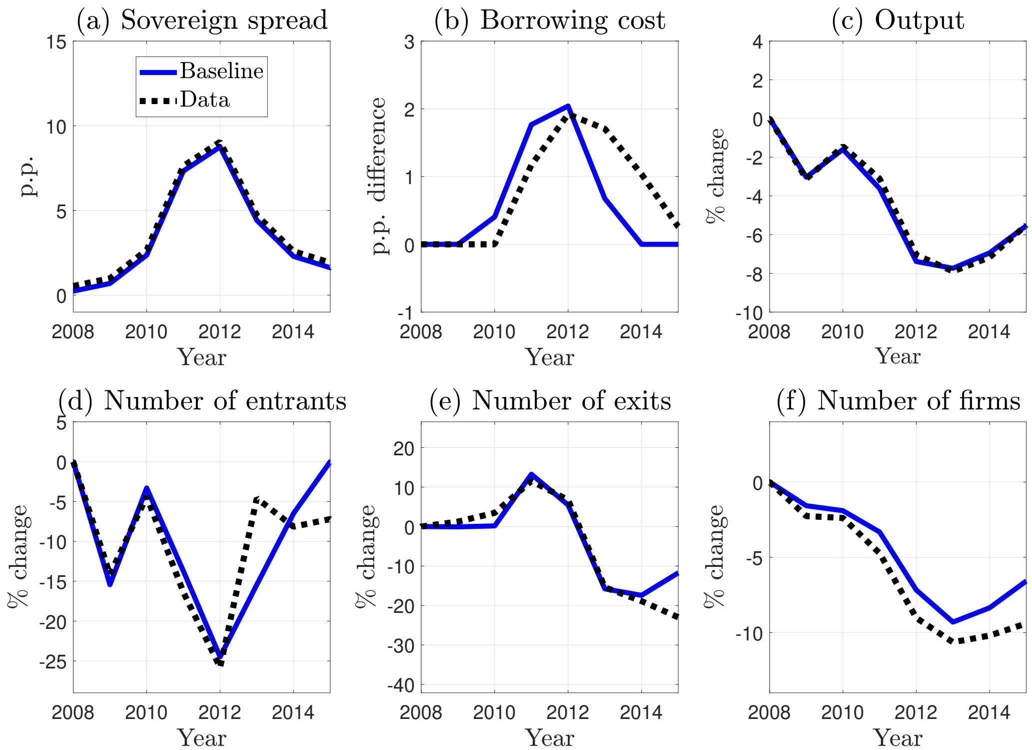
To study the output costs of the sovereign debt crisis, we perform the following exercise. We feed our model economy with the sequences of shocks to sovereign default probability and aggregate productivity so that the model-implied dynamics of sovereign spreads and output matches the data counterparts in Portugal over the period 2008-2015. We then quantify the effect of sovereign risk on output costs by generating the dynamics of key macro aggregates in the counterfactual scenario with only shocks to sovereign risk; that is, we set the aggregate productivity at its mean value throughout the entire event window.

Figure 8 shows that the model-implied dynamics of key macroeconomic variables in response to the constructed shock sequences closely matches the dynamics observed in Portugal over the period 2008-2015. The solid lines represent the dynamics from our baseline model while the dotted lines are the data. By construction, the sequences of aggregate shocks ensure that the baseline model matches sovereign spreads (Figure 8a) and output dynamics (Figure 8c) in the data almost perfectly.[20] Figure 8(b) shows that the behavior of firms' borrowing interest rates, implied by equation (1), matches the data well. Our estimates imply that the pass-through from the sovereign spread to the borrowing rates was around 35%, i.e., a seven percentage point increase in the sovereign spread in 2012 (relative to 2010) resulted in a two percentage point increase in corporate spreads.

Figures 8(d) and 8(e) show that the dynamics of firm entry and exit in the baseline model also very closely track the data throughout the entire event window. Particularly, in 2012, when sovereign spreads peaked, the fall in the number of entrants was 25.8% in the data versus 24.5% in the model. At the same time, the increase in firm exit was 11.5% in the data versus 13.5% in the model. Overall, Figure 8(e) shows that the model closely accounts

[20] Appendix Figure A1 displays the implied sequences of the sovereign default and TFP shocks.

Figure 8: Macro dynamics and sovereign crisis in Portugal: Model vs. Data



for the drop and the persistence in the total number of firms – the net effect of the entry and exit dynamics.

In Appendix E.1, Figure 15 shows that in the model, as in the data, the crisis (2010-2012) cohorts consists of fewer firms and employ fewer number of workers at entry and over time compared to their non-crisis counterparts. In Appendix E.1 (Figure 14) we additionally show that the entry and exit dynamics across high- and low-EFD sectors is also in line with the data. Interestingly, the model predicts that during 2009-2010 when the level of sovereign risk was benign, and thus, the economy was mostly driven by the TFP shocks, the entry dynamics in high and low-EFD sectors coincided, like in the data. However, during the Portuguese sovereign debt crisis, entry fell more in high-EFD relative to low-EFD sectors both in the model and in the data. The model also has a data-consistent prediction about the exit dynamics during the debt crisis: the number of exiting firms increased more in low-EFD compared to high-EFD sectors. These results are reassuring, especially because we do not target any sectoral or cohort-level dynamics in constructing the crisis event study.

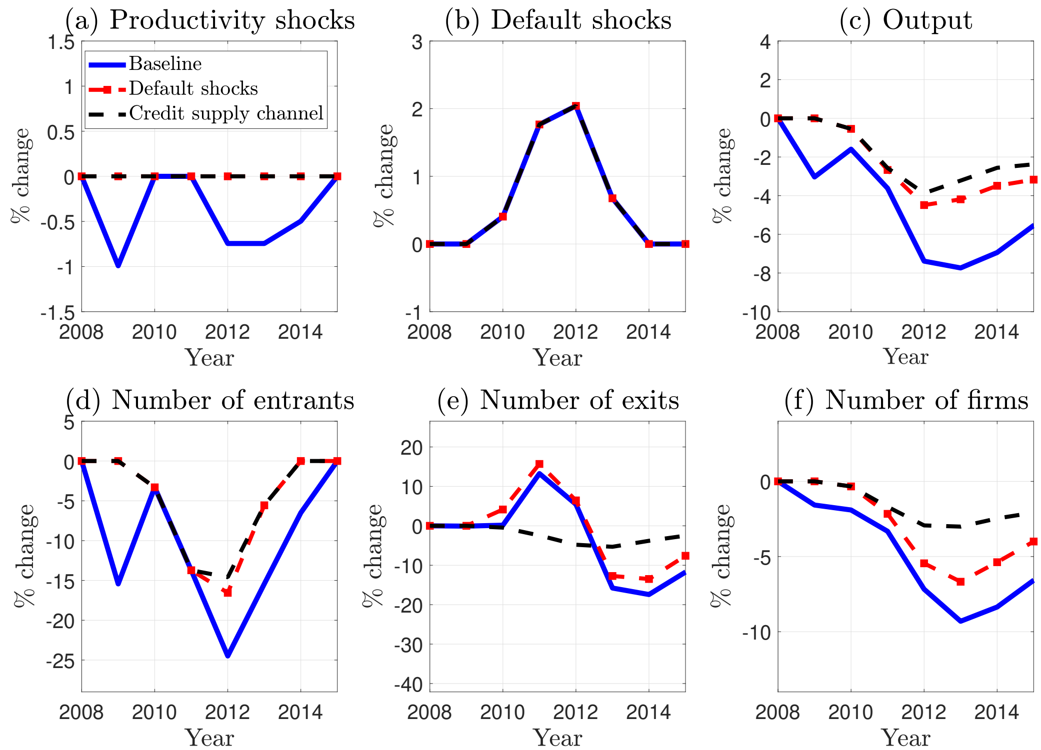
The Output Costs of Sovereign Risk Having established that our model successfully fits the macro dynamics in Portugal during 2008-2015, we next evaluate the quantitative importance of the sovereign debt crisis. To do so, we consider a counterfactual scenario where we shut down the aggregate productivity shocks while keeping the original default shock series throughout the event window. Within this exercise, we also assess the contribution of the credit supply channel of sovereign risk by allowing sovereign default shocks to only affect non-financial firms through the interest rate. That is a counterfactual economy with $\zeta = 0$ in equation 5. Figure 9 displays the baseline scenario (solid blue lines) together with the counterfactual scenarios: "default shocks only" (red-square-dashed lines) and "credit supply channel" (black dashed lines).

Figure 9(c) shows that the increased sovereign default risk had a significant and persistent effect on the aggregate output dynamics. Specifically, in 2012, at the peak of the crisis, the increased sovereign risk was responsible for about 4.5% out of a total 7.6% decline in output. For comparison, Arellano et al. (2020) find that the sovereign debt crisis accounted for about 50% of the output drop in Italy during 2012. Importantly, our model additionally predicts that the negative contribution of the sovereign risk persists long after the sovereign crisis. For example, by the end of 2015, it is responsible for around a 3.2% drop in output out of a total of 5.6%.

Figures 9(d)-9(f) illustrate that the sovereign risk played an important role in driving the observed dynamics of firm entry and exit in Portugal. In particular, the increased sovereign risk fully explains the model-implied drop in the number of entrants in 2010-2011. The default shocks account for a 14.6% drop in entry, which is 60.8% of the total drop in the number of entrants observed in 2012. The changes in sovereign default risk explain most of the increase in firm exits during the period 2011-2012. Overall, the model predicts that the increased sovereign risk accounts for around 76% and 60% drop in the total number of firms in 2012 and 2015, respectively.

Finally, Figure 9 illustrates the importance of the credit supply channel in the amplification and propagation of the sovereign default shocks. This channel fully accounts for the output costs of sovereign risk until 2012, and it is responsible for about four-fifths of the decline in output throughout 2013-2015. As for the extensive margin, the credit supply

Figure 9: The output costs of sovereign risk



channel completely explains the dynamics of firm entry but not firm exits, which is consistent with the empirical findings from Section 2. The sharp increase in exit, not accounted for by the credit supply channel in 2011-2012, drives the drop in the total number of firms starting from 2012.

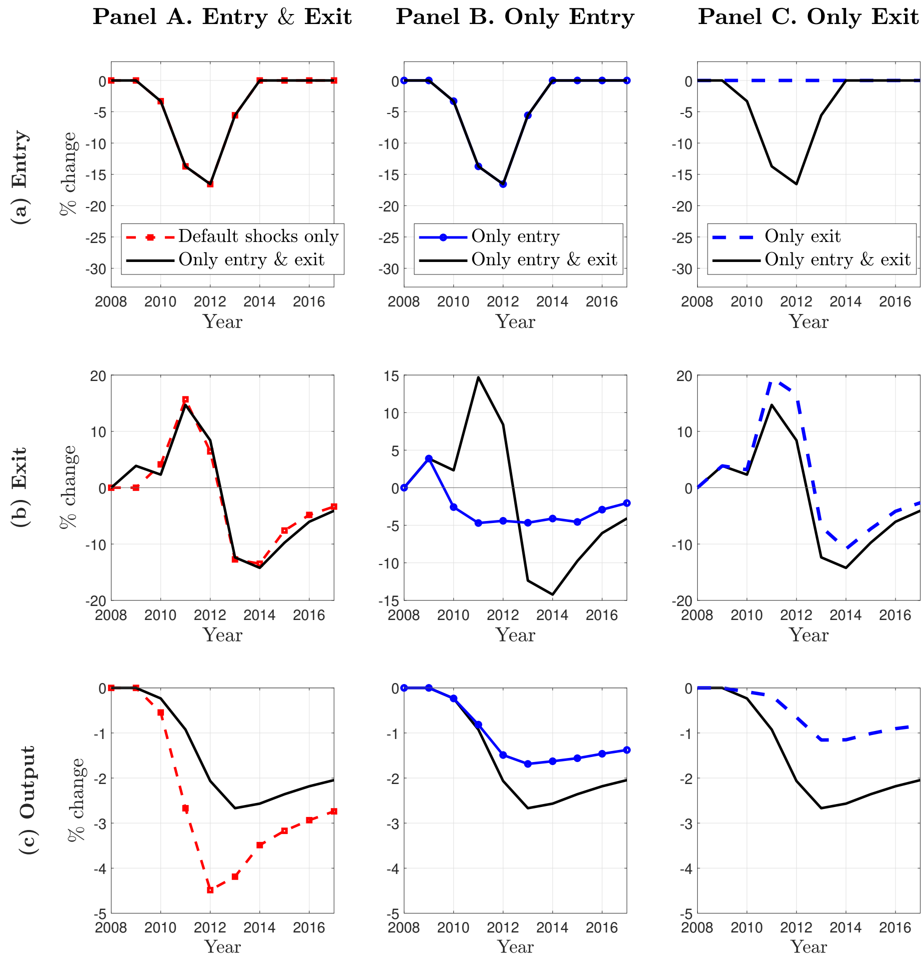
6.2 The Role of Firm Entry and Exit

In this section, we present our main finding that the observed sharp decline in entry and increase in exit are largely responsible for the persistent effects of the Portuguese sovereign debt crisis. Toward this end, we consider various counterfactual scenarios where the sovereign default shock series only affect entry and/or exit margins and have no effect on firms' adjustments at the intensive margin. The shocks to aggregate productivity are set to zero throughout these scenarios.

First, Panel A of Figure 10 considers a scenario ("only entry & exit") where the default shocks affect both entry and exit and have no effect on the intensive margin.[21] Comparing

[21]Specifically, in this case, firms decisions about entry and exit optimally respond to the sovereign default

Figure 10: Sovereign risk and economic activity: The role of firm entry and exit



Note: This figure shows the dynamics of the selected variables in response to the same default shock series as in Figure 9. In the "Default shocks only" scenario, the economy is affected by only the default shocks series while setting the shocks to aggregate productivity to zero. In the "Only entry & exit" scenario, the default shocks affect both entry and exit and have no effect on the intensive margin; and "only entry" and "only exit" scenarios shut down entry and exit margins within the "Only entry & exit" scenario.

the "only entry & exit" counterfactual with the "only default shocks" scenario identifies the full effect of the extensive margin in propagating and amplifying the sovereign default shocks. Figure 10A(c) shows that the entry and exit together accounted for around 47% of the total output costs of the sovereign crisis in 2011-2012; that is, 27% of the actual drop in output in Portugal over the same period. Over time the contribution of the extensive margin goes up and by 2017 is responsible for 80% of the persistent decline in output due to the sovereign crisis.

shocks, while the decisions about output, investment, and labor are set at the steady state level throughout the event study.

To evaluate the individual contributions of firm entry and exit dynamics on economic activity, we consider the following two counterfactual scenarios. Panel B of Figure 10 illustrates the role of entry by shutting down the exit margin in the "only entry & exit" scenario ("only entry"), while Panel C of Figure 10 isolates the role of exit by shutting down the entry margin ("only exit").[22] Figures 10B(c) and 10C(c) show that the entry and exit margins contribute, respectively, around 1.2% and 1.0% drop in the persistent negative effect of the sovereign debt crisis on output.

6.3 The Productivity Costs of Sovereign Risk

In this section, we study the short-run and long-run effects of the sovereign crisis on the dynamics of total factor productivity. In the model, we measure the total factor productivity as the Solow residual for the aggregate economy:

$$TFP_t = log(Y_t) - \alpha\theta log(K_t) - (1-\alpha)\theta log(L_t),$$

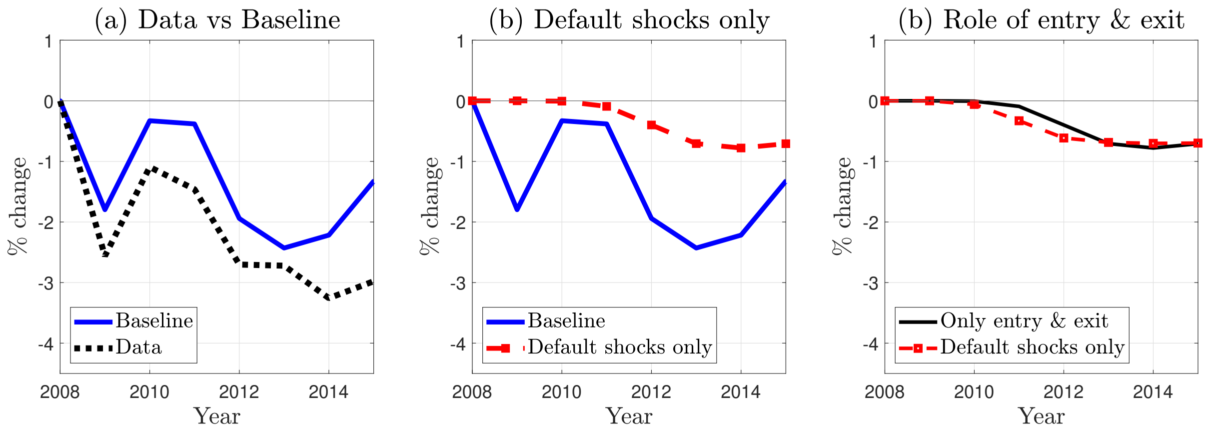
where Y_t, K_t, and L_t represent, respectively, the aggregate output, capital, and labor.

Figure 11(a) illustrates the dynamics of aggregate productivity in Portugal over the period 2008-2015 in the data and the model. The data time series comes from the publicly available EU KLEMS Growth and Productivity Accounts. "Baseline" refers to the baseline scenario in which the economy is affected by both the aggregate productivity and the default shocks.[23] Interestingly, the total factor productivity from the main event study closely tracks the data counterpart. To evaluate the quantitative importance of the sovereign debt crisis in the observed dynamics of the TFP, we shut down the aggregate productivity shocks while keeping the original default shocks throughout the event window ("default shocks only"). Figure 11(b) illustrates that most of the dynamics of the total factor productivity are due to the aggregate productivity shocks. However, note that while the contribution of sovereign risk is minor on impact, over time the contribution increases and accounts for half of the decline in productivity in the baseline scenario by the year 2015.

[22]Specifically, in Panel B of Figure 10 only firm entry decision changes with the sovereign default shocks, while the decisions about exit, output, investment, and labor are set at the steady state level throughout the event study. Similarly, Panel C of Figure 10 only varies exit decisions in response to the default shocks.

[23]The time series of the shocks are the same as in the main exercise described in Figure 8.

Figure 11: The productivity cost of sovereign risk



Finally, to measure the role of the extensive margin, Figure 11(c) illustrates the "only entry & exit" scenario – where the sovereign default shock series only affect entry and exit margins and have no effect on firms' adjustment at the intensive margin. We find that the persistent effect of the sovereign crisis on the total factor productivity comes solely from the fact that the model accounts for the dynamics of firms at extensive – entry and exit margins.

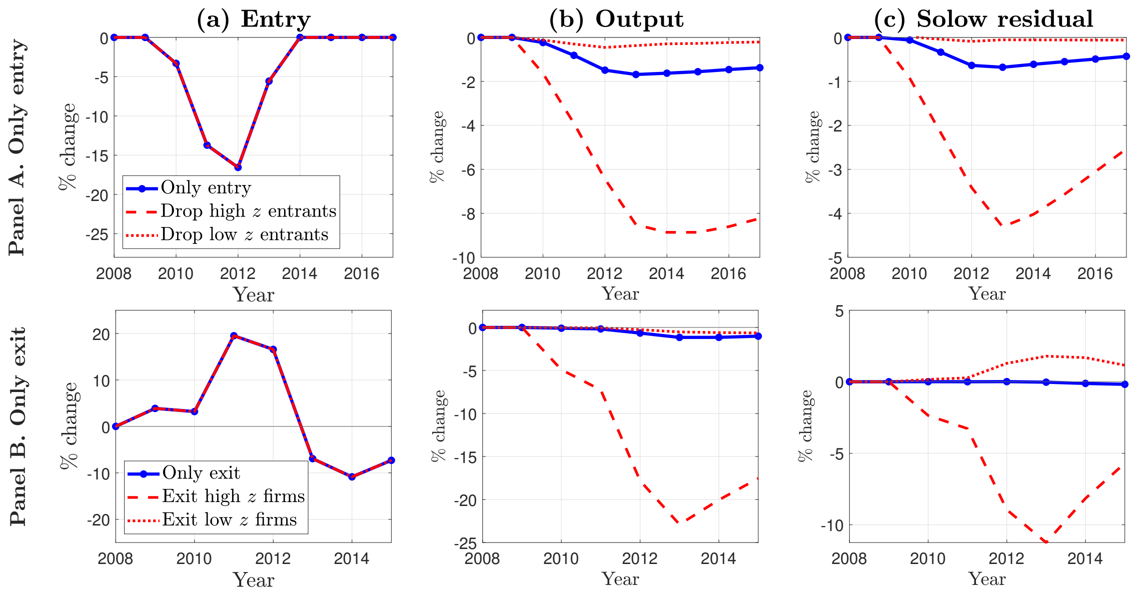
6.4 "Missing" and "Wasted" Generation Effects

How does the transitory decline in the number of startups and exits generate the persistent fall in aggregate output or total factor productivity? In the section, we show the importance of the dynamics of the productivity composition of entrants and exits: it is not a decline (an increase) in the *number* of entrants (exits) per se, but the change in the share of high-productivity, high-survival rate firms in the entrant or exiting cohorts that determine the propagation.

To illustrate the point we consider the "only entry" scenario from Panel B of Figure 10 – a counterfactual economy where the default shock series affect firm entry decisions; firm decisions about exit, investment, output, and labor are set to their steady-state level.[24] To evaluate the importance of the composition of firms, we additionally consider two counterfactual economies with the same dynamics in the number of entrants, but we systematically vary the productivity composition of new cohorts. Specifically, in one scenario, we cut the *lowest*

[24]The productivity shocks are set to zero throughout the event study.

Figure 12: Persistent effects of entry and exit: The role of selection



productivity firms from the steady-state distribution of entrants, while in the other scenario, we lower the number of firms at entry by dropping the *highest* productivity entrants.[25]

Panel A of Figure 12 illustrates this exercise. Figure 12(a) shows that the dynamics of the number of entrants are the same across these scenarios by construction. The only difference between the dynamics of these economies comes from the variation in the composition of entrants. Figures 12A(b) and 12A(c) show that the economy where the only low productivity entrants get hurt does not exhibit a persistent fall in aggregate output or the total factor productivity (the red-dotted line). However, losing the high-productivity firms significantly increases the output and productivity costs of the sovereign crisis (the red dashed line).

Panel B of Figure 12 repeats the above exercise but considers the "only exit" scenario – a counterfactual economy where the default shocks affect firm exit decisions, while decisions about entry, output, and labor are set to their steady state level. As in the above exercise, we additionally consider two other scenarios with the same dynamics of the number but different productivity compositions of exiting firms (Figure 12Ba). After examining Figures 12B(b) and 12B(c), once again, we conclude that the strength of the propagation of the extensive

[25] In Appendix E.2, Figure 16 plots the entrants' productivity distributions during the crisis year under different selection scenarios together with the stationary (non-crisis) distribution. Figure **??** Panel (a) shows the productivity distribution of entrants during the crisis in our baseline economy, while Panels (b) and (c) display the distributions from the previously described counterfactual scenarios.

margin hinges solely on the effect of the sovereign crisis on the share of the high-productive firms in the entrant and existing firms.

The mechanism above is similar to the “missing generation” effect studied by Gourio et al. (2016) and Sedláček (2020) in the context of the United States during the Great Recession. They show that the “missing generation” of high-productivity, high-growth, and high-survival startups has a persistent negative impact on employment and economic activity. We show that exit dynamics also generate a persistent negative “wasted generation” effect when the sovereign crisis drives out high-productivity firms from the market.

7 Conclusion

This paper quantifies the role of firm entry and exit in shaping the output costs of a sovereign debt crisis. Using annual industry-level data from European countries, we document that increased sovereign default risk is associated with a decline in firm entry and an increase in firm exits. We find strong support for the bank credit supply channel driving the observed negative relationship between sovereign risk and firm entry, while this channel does not explain the positive association between sovereign risk and firm exit. Then, we develop a quantitative heterogeneous firm dynamics model with endogenous entry and exit, sovereign default risk, and financial frictions. We find that the increased sovereign risk accounts for 60% fall in firm entry and most of the firm exit dynamics during the Portuguese debt crisis. The entry and exit dynamics, in turn, are responsible for about 80% of the persistent drop in output.

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APPENDICES

A Data Description

This section provides a brief description of the main dataset and relevant statistics for our empirical analysis given in Section 2. The corresponding manual provides the detailed description of the dataset, see the Eurostat's webpage. The Eurostat's annual Business Demography Data provides information about the characteristics and demography of the businesses for European Union (EU) and European Free Trade Association (EFTA) members. This information are mainly collected from the respective countries' business registers and for comparability are harmonized across these countries. Some countries additionally use other sources to improve the availability of data on employment.

Below we provide definitions of variables relevant to our empirical analysis. The unit of analysis in the Eurostat's Business Demography database is *enterprise*. *enterprise* is defined as "the smallest combination of legal units that is an organizational unit producing goods or services, which benefits from a certain degree of autonomy in decision-making, especially for the allocation of its current resources. An enterprise carries out one or more activities at one or more locations. An enterprise may be a sole legal unit".[26]

We refer to *enterprise birth* as entry of a firm. The former is defined "a birth amounts to the creation of a combination of production factors with the restriction that no other enterprises are involved in the event. It does not include entries into a sub-population resulting only from a change of activity. Births do not include entries into the population due to mergers, break-ups, split-off or restructuring of a set of enterprises. A birth occurs when and enterprise starts from scratch and actually starts activity. An enterprise creation can be considered an enterprise birth if new production factors, in particular new jobs, are created. If a dormant unit is reactivated within two years, this event is not considered a birth";[27]

[26]Source: Council Regulation (EEC), No. 696/93, Section III A of 15.03.1993 on the statistical units for the observation and analysis of the production system in the Community.

[27]Source: Definitions of SBS Regulation variables (11 12 0), Eurostat-OECD Manual on Business Demography Statistics (chapter 5).

In the analysis, we use the employer enterprise as an unit of analysis. These are the enterprises that have at least one employee. The latter is defined as "as those persons who work for an employer and who have a contract of employment and receive compensation in the form of wages, salaries, fees, gratuities, piecework pay or remuneration in kind." The subset of the dataset is labeled as the 'Employer Business Demography' in the Eurostat.

Sectors In the analysis, we use the annual sector-level data on the entry and exit across countries. We consider the dynamics of entry and exit covered in the following NACE Rev.2 sectors: Sectors from B to N (B-E - industry, F- construction, and G-N - services), excluding group 64.2 (management activities of holding companies). These sectors in Eurostat business demography dataset are refereed as Business Economy except Activities of Holding Companies. These activities exclude voluntarily sections P to S (O - public administration and defense, compulsory social security; P - Education; QA - Human health services; AB - Residential care and social work activities; R - Arts, entertainment and recreation; S - Other activities).

A.1 Coverage and Summary Statistics

Table A1 reports summary statistics by each country about the number of entrants, the number of exits, entry rate, and exit rates. Specifically, these table shows the earliest year the data series is available for each country (start year). The end date of each time series for each country is the year 2018. The table also report the mean and standard deviation of each time series by each country.

For our main analysis we consider the group of large countries for which the data on the entry and exit is available at least starting from 2010. These countries are Spain, Italy, Hungary, Czech Republic, Austria, Slovenia, Portugal, Netherlands, and France. In robustness checks we also consider a sample that includes all countries and all available periods in the Eurostat Employer Business Demography Database.[28] See Table A1 for more details.

[28] We exclude Estonia from the analysis since we do not have long-term government bond yields data for Estonia. The country first issued its 10-year government bond in June 2020. Similarly, we exclude Luxembourg as the data on sovereign spreads start in 2010. For more information follow the link.

Table A1: Coverage and Summary Statistics

	Entry (Number)			**Exit** (Number)		
Country	Start year	Mean	Standard Dev.	Start year	Mean	Standard Dev.
*Spain	2004	145109	20212	2008	149793	31304
*Italy	2004	135322	17110	2008	125510	15183
*Hungary	2004	50106	12643	2008	54334	39704
*Czech Republic	2004	22467	3790	2008	22612	5889
*Austria	2004	18059	983	2004	15130	1979
*Portugal	2005	29416	8756	2005	31276	4887
*Netherlands	2007	23636	2626	2007	23067	2104
*France	2008	132251	8858	2008	129281	13172
Slovenia	2004	6211	773	2008	6138	697
Latvia	2007	7218	2931	2007	3854	1764
Lithuania	2009	7346	1585	2008	5850	2575
Iceland	2010	2283	726	2008	1851	466
UK	2012	306223	40873	2012	222776	37095
Poland	2012	117760	35492	2010	102006	20285
Sweden	2012	27490	2225	2011	25922	2080
Bulgaria	2012	22073	1483	2010	19427	5559
Slovakia	2012	16176	4721	2010	19598	15045
Finland	2012	15331	3447	2013	14504	1488
Denmark	2012	14425	2704	2011	9958	7610
Croatia	2012	13060	5431	2010	12709	5428
Norway	2012	12065	638	2010	8981	1138
Belgium	2012	6773	814	2010	1993	890
Switzerland	2013	13439	586	2013	11687	1054
Ireland	2014	4475	438	2012	3383	824

Note. *Source*: Eurostat, Employer business demography by size class (from 2004 onwards, NACE Rev. 2) Last update: 15-04-2021. *Start year* indicates the year from which the respective time series is available for each country. Each of the time series goes up to the year 2018. We drop few countries for which the data are not available until 2015 (Malta, and Cyprus). We dropped Turkey, Romania, Greece, Germany from the analysis. **We exclude Estonia from the analysis since we do not have long-term government bond yields data for Estonia. The country first issued its 10-year government bond in June 2020. Similarly, we exclude Luxembourg as the data on sovereign spreads start in 2010. See the link. Countries with * are included in main analysis. The rest of the countries are included are considered in the robustness checks.

B Evidence from the European Sovereign Debt Crisis

In Section 2 we used sovereign spreads as a proxy for sovereign risk. Here we exploit the European sovereign debt crisis, an episode with elevated sovereign default risk among the Eurozone periphery countries, to evaluate the role of financial constraints for firm entry and exit dynamics. The existing empirical studies document that the sovereign debt crisis was accompanied by severe tightening of credit conditions for non-financial firms. This literature identifies the bank lending channel behind this credit tightening especially in the context of the periphery countries where domestic banks are highly exposed to their own governments' debt (e.g., Bofondi et al. (2018), Balduzzi et al. (2018), Bottero et al. (2020), Crosignani et al. (2015)).

Therefore, we use the following regression specification to identify the credit supply channel,

$$
\begin{aligned}
Y_{i,c,t} &= \beta_0 + \beta_1 sovcrisis_t \times high\text{-}EFD_i \times periphery_c \\
&\quad + \alpha_i + \gamma_c + \phi_{i,c} + \eta_t + \psi_{i,t} + \theta_{c,t} + \varepsilon_{i,c,t}, \qquad (18)
\end{aligned}
$$

where $sovcrisis_t$ is a dummy variable taking a value of one for the period 2011-2012. The definitions of the other two dummy variables are the same as before. Note that this regression follows a standard triple difference strategy in which the high-EFD industries in the periphery countries represent a treatment group.

Panel A of Table B1 shows the results from the above regression and provides evidence of sovereign risk-bank credit channel in driving entry, exit and net-entry dynamics during sovereign crisis. The triple difference estimator suggests that credit constraints reduced entry by around 9.3 percentage points in high-EFD sectors relative to low-EFD sectors. The estimated coefficient for exit shows that the credit channel increased exit by 5.3 percentage points. While the latter effect is not statistically significant, the coefficient on net-entry - the log difference between entry and exit - is highly significant and negative.

In Panel B of Table B1, we estimate the version of regression (18) where we allow for the effects of varying degree of sovereign risk among the periphery countries during the European sovereign crisis. Specifically, we interact the $sovcrisis \times high\text{-}EFD \times periphery$

Table B1: The European sovereign debt crisis, firm entry and exit: Credit supply channel

	Panel A			Panel B		
	Entry	Exit	Net entry	Entry	Exit	Net entry
	(1)	(2)	(3)	(1)	(2)	(3)
Sov. crisis×high-EFD×periphery	-0.093**	0.053	-0.131*			
	(0.045)	(0.037)	(0.06)			
Sov. crisis×high-EFD×periphery×spread				-0.024***	0.010	-0.027***
				(0.008)	(0.010)	(0.011)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Industry×Year FE	✓	✓	✓	✓	✓	✓
Country×Year FE	✓	✓	✓	✓	✓	✓
Controls	–	✓	–	–	✓	–
Observations	5,197	4,398	4,346	5,197	4,398	4,346
R^2	0.987	0.992	0.2531	0.987	0.993	0.707

Note: Robust standard errors clustered at industry×country level are in parentheses. Sovereign crisis is a dummy variable taking a value of one for the period 2011-2012. Spread refers to sovereign spread and is defined as a percentage point (p.p.) difference between yields on 10-year domestic government bonds and German bonds of the similar maturity. Periphery is a dummy variable taking a value of one for Portugal, Spain, and Italy. When the outcome variables is (log) exit, we also control for (log) entry. See Appendix A for a detailed description of our sample and data coverage. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

variable with sovereign spreads. Table B1, Panel B, illustrates that during the sovereign crisis episode higher spreads were associated with stronger declines in entry. Increase in exit in high-EFD sectors is minor and not statistically significant. Overall, the higher sovereign risk during the crisis were associated with statistically significant fall in net-entry of firms.

In Appendix C.2.1, we conduct a series of robustness checks. The above results hold when we (i) consider only post-Great recession period, 2010-2018 (Table C11); (ii) include the rest of the countries and all available periods (Table C10); (iii) include the rest of the countries and consider only post-Great Recession period (Table C11); (v) categorize industries into high, medium and low EFD groups (Table C12). In the Appendix B.1 we also show the robustness of our results using alternative measures of external financial dependence.

B.1 Alternative Measures of External Finance Dependence

We also explore the robustness of our results to using alternative measures of external financial dependence. For our sample of the European countries, we construct a country-specific, industry-level measure of external financial dependence based on firms' leverage using firm-level balance sheet data from the ORBIS dataset. Leverage is defined as a firm's debt-to-assets ratio. Following Arellano et al. (2020) we measure debt as the sum of short-term loans, long-term loans, and accounts receivable. To mitigate concerns about endogeneity of leverage, we compute industry-level leverage measure using data for 2006-2007 and for relatively mature firms, e.g., firms with age 10 years and older.

To calculate the sectoral measure of financial dependence we compute the median leverage across firms within each 2-digit NACE industry for each country for the years 2006-2007. That is, for each year $t = \{2006, 2007\}$ and country c, for each firm j in industry i we compute $lev_{jict} \equiv (LOAN_{jict} + LTBD_{jict} + CRED_{jict})/TOAS_{jict}$, where $LOAN$ refers to short-term loans, $LTBD$ are long-term loans, $CRED$ are trade receivable, and $TOAS$ represents total assets. Using lev_{jict} we compute an industry-level measure of leverage by taking the median across all lev_{jict} within each industry i and each year t and country c. Finally, we divide sectors into high- and low-leverage groups based on whether lev_i is above or below the 50^{th} percentile of leverage values across sectors within a country.[29]

We use the leverage-based measure to re-estimate the same triple-diff specification described in regression equation (18). Note that in this case, since the leverage-based measure varies with industry and country, we can control the interaction of the crisis with the high-leverage sector dummy – sov. crisis× high-leverage. Table B2 reports the results of the regression. Panel A uses all available years and countries. To further mitigate the concerns of the endogeneity of our leverage-based EFD measure, Panel B restricts the sample to the post-Great Recession period 2010-2018. Panel A shows that entry falls by about 13.6 percent in high-leverage sectors in periphery countries during the European sovereign default crisis. The result is close in magnitude to the one obtained in the baseline specification. As for the exit, we find that increase in exit in high-EFD sectors during the financial crisis is around 6.1 percent, but the coefficient is not significant. However, the overall effect on net entry is a fall of 14.2 percent, which is again similar to our baseline estimate of -11.6.

Panel B of Table B2 shows that the results are robust to restricting the sample to the period 2010-2018. Moreover, the magnitude of the effects is comparable to the previous

[29] In Appendix B.1, we also consider two alternative measures of leverage: First, when we define the debt as only short-term loans, and second, when we define debt as a sum of short-term and long-term loans.

Table B2: The European sovereign debt crisis, credit channel, and firm entry and exit: Leveraged-based measure of EFD

	Panel A. Full sample			Panel B. 2010-2018 sub-sample		
	Entry	Exit	Net entry	Entry	Exit	Net entry
	(1)	(2)	(3)	(1)	(2)	(3)
Sov. crisis× high-leverage	0.086	0.023	-0.035	0.043	-0.004	0.035
	(0.036)	(0.049)	(0.060)	(0.037)	(0.048)	(0.057)
Sov. crisis× high-lev ×periphery	-0.136***	0.061	-0.142**	-0.130**	0.087*	-0.184**
	(0.049)	(0.050)	(0.069)	(0.051)	(0.051)	(0.072)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Industry×Year FE	✓	✓	✓	✓	✓	✓
Country×Year FE	✓	✓	✓	✓	✓	✓
Controls	–	✓	✓	–	✓	✓
Observations	3,695	3,227	3,227	2,434	2,430	2,430
R^2	0.993	0.994	0.748	0.994	0.995	0.747

Note: Robust standard errors clustered at industry×country level are in parentheses. Sovereign crisis is a dummy variable taking a value of one for the 2011-2012. high-lev is a dummy variable with a value of one if a sector lev_j is above the 50^{th} percentile of leverage values across sectors within a country. All other variables are defined as before. Periphery is a dummy variable taking a value of one for Portugal, Spain, and Italy. When the outcome variables are (log) exit we also control for (log) entry. See Appendix A for a detailed description of our sample and data coverage. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

estimates. Specifically, Panel B shows that entry decreases by 13.0 percentage points, exit increases by 8.7 percentage points and is significant with 10% confidence, and net entry falls by 18.4 percentage points. We also consider the following alternative definitions of leverage: (i) the ratio of short-term loans to total assets; and (ii) the ratio of the sum of short-term and long-term loans to total assets. Table B3 shows that the results are robust to these alternative definitions of leverage.

Overall, our empirical results indicate that the increased sovereign risk disrupted credit supply to the corporate sector and negatively affected firm entry in the European periphery during the 2011-2012 debt crisis. We find weaker evidence that the higher firm exit during this period was driven by a credit crunch, indicating that other factors played a more important role.

Table B3: The European sovereign debt crisis, credit channel, and firm entry and exit: Alternative measures of leverage

	Panel A Dependent Variable			Panel B Dependent Variable		
	Entry	Exit	Net Entry	Entry	Exit	Net Entry
Crisis× Lev 2-high	0.008	0.028	-0.013			
	(0.048)	(0.056)	(0.058)			
Crisis× Lev 2-high ×periphery	-0.029***	0.005	-0.022*			
	(0.010)	(0.009)	(0.012)			
Crisis× Lev 3-high				0.055	0.057	-0.018
				(0.035)	(0.036)	(0.045)
Crisis× Lev 3-high ×periphery				-0.026**	-0.004	-0.017
				(0.013)	(0.009)	(0.012)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Industry×Year FE	✓	✓	✓	✓	✓	✓
Country×Year FE	✓	✓	✓	✓	✓	✓
Controls	–	✓	✓	–	✓	✓
Observations	3,695	3,227	3,227	3,695	3,227	3,227
R^2	0.993	0.994	0.748	0.993	0.994	0.748

Note: Robust standard errors clustered at industry×country level are in parentheses. Sovereign crisis is a dummy variable taking a value of one for the 2011-2012. Lev 2 represents a leverage measure where debt is defined as only the short-term loans. Lev 2-high refers to sectors for which the average leverage is above the 75*th*-percentile of leverage. Second, Lev 3 represents a leverage measure where debt is defined as a sum of the short-term and long-term loans. Lev 3-high refers to sectors for which the average leverage is above the 50*th*-percentile of leverage. Sovereign spread is defined as a percentage point (p.p.) difference between yields on 10-year domestic government bonds and German bonds of the similar maturity. Periphery is a dummy variable taking a value of one for Portugal, Spain, and Italy. When the outcome variable is (log) exit we also control for (log) entry. See Appendix A for a detailed description of our sample and data coverage. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

C Robustness

This section provides series of robustness checks for our main empirical results, described in the Empirical Evidence (Section 2). Specifically, Appendix C.1 provides robustness checks for the Sovereign Risk, Firm Entry and Exit (Section 2.1). Appendix C.2 provides robustness checks for the Evidence on Credit Supply Channel (Section 2.2). Appendix C.2.1 provides robustness checks for the Evidence from the Sovereign Debt Crisis.

C.1 Sovereign risk, firm entry and exit

Table C1: Sovereign risk, firm entry and exit: Post-Great Recession period (2010-2018)

	Panel A. Entry			Panel B. Exit		
	(1)	(2)	(3)	(1)	(2)	(3)
Sovereign spread	-0.028***	-0.034***	-0.034***	0.037***	0.023***	0.023***
	(0.005)	(0.007)	(0.007)	(0.006)	(0.007)	(0.007)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	–	✓	✓	–	✓	✓
Industry×Year FE	–	–	✓	–	–	✓
Controls	–	✓	✓	–	✓	✓
Observations	2,951	2,904	2,904	2,953	2,900	2,900
R^2	0.986	0.986	0.989	0.977	0.986	0.988

Note: Robust standard errors clustered at industry×country level are in parentheses. Sovereign spread is defined as a percentage point (p.p.) difference between yields on 10-year domestic government bonds and German bonds of the similar maturity. Controls include real GDP growth, y-o-y inflation rate, (log) population, the current account to GDP ratio, and country-specific linear time trends. When the outcome variable is (log) exit we also control for (log) entry. See Appendix A for a detailed description of our sample and data coverage. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table C2: Sovereign risk, firm entry and exit: Controlling for the lagged sovereign spreads

	Panel A. Entry			Panel B. Exit		
	(1)	(2)	(3)	(1)	(2)	(3)
Sovereign spread	-0.025***	-0.047***	-0.047***	0.039***	0.020***	0.018**
	(0.004)	(0.008)	(0.007)	(0.004)	(0.007)	(0.007)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	–	✓	✓	–	✓	✓
Industry×Year FE	–	–	✓	–	–	✓
Controls	–	✓	✓	–	✓	✓
Observations	4,496	4,449	4,449	3,938	3,885	3,885
R^2	0.977	0.979	0.984	0.976	0.984	0.987

Note: Robust standard errors clustered at industry×country level are in parentheses. Sovereign spread is defined as a percentage point (p.p.) difference between yields on 10-year domestic government bonds and German bonds of the similar maturity. Controls include real GDP growth, y-o-y inflation rate, (log) population, the current account to GDP ratio, and country-specific linear time trends. When the outcome variable is (log) exit we also control for (log) entry. See Appendix A for a detailed description of our sample and data coverage. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table C3: Sovereign risk, firm entry and exit: All countries

	Panel A. Entry			Panel B. Exit		
	(1)	(2)	(3)	(1)	(2)	(3)
Sovereign spread	-0.010***	-0.009*	-0.009**	0.038***	0.049***	0.049***
	(0.003)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	–	✓	✓	–	✓	✓
Industry×Year FE	–	–	✓	–	–	✓
Controls	–	✓	✓	–	✓	✓
Observations	10,510	9,758	9,758	10,327	8,856	8,856
R^2	0.977	0.980	0.983	0.977	0.977	0.979

Note: Robust standard errors clustered at industry×country level are in parentheses. Sovereign spread is defined as a percentage point (p.p.) difference between yields on 10-year domestic government bonds and German bonds of the similar maturity. Controls include real GDP growth, y-o-y inflation rate, (log) population, the current account to GDP ratio, and country-specific linear time trends time trends. When the outcome variable is (log) exit we also control for (log) entry. For the list of all countries see Table A1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table C4: Sovereign risk, firm entry and exit: All countries and post-Great Recession period (2010-2018)

	Panel A. Entry			Panel B. Exit		
	(1)	(2)	(3)	(1)	(2)	(3)
Sovereign spread	-0.014***	-0.019***	-0.019***	0.047***	0.070***	0.070***
	(0.004)	(0.006)	(0.006)	(0.004)	(0.008)	(0.008)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	–	✓	✓	–	✓	✓
Industry×Year FE	–	–	✓	–	–	✓
Controls	–	✓	✓	–	✓	✓
Observations	8,121	7,651	7,651	8,543	7,495	7,495
R^2	0.981	0.983	0.985	0.976	0.977	0.978

Note: Robust standard errors clustered at industry×country level are in parentheses. Sovereign spread is defined as a percentage point (p.p.) difference between yields on 10-year domestic government bonds and German bonds of the similar maturity. Controls include real GDP growth, y-o-y inflation rate, (log) population, the current account to GDP ratio, and country-specific linear time trends time trends. When the outcome variable is (log) exit we also control for (log) entry. For the list of all countries see Table A1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

C.2 Evidence on Credit Supply Channel

Table C5: Sovereign risk, firm entry and exit: Credit supply channel (Post-Great Recession period)

	Panel A. Entry		Panel B. Exit		Panel C. Net entry	
	(1)	(2)	(1)	(2)	(1)	(2)
Sovereign spread	-0.072***		0.034		-0.081***	
	(0.021)		(0.015)		(0.023)	
Sovereign spread×periphery	0.051***		-0.020		0.053***	
	(0.019)		(0.015)		(0.020)	
Sovereign spread×high-EFD	0.038	0.038	-0.002	-0.001	0.028	0.028
	(0.034)	(0.034)	(0.017)	(0.017)	(0.028)	(0.027)
Sovereign spread×high-EFD×periphery	-0.067**	-0.068**	0.024	0.020	-0.069**	-0.069**
	(0.033)	(0.033)	(0.018)	(0.018)	(0.027)	(0.027)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Industry×Year FE	✓	✓	✓	✓	✓	✓
Country×Year FE	–	✓	–	✓	–	✓
Controls	✓	–	✓	✓	✓	–
Observations	3,276	3,323	3,272	3,319	3,272	3,319
R^2	0.990	0.992	0.988	0.993	0.572	0.721

Note: Robust standard errors clustered at industry×country level are in parentheses. Sovereign spread is defined as a percentage point (p.p.) difference between yields on 10-year domestic government bonds and German bonds of the similar maturity. Controls include real GDP growth, y-o-y inflation rate, the current account to GDP ratio, (log) population, and country-specific linear time trends. When the outcome variable is (log) exit we also control for (log) entry. See Appendix A for a detailed description of our sample and data coverage. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table C6: Sovereign risk, firm entry and exit: Credit supply channel (All countries)

	Panel A. Entry		Panel B. Exit		Panel C. Net entry	
	(1)	(2)	(1)	(2)	(1)	(2)
Sovereign spread	0.004		0.065***		-0.060***	
	(0.007)		(0.009)		(0.010)	
Sovereign spread×periphery	-0.017**		-0.028***		0.016	
	(0.008)		(0.009)		(0.011)	
Sovereign spread×high-EFD	0.006	0.013	0.001	-0.001	0.003	0.010
	(0.009)	(0.009)	(0.010)	(0.010)	(0.012)	(0.011)
Sovereign spread×high-EFD×periphery	-0.031**	-0.034***	-0.008	-0.011	-0.014	-0.019
	(0.013)	(0.012)	(0.012)	(0.012)	(0.015)	(0.015)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Industry×Year FE	✓	✓	✓	✓	✓	✓
Country×Year FE	–	✓	–	✓	–	✓
Controls	✓	–	✓	✓	✓	–
Observations	9,758	10,510	8,856	9,326	8,856	8,326
R^2	0.983	0.987	0.979	0.988	0.629	0.748

Note: Robust standard errors clustered at industry×country level are in parentheses. Sovereign spread is defined as a percentage point (p.p.) difference between yields on 10-year domestic government bonds and German bonds of the similar maturity. Controls include real GDP growth, y-o-y inflation rate, (log) population, the current account to GDP ratio, and country-specific linear time trends. When the outcome variable is (log) exit we also control for (log) entry. For the list of all countries see Table A1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table C7: Sovereign risk, firm entry and exit: Credit supply channel (All countries, post-Great Recession period)

	Panel A. Entry		Panel B. Exit		Panel C. Net entry	
	(1)	(2)	(1)	(2)	(1)	(2)
Sovereign spread	-0.009		0.10***		-0.104***	
	(0.010)		(0.012)		(0.015)	
Sovereign spread×periphery	-0.017		-0.061***		0.052***	
	(0.010)		(0.012)		(0.014)	
Sovereign spread×high-EFD	0.024*	0.033***	0.009	0.004	0.005	0.021
	(0.012)	(0.012)	(0.013)	(0.012)	(0.015)	(0.014)
Sovereign spread×high-EFD×periphery	-0.049****	-0.055***	0.008	0.006	-0.036*	-0.046**
	(0.017)	(0.016)	(0.016)	(0.015)	(0.020)	(0.018)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Industry×Year FE	✓	✓	✓	✓	✓	✓
Country×Year FE	–	✓	–	✓	–	✓
Controls	✓	–	✓	✓	✓	–
Observations	7,651	8,121	7,495	7,965	7,495	7,965
R^2	0.985	0.989	0.978	0.989	0.646	0.764

Note: Robust standard errors clustered at industry×country level are in parentheses. Sovereign spread is defined as a percentage point (p.p.) difference between yields on 10-year domestic government bonds and German bonds of the similar maturity. Controls include real GDP growth, y-o-y inflation rate, (log) population, the current account to GDP ratio, and country-specific linear time trends. When the outcome variable is (log) exit we also control for (log) entry. For the list of all countries see Table A1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table C8: Sovereign risk and credit supply channel: High, medium and low-EFD sectors

	Entry (1)	Exit (2)	Net Entry (3)
Sovereign spread×High-EFD	0.027	-0.011	0.028
	(0.030)	(0.018)	(0.029)
Sovereign spread×Low-EFD	-0.039	-0.001	-0.031
	(0.033)	(0.021)	(0.034)
Sovereign spread×High-EFD×Periphery	-0.054*	0.007	-0.049*
	(0.031)	(0.019)	(0.030)
Sovereign spread×Low-EFD×Periphery	0.031	0.004	0.020
	(0.033)	(0.021)	(0.034)
Country FE	✓	✓	✓
Industry FE	✓	✓	✓
Country×Industry FE	✓	✓	✓
Year FE	✓	✓	✓
Industry×Year FE	✓	✓	✓
Country×Year FE	✓	✓	✓
Controls	–	✓	✓
Observations	5,197	4,398	4,398
R^2	0.987	0.992	0.714

Note: Robust standard errors clustered at industry×country level are in parentheses. Sovereign spread is defined as a percentage point (p.p.) difference between yields on 10-year domestic government bonds and German bonds of the similar maturity. When the outcome variable is (log) exit we also control for (log) entry. High-EFD sectors are defined as the sectors with EFD values above 70th percentile and low-EFD sectors have EFD values below 30th percentile. See Appendix A for a detailed description of our sample and data coverage. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

C.2.1 Evidence from the European Sovereign Debt Crisis

Table C9: The European sovereign debt crisis, firm entry and exit: Credit supply channel (post-Great Recession period, 2010-2018)

	Panel A			Panel B		
	Entry (1)	Exit (2)	Net entry (3)	Entry (1)	Exit (2)	Net entry (3)
Sov. crisis×high-EFD×periphery	-0.098**	0.080**	-0.155***			
	(0.045)	(0.040)	(0.053)			
Sov. crisis×high-EFD×periphery×spread				-0.021**	0.017**	-0.033**
				(0.008)	(0.008)	(0.011)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Industry×Year FE	✓	✓	✓	✓	✓	✓
Country×Year FE	✓	✓	✓	✓	✓	✓
Controls	–	✓	–	–	✓	–
Observations	3,323	3,319	3,287	3,323	3,319	3,287
R^2	0.992	0.993	0.708	0.992	0.993	0.709

Note: Robust standard errors clustered at industry×country level are in parentheses. Sovereign crisis is a dummy variable taking a value of one for the 2011-2012. Spread refers to sovereign spread and is defined as a percentage point (p.p.) difference between yields on 10-year domestic government bonds and German bonds of the similar maturity. Periphery is a dummy variable taking a value of one for Portugal, Spain, and Italy. When the outcome variable is (log) exit, we also control for (log) entry. See Appendix A for a detailed description of our sample and data coverage. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table C10: The European sovereign debt crisis, firm entry and exit: Credit supply channel (All countries)

	Panel A			Panel B		
	Entry	Exit	Net entry	Entry	Exit	Net entry
	(1)	(2)	(3)	(1)	(2)	(3)
Sov. crisis×high-EFD×periphery	-0.076**	0.002	-0.068			
	(0.038)	(0.033)	(0.050)			
Sov. crisis×high-EFD×periphery×spread				-0.020***	0.001	-0.016
				(0.008)	(0.007)	(0.0110)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Industry×Year FE	✓	✓	✓	✓	✓	✓
Country×Year FE	✓	✓	✓	✓	✓	✓
Controls	–	✓	–	–	✓	–
Observations	10,510	9,326	9,096	10,510	9,326	9,096
R^2	0.987	0.998	0.767	0.987	0.988	0.7667

Note: Robust standard errors clustered at industry×country level are in parentheses. Sovereign crisis is a dummy variable taking a value of one for the 2011-2012. Spread refers to sovereign spread and is defined as a percentage point (p.p.) difference between yields on 10-year domestic government bonds and German bonds of the similar maturity. Periphery is a dummy variable taking a value of one for Portugal, Spain, and Italy. When the outcome variable is (log) exit, we also control for (log) entry. See Appendix A for a detailed description of our sample and data coverage. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table C11: The European sovereign debt crisis, firm entry and exit: Credit supply channel (All countries & post-Great Recession period, 2010-2018)

	Panel A			Panel B		
	Entry (1)	Exit (2)	Net entry (3)	Entry (1)	Exit (2)	Net entry (3)
Sov. crisis×high-EFD×periphery	-0.080**	0.0289	-0.084			
	(0.039)	(0.037)	(0.052)			
Sov. crisis×high-EFD×periphery×spread				-0.018**	0.007	-0.021*
				(0.007)	(0.008)	(0.010)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Industry×Year FE	✓	✓	✓	✓	✓	✓
Country×Year FE	✓	✓	✓	✓	✓	✓
Controls	–	✓	–	–	✓	–
Observations	8,121	7,965	7,765	8,121	7,965	7,765
R^2	0.989	0.987	0.783	0.989	0.987	0.783

Note: Robust standard errors clustered at industry×country level are in parentheses. Sovereign crisis is a dummy variable taking a value of one for the 2011-2012. Spread refers to sovereign spread and is defined as a percentage point (p.p.) difference between yields on 10-year domestic government bonds and German bonds of the similar maturity. Periphery is a dummy variable taking a value of one for Portugal, Spain, and Italy. When the outcome variable is (log) exit, we also control for (log) entry. See Appendix A for a detailed description of our sample and data coverage. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table C12: The European sovereign debt crisis, firm entry and exit: Credit supply channel (High, medium and low-EFD sectors)

	Panel A			Panel B		
	Entry	Exit	Net entry	Entry	Exit	Net entry
	(1)	(2)	(3)	(1)	(2)	(3)
Sov. crisis×high-EFD×periphery	-0.087*	0.067	-0.139**			
	(0.048)	(0.043)	(0.060)			
Sov. crisis×low-EFD×periphery	-0.015	0.035	0.017			
	(0.044)	(0.037)	(0.051)			
Sov. crisis×high-EFD×periphery×spread				-0.026***	0.011	-0.028**
				(0.007)	(0.009)	(0.012)
Sov. crisis×low-EFD×periphery×spread				-0.006	0.005	-0.004
				(0.008)	(0.008)	(0.010)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Industry×Year FE	✓	✓	✓	✓	✓	✓
Country×Year FE	✓	✓	✓	✓	✓	✓
Controls	–	✓	–	–	✓	–
Observations	5,197	4,398	4,346	5,197	4,398	4,346
R^2	0.987	0.992	0.701	0.987	0.992	0.707

Note: Robust standard errors clustered at industry×country level are in parentheses. The sovereign crisis is a dummy variable taking a value of one for 2011-2012. Spread refers to sovereign spread and is defined as a percentage point (p.p.) difference between yields on 10-year domestic government bonds and German bonds of similar maturity. Periphery is a dummy variable taking a value of one for Portugal, Spain, and Italy. When the outcome variable is (log) exit, we also control for (log) entry. See Appendix A for a detailed description of our sample and data coverage. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

D Aggregate Effects of Entry and Exit: A Simple Accounting Exercise

In this section, we use Portuguese enterprise-level data to evaluate the potential quantitative importance of the drop in the number of entrants over 2011-2012. Through a simple accounting exercise we argue that, for those cohorts exposed to the increased sovereign default risk, the cumulative drop in employment is sizable and long-lasting.

Consider the following exercise. The aggregate employment at time t can be represented as a sum of total employment of cohorts of firms at different ages:

$$N_t = n_{0,t} + n_{1,t} + n_{2,t} + n_{3,t} + n_{4,t} + n_{5,t} + Res_t, \tag{19}$$

where N_t denotes aggregate employment and $n_{g,t}$ refers to employment of a cohort of age g at time t, $g = 0, 1, 2, 3, 4, 5$.[30] Res_t describes the rest of the employment.[31]

Define by $\hat{N}_t$ the counterfactual level of aggregate employment that would have prevailed had there been no increase in sovereign default risk during the period 2011-2012:

$$\hat{N}_t = \hat{n}_{0,t} + \hat{n}_{1,t} + \hat{n}_{2,t} + \hat{n}_{3,t} + \hat{n}_{4,t} + \hat{n}_{5,t} + \hat{Res}_t, \tag{20}$$

where $\hat{n}_{g,t}$ refers to a counterfactual employment level of a cohort of age g at time t. Using equations (19) and (20) we can decompose changes in the aggregate employment as a sum of the changes in the cohorts' employment by age,

$$\Delta\hat{N}_t = \Delta\hat{n}_{0,t} + \Delta\hat{n}_{1,t} + \Delta\hat{n}_{2,t} + \Delta\hat{n}_{3,t} + \Delta\hat{n}_{4,t} + \Delta\hat{n}_{5,t} + ... + \Delta\hat{Res}_t, \tag{21}$$

where $\Delta\hat{N}_t = \dfrac{N_t - \hat{N}_t}{\hat{N}_t}$ and $\Delta\hat{n}_{g,t} = \dfrac{n_{g,t} - \hat{n}_{g,t}}{\hat{N}_t}$ for $g = 1, 2, 3, 4, 5$. $\Delta\hat{n}_{g,t}$ shows how much of the changes in the cohort employment of age g contributes to the changes in the aggregate employment at time t.[32]

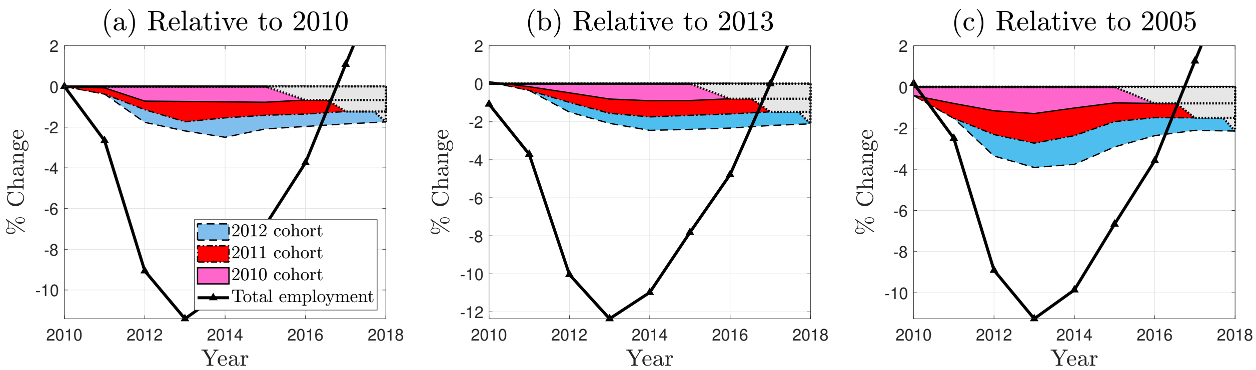
[30] The Eurostat dataset provides information about enterprises only up to 5 years of operation.

[31] Res_t combines part of the aggregate employment that belongs to employer businesses with age more than 6+ and the rest of the employment.

[32] One can also think about it as a percentage deviation of the actual cohort level employment from the predicted cohort-level employment multiplied by the weight of the cohort employment in the aggregate employment:

$$\frac{N_t - \hat{N}_t}{\hat{N}_t} = \left(\frac{n_{0,t} - \hat{n}_{0,t}}{\hat{n}_{0,t}}\right)\frac{\hat{n}_{0,t}}{\hat{N}_t} + \left(\frac{n_{1,t} - \hat{n}_{1,t}}{\hat{n}_{1,t}}\right)\frac{\hat{n}_{1,t}}{\hat{N}_t} + .. + \Delta\hat{Res}_t$$

Figure 13: Changes in aggregate employment accounted by cohorts born over 2010-2012



Using equation (21) we can quantify the changes in the total employment accounted by firms that started operating over the period 2010-2012. For the sake of this exercise, we choose employment in year 2010 as the counterfactual level of aggregate employment ($\hat{N}_{2010}$). Respectively, we choose the cohort-level employment by age in year 2010 as a counterfactual employment of cohorts born over 2010-2012 (i.e., $\hat{n}_{g,t} = \hat{n}_{g,2010}$ for any g and t). Under the assumption that 2010's employment levels by cohorts constitute a representative benchmark, we estimate how much of the drop in aggregate employment after 2010 was due to cohorts born during 2010-2012. As a robustness check, we also consider employment in 2013 and 2005 as benchmark years.

Panel (a) of Figure 13 shows the result of our accounting exercise when we use 2010 as the benchmark year. The black line represents the aggregate drop in employment. The purple, red, and blue areas show, respectively, the contributions to the employment drop of the cohorts of firms born in 2010, 2011 and 2012. The cumulative contribution of the exposed cohorts' employment was 2.2% by 2013, and the contribution persists at around 2% by 2016. To put these numbers into perspective, they account for 15.6% and 33.24% of the total drop in a aggregate employment by 2013 and 2015. Panels (b) and (c) of Figure 3 show that the exercise is robust if using year 2013 or 2005, as baseline periods, respectively.

Motivated by these findings, we next use a heterogeneous firm dynamics model with endogenous firm entry and exit to assess the quantitative importance of sovereign risk in shaping the extensive margin of firm dynamics. We then turn to quantify the role that entry and exit play in propagating the effects of the debt crisis to the real economic activity.

E Quantitative Section Appendix

E.1 The Output Costs of Portuguese Sovereign Crisis

Figure 14: Dynamics of firm entry and exit in high- and low-EFD sectors: Data and Model

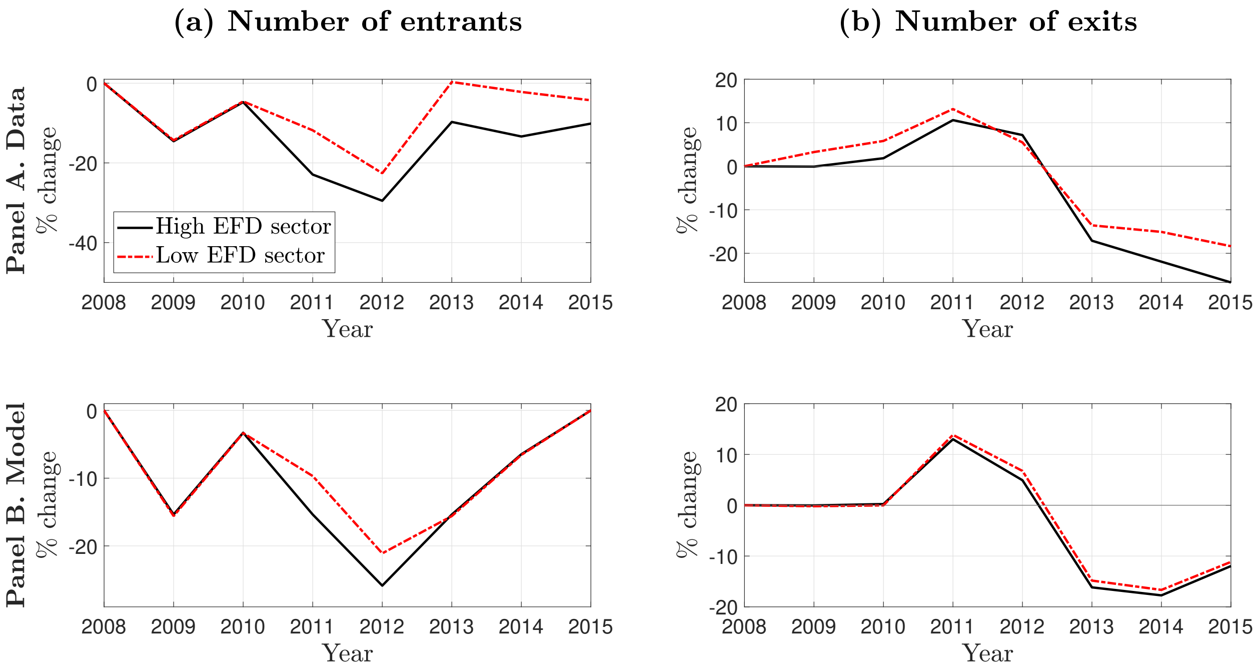
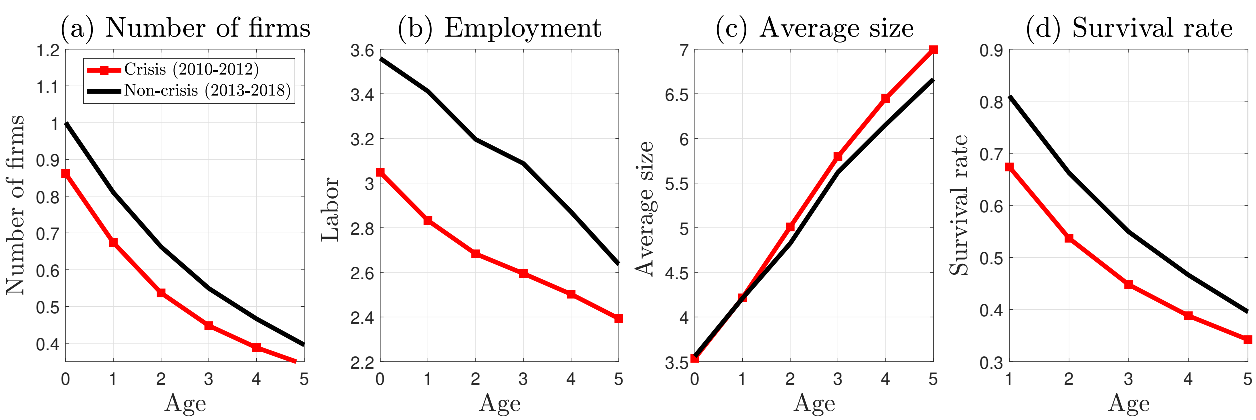


Figure 15: Crisis and non-crisis cohorts' post-entry dynamics: Model



E.2 The "Missing Generation" Effect

Figure 16: Selection of entrants during crisis: Baseline and counterfactual scenarios