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

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Abstract

This paper quantifies the role of firm entry and exit in propagating the sovereign default risk on the real economy. Using annual industry-level data from European countries, we document that an increased sovereign default risk is associated with a decline in firm entry and increase in firm exits. We find strong evidence in favor of the sovereign–bank lending channel in explaining the observed negative relationship between sovereign risk and firm entry, while this channel plays a minor role in sovereign risk - exit relationship. Using the firm-level data from Portugal, we additionally document the persistent effects of the sovereign crisis on the entrant cohorts' life-cycle dynamics. Motivated by the empirical facts, we develop a heterogeneous firm dynamics model with endogenous entry and exit, sovereign default risk, and financial frictions. The calibrated model generates a close match to firms' life-cycle dynamics in Portugal. We find that the sovereign–bank lending channel plays an important role in the observed dynamics of entry, which, in turn, has a long-lasting negative effect on the dynamics of the economic aggregates.

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 heightened sovereign default risk can depress economic activity via disruptions in bank credit supply to non-financial firms (Gennaioli, Martin and Rossi 2014, Bocola 2016, Acharya et al. 2018, Becker and Ivashina 2018, Arellano, Bai and Bocola 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: How does heightened 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, we empirically analyze the relationship between sovereign default risk and firm entry and exit. Using annual industry-level data from European countries we document that an increased sovereign default risk is associated with a decline in firm entry and an increase in firm exits. We then explore the role of bank credit supply in driving the above relationships. We find strong support for this channel in explaining the observed negative relationship between sovereign risk and firm entry dynamics. However, the effect of sovereign risk on firm exit seems to be driven by other factors instead of disruptions in the credit supply.

Our empirical analysis uses industry-level annual data on firm entry and exit from the Eurostat's Business Demography Statistics over the period 2004-2018. We proxy sovereign default risk using sovereign spreads, i.e., the difference between yields on long-term domestic government bonds and German bonds. 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 2.8% decline in the number of entrants and a 2.9% increase in the number of exiting firms. To evaluate the relevance of banks' credit supply during the debt crisis we exploit variation in entry and exit dynamics across industries with varying degrees of external financial dependence and across countries with different levels of banks' exposures to domestic sovereign debt.[1] Our results show that the increased sovereign stress lowers the number of startups particularly strongly in high external finance dependent industries in the eurozone periphery countries.[2] Thus, variations in credit availability seem to be an important transmission channel of sovereign risk to firm entry.

Next, we use data from Portugal - a country severely hit by the European sovereign debt crisis - to document the persistent effects of the sovereign crisis on the entrant 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. Through a simple accounting exercise we show that the cumulative drop in employment across exposed cohorts is significant and has a long-lasting negative effect on the dynamics of aggregate employment.

Motivated by our empirical findings, we develop a quantitative 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 interest rate on bank loans to the corporate sector is affected by the price of sovereign bonds. We model this relationship by specifying a response function of interest rate on corporate loans that depends on the sovereign spread. This relationship captures, in a reduced form, the balance sheet and crowding out effects of sovereign risk emphasized by the previous literature.

In the model, the only source of transmission of sovereign risk to firm entry, growth, survival, and exit, is through its effect on firms' borrowing costs. Thus, matching firms' borrowing needs over the life cycle is vital to correctly account for the effect of sovereign risk on the real economy. We show that a simple working capital constraint combined with heterogeneous life cycle firm dynamics endogenously generates rich heterogeneity over firms' borrowing needs. Specifically, in the model, firm leverage increases with firm size, productivity, and decreases with age. These relationships are consistent with the empirical facts that we document using the ORBIS dataset for Portugal over the period 2005-2015.

[1] We use Rajan and Zingales (1998) sectoral measure of external financial dependence (EFD) and various leverage-based measures to characterize an industry's needs for external funds.

[2] It is well-documented that the strength of sovereign risk pass-through to private borrowing costs depends on the domestic banks' holdings of their own government's debt - a prominent feature of the banking systems in the eurozone periphery.

We calibrate the model to the Portuguese economy. The calibrated model closely replicates the main characteristics of firm dynamics in Portugal including average size, employment share, survival rates, and exit hazard rates at entry and over time. The model also closely matches the distribution and life cycle dynamics of leverage observed in the data. We use the calibrated model for two purposes. First, we examine the pass-through of sovereign risk, through bank-lending, to the intensive (production, investment, hiring) and extensive (entry and exit) margins of firm dynamics. Second, we assess the role of the extensive margin in shaping aggregate dynamics during the sovereign debt crisis.

An increase in sovereign default risk pushes up borrowing costs for non-financial firms affecting firms' production, investment, and hiring decisions. During the crisis high-leverage firms decrease employment and investment significantly more compared to their low-leverage counterparts. The slower capital accumulation also dampens the hiring decisions, lowers revenues and profits in the upcoming periods, providing additional propagation mechanism for the sovereign default shocks. Due to the endogenous dynamics of leverage over the firm life cycle the model predicts that during the sovereign crisis young and small firms are harmed disproportionately more. The results complement the sovereign default literature that studies the role of firm heterogeneity in the transmission of the sovereign risk to the real economy, by additionally showing the importance of accounting for the heterogeneity over the firm life cycle (Arellano et al. 2020, Rojas 2020, Deng and Liu 2021, Buera and Karmakar 2018).

We find that the higher interest rate increases the number of firm exits and more so among young firms. However, it is interesting that the firms with low-leverage end up exiting more from the market than their high-leverage counterparts. Thus, consistent with our empirical findings, in the model, the degree of external finance dependence does not account for the negative effect of the sovereign crisis on firm exits. The intuition is that high leverage firms are usually the ones with high growth potential, i.e., the firms that experience favorable productivity shocks and are relatively far away from their optimal size with stronger incentives to grow. Such firms, therefore, have relatively high continuation values, and even with the increased interest rates, it might be worthwhile for them to continue operations.

Consistent with our empirical results, we find that the increased sovereign risk is negatively associated with firm entry. During the credit crunch, triggered by the increased sovereign default risk, the higher interest rate discourages entry for the following two reasons: First, the higher interest rate decreases the value of being an incumbent today and increases the cost of entry. Second, it increases the value of waiting by reducing the value of entry today relative to tomorrow. During the crisis, the increased opportunity cost of entry also leads to the variation in the productivity composition of firms in the entrant cohort – only firms that hold a relatively higher range of productivity signals find it optimal to enter the market. That said, cohorts that start operating during the crisis are fewer but have relatively higher productivity compared to their non-crisis counterparts.[3]

We use the calibrated model to study the transmission of sovereign default risk through the extensive margin. We focus on the Portuguese sovereign debt crisis of 2011-2012 and its aftermath. We consider the following exercise: We feed our model economy with the sequence of shocks to sovereign default risk so that the model-implied sovereign spread dynamics matches that of Portugal during the period 2010-2017. We show that the model successfully replicates firm entry dynamics during the sovereign crisis. In 2012 the fall in the number of entrants is about 22% in the data versus 18% in the model. The result points that the heightened sovereign risk affected firm entry primarily through tightening in credit conditions. Importantly, the model generates a persistent drop in aggregate employment as in the data. By 2017, long after the sovereign spread starts declining towards its pre-crisis levels, employment remains about 1.7% below its 2010 level.

To isolate the role of the extensive margin, we consider a counterfactual scenario without firm entry and exit. The economy with only the intensive margin of adjustment fully recovers by 2017 while our baseline model with entry and exit margins predicts that employment stays persistently below the pre-crisis trend. We show that the entry margin propagates the sovereign crisis due to variation in the share of high productivity-high survival rate firms in the entrant cohorts. The mechanism above is similar with the "missing generation" effect studied by Gourio et al. (2016) and Sedláček (2020) in the context of the United States during the Great Recession.

[3]This result is in line with the findings in Ates and Saffie (2021) who find that crisis cohorts are on average more productive at entry and over time.

Related Literature. This paper is related to three strands of the literature. First, our work contributes to the literature exploring transmission mechanisms of sovereign default risk 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 an increase in sovereign default risk hurts domestic financial stability by deteriorating banks' balance sheets as the latter hold long-term sovereign bonds in their asset portfolio. This in turn reduces bank lending, investment and output. We share with these papers the role of banks' credit supply, but we depart from their analyses by focusing on the propagation mechanism generated by the extensive margin of firm dynamics. Importantly, the endogenous firm entry allows us to also explain the relatively persistent drop in output and employment in response 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) , Rojas (2020), Moretti (2021), Deng and Liu (2021), Buera and Karmakar (2021). Our main contribution to this literature is that we allow for endogenous dynamics of firm entry and exit - the margins absent from the above papers - and study their quantitative relevance for the effects of sovereign default risk.

Arellano et al. (2020) quantifies the output costs of sovereign risk using a combination of the quantitative model and detailed firm- and bank level data from Italy. They find that the increased sovereign default risk contributed significantly to the output decline during the Italian debt crisis.[4] Using Portuguese firm and bank-level

[4] Arellano et al. (2020) allow for a two-way feedback between economic activity and sovereign risk in a model with strategic sovereign default. In our model, sovereign risk is exogenous as in Bocola (2016). A similar approach in modeling sovereign default risk is also taken by Rojas (2020) and Moretti (2021).

data, Buera and Karmakar (2021) 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 the firm-level data from the eurozone periphery countries, Rojas (2020) shows that smaller firms adjusted their employment, sales and financial positions more than larger firms during the European debt crisis. He then develops a quantitative model with corporate defaults and costly equity issuance to generate cross-sectional heterogeneity of financing structure across firms. In response to heightened sovereign risk, debt financing becomes more costly which has stronger negative effects on small high-leverage firms.

While the firm's financing structure in our model is not as rich as in Rojas (2020), we show that a working capital constraint can generate a realistic distribution of leverage over firm size and age.[5] Our quantitative results regarding the heterogeneous effects of sovereign risk are thus in line with those in Rojas (2020). In addition to size-dependent responses, we show that the sovereign risk shock has a disproportionately stronger negative effect on young firms since in the stationary distribution the young firms are more leveraged than older ones. This is because the latter are closer to their optimal size lowering the need for additional investment and therefore, external finance. On the contrary, younger firms, and especially those with high productivity potential, are far away from their optimal size and would like to borrow more. The stronger need for external finance (i.e., high leverage) then makes younger firms more vulnerable to the hike in borrowing costs during the sovereign crisis.

Moretti (2021) studies the role of non-financial firms' default risk during sovereign debt crisis. After empirically documenting that corporate risk increases with sovereign risk through bank lending channel, he uses a heterogeneous firm dynamics model to show that the corporate risk channel significantly amplifies and propagates the effects sovereign crisis.[6]

Finally, our paper relates to the large existing literature on the role of firm entry

[5]The existing empirical evidence shows that in advanced economies larger firms generally tend to be more leveraged (Arellano et al. 2020, Gopinath et al. 2017, Dinlersoz et al. 2019). Dinlersoz et al. (2019) find that leverage declines with firm's age. Our model's predictions on the relationship between leverage and firm's size and age are consistent with these facts.

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

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, Sedlacek and Sterk 2017, Sedlacek 2020, among others). This literature finds that endogenous entry and exit margin 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. Closely related work by Ates and Saffie (2021) studies effects of a financial crisis in the form of a transitory sudden stop and focuses on the consequences on innovation and long-run growth. 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.[7] For our main analysis, we consider a sample of relatively large countries for which the 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 B we show that our main findings hold if we consider a sample that includes all countries in the Eurostat Employer Business Demography database.[8]

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 quantitative importance of firm entry and exit in propagating the heightened sovereign risk to the real economy.

[7]See Appendix A for detailed information about the Eurostat Employer Business Demography database.

[8]See Table A1 for a detailed description of our sample and data coverage.

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:

$$log(Y_{s,j,t}) = \beta_0 + \beta_1 spread_{j,t} + \alpha_s + \gamma_j + \phi_{s,j} + \eta_t + \psi_{s,t} + X_{s,j,t} + \varepsilon_{s,j,t}, \qquad (1)$$

where $Y_{s,j,t}$ denotes an outcome variable, such as the number of entrants or exits in industry (sector) s, country j, at time t. $spread_{j,t}$ denotes sovereign spreads in country j at time t.[9] The terms α_s, γ_j and $\phi_{s,j}$ control for industry, country, and industry-country specific fixed effects. η_t and $\psi_{j,t}$ denote year and industry-specific year fixed effects. $X_{s,j,t}$ is a vector of controls, which depending on a specification, may include a real GDP growth, inflation, current account and country-specific linear time trends.

Table 1: Sovereign risk, firm entry and exit

	Panel A. Entry			Panel B. Exit		
	(1)	(2)	(3)	(1)	(2)	(3)
Sovereign spread	-0.026***	-0.028***	-0.028***	0.022***	0.035***	0.031***
	(0.005)	(0.007)	(0.006)	(0.005)	(0.006)	(0.005)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	–	✓	✓	–	✓	✓
Industry×Year FE	–	–	✓	–	–	✓
Controls	–	✓	✓	–	✓	✓
Observations	4,731	4,449	4,449	4,032	3,789	3,742
R^2	0.976	0.978	0.984	0.976	0.983	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, the current account to GDP ratio, and country-specific linear time trends. When the outcome variable is (log) exit we also control for lagged (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 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

[9] 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

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 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 2.8% and increases exit by about 3.1%. 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 B.1 we perform an extensive set of robustness checks and confirm our results. We (i) restrict the sample to include only the post-Great Recession period 2010-2018 (Table B1); (ii) control for lagged sovereign spreads (Table B2); (iii) using all available data on firms' entry and exit for all countries in the Eurostat database (Table B3); (iv) using all available data on firms' entry and exit for all countries restricted to the post-Great Recession period 2010-2018 (Table B4).

Overall, our results provide strong evidence that an increase in sovereign default risk, proxied by sovereign spreads, is associated with 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 heightened sovereign default risk can cause disruptions in credit supply in the economies where domestic banks are exposed to their own governments' debt.[10] 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 the negative association between sovereign default risk and entry and exit that we documented in the previous section.

To do so 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 expenditure 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).[11] As is common 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).[12]

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

[11]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 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.

[12]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

Second, we choose a specific group of countries - the eurozone periphery[13] - 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. To evaluate the role of the credit channel, we estimate the following regression,

$$
\begin{aligned}
log(Y_{s,j,t}) \quad = \quad & \beta_0 + \beta_1 spread_{j,t} + \beta_2 spread_{j,t} \times high\text{-}EFD_s \\
& + \beta_3 spread_{j,t} \times periphery_j + \beta_4 spread_{j,t} \times high\text{-}EFD_s \times periphery_j \\
& + \alpha_s + \gamma_j + \phi_{s,j} + \eta_t + \eta_{j,t} + \psi_{s,t} + \theta_{j,t} + X_{s,j,t} + \varepsilon_{s,j,t}, \qquad (2)
\end{aligned}
$$

where $high\text{-}EFD_s$ 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. $periphery_j$ is a dummy equal to 1 for the group of periphery countries. In our most stringent specification we also include country-year fixed effects $\theta_{j,t}$.[14] 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.

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 sovereign risk to firm entry. The result is robust when we additionally control for country×year fixed effects (the second column of Panel A)

2003, Dell'Ariccia et al. 2006), 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.

[13] 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.

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

that account for any country-specific shocks that could simultaneously affect sovereign spreads and entry and exit dynamics within a country.

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	-0.034*		-0.010		-0.040**	
	(0.018)		(0.012)		(0.019)	
Sovereign spread× periphery	0.015		0.041***		0.005	
	(0.017)		(0.011)		(0.017)	
Sovereign spread×high-EFD	0.035	0.043	-0.004	-0.005	0.043*	0.042*
	(0.029)	(0.028)	(0.016)	(0.016)	(0.026)	(0.025)
Sovereign spread×high-EFD×periphery	-0.062**	-0.066**	0.001	0.001	-0.067**	-0.064**
	(0.029)	(0.028)	(0.016)	(0.016)	(0.026)	(0.025)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Industry×Year FE	✓	✓	✓	✓	✓	✓
Country×Year FE	–	✓	–	✓	–	✓
Controls	✓	–	✓	✓	✓	✓
Observations	4,915	5,197	4,633	4,163	4,108	4,155
R^2	0.985	0.987	0.987	0.993	0.579	0.720

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, and country-specific linear time trends. When the outcome variables are (log) exit and net entry we also control for lagged (log) entry. See Appendix A for a detailed description of our sample and data coverage. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

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 6.4 percent fall in net entry in the high-EFD industries in the periphery countries relative to the non-periphery countries.

Appendix B.2 has various robustness checks showing that our empirical results hold when we (i) restrict the sample to post-Great Recession period, 2010-2018 (Table B5); (ii) use all available data on exit and entry from all countries (Table B6); (iii) restrict the sample that includes all countries to the post-Great Recession period, 2010-2018 (Table B7); (iv) categorize industries into high, medium and low EFD groups (Table B8).

2.2.1 Evidence from the European Sovereign Debt Crisis

In the previous regression we used sovereign spreads as a proxy for sovereign risk. Here we exploit the European sovereign debt crisis – an episode with substantially alleviated 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 (Bofondi et al. 2018, Balduzzi et al. 2018, Bottero et al. 2020, Crosignani, Faria-e-Castro, and Fonseca 2015).

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

$$\begin{aligned} Y_{s,j,t} &= \beta_0 + \beta_1 sovcrisis_t \times high\text{-}EFD_s \times periphery_j \\ &\quad + \alpha_s + \gamma_j + \phi_{s,j} + \eta_t + \eta_{j,t} + \psi_{s,t} + \theta_{j,t} + \varepsilon_{s,j,t}, \end{aligned} \tag{3}$$

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 difference-in-differences-in-differences (DDD) identification strategy in which the high-EFD industries in the periphery countries represent a treatment group. We first difference entry (exit) across high- and low-EFD sectors within the periphery countries during the European sovereign crisis. This difference identifies the effect of the credit supply channel combined with high- and low-EFD industry effect. To remove the industry effect we use difference-in-differences (DD) using a similar comparison between high- and low-EFD industries in non-sovereign crisis periods. However, the remaining issue with the DD is that

Table 3: 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**	0.041	-0.129**			
	(0.045)	(0.036)	(0.030)			
Sov. crisis×high-EFD×periphery×spread				-0.024***	0.007	-0.027***
				(0.008)	(0.007)	(0.011)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Industry×Year FE	✓	✓	✓	✓	✓	✓
Country×Year FE	✓	✓	✓	✓	✓	✓
Controls	–	✓	✓	–	✓	✓
Observations	5,197	4,163	4,398	5,197	4,163	4,398
R^2	0.987	0.993	0.714	0.987	0.993	0.714

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 are (log) exit and net entry we also control for lagged (log) entry. See Appendix A for a detailed description of our sample and data coverage. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

it identifies the credit supply channel with potentially different elasticities of high- and low-EFD sectors with respect to sovereign risk. To address the latter concern we additionally use the group of non-periphery countries. A further difference between the periphery and non-periphery countries, the DDD methodology, should allow us to identify the credit supply channel.

Panel A of Table 3 shows that 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 DDD 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 4 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 3 we estimate the version of the DDD regression 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 variable with sovereign spreads. Table 3, 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 B.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 B11); (ii) include the rest of the countries and all available periods (Table B10); (iii) include the rest of the countries and consider only post-Great Recession period (Table B11); (v) categorize industries into high, medium and low EFD groups (Table B12).

2.2.2 Alternative Measures of External Finance Dependence

We also explore the robustness of our results to using alternative measures of external financial dependence. The measure of EFD used above is computed for the US industries using data for mature, listed firms. We construct an alternative 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 sector for each country for the years 2006-2007. That is, for each year $t = \{2006, 2007\}$ and country c, for each firm i in sector j we compute $lev_{ijct} \equiv (LOAN_{ijt} + LTBD_{ijt} + CRED_{ijt})/TOAS_{ijt}$, where $LOAN$ refers to short-term loans, $LTBD$ are long-term loans, $CRED$ are trade receivable, and $TOAS$ represents total assets. Using lev_{ijct} we compute sector-level measure of leverage by taking the median across all lev_{ijct} within each sector j and each year t for each country. Finally, we divide sectors into high- and low-leverage groups based on whether lev_j is above or below the 50^{th} percentile of leverage values across sectors within a country.[15]

[15] In Appendix B.2.2, 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

Table 4: The European sovereign debt crisis, credit channel, and firm entry and exit

	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	0.000	-0.035	0.043	-0.034	0.035
	(0.036)	(0.054)	(0.060)	(0.037)	(0.057)	(0.061)
Sov. crisis× high-lev ×periphery	-0.136***	0.069	-0.142**	-0.130**	0.096*	-0.184**
	(0.049)	(0.054)	(0.069)	(0.051)	(0.057)	(0.072)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Industry×Year FE	✓	✓	✓	✓	✓	✓
Country×Year FE	✓	✓	✓	✓	✓	✓
Controls	–	✓	✓	–	✓	✓
Observations	3,695	3,037	3,227	2,434	2,381	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 and net entry we also control for lagged (log) entry. See Appendix A for a detailed description of our sample and data coverage. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

We use the leverage-based measure to re-estimate the same triple-diff specification described in regression equation (3). 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 4 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 13.5 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 7 percent, but the coefficient is not significant. However, the overall effect on net-entry is a fall of 13.9 percent, which is again similar to our baseline estimate of -11.6.

Panel B of Table 4 shows that the results are robust to restricting the sample

and long-term loans.

to the period 2010-2018. Moreover, the magnitude of the affects are comparable to the previous estimates. Specifically, Panel B shows that entry decreases by 13.0 percentage points, exit increases by 9.6 percentage points and is significant with 10% confidence, and net entry falls by 17.2 percentage points. In the Appendix B.2.2, 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 B13 shows that the results are robust to these alternative definitions of leverage.

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

These results are complementary to the well-established finding in the literature that the European sovereign debt crisis of 2011-2012 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) also find that in response to increased sovereign risk, Italian banks with exposures to domestic sovereign debt cut lending to all types of firms, with negative real economic consequences only for small firms.[16] Our results complement the above findings by focusing on the entry and exit margin of firm dynamics and the role of credit constraints during a sovereign debt crisis.

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 heightened sovereign default risk.

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

We document the persistent effects of the sovereign crisis on the entrant 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 show that the cumulative drop in employment across exposed cohorts is significant and has a long-lasting negative effect on the dynamics of aggregate employment.

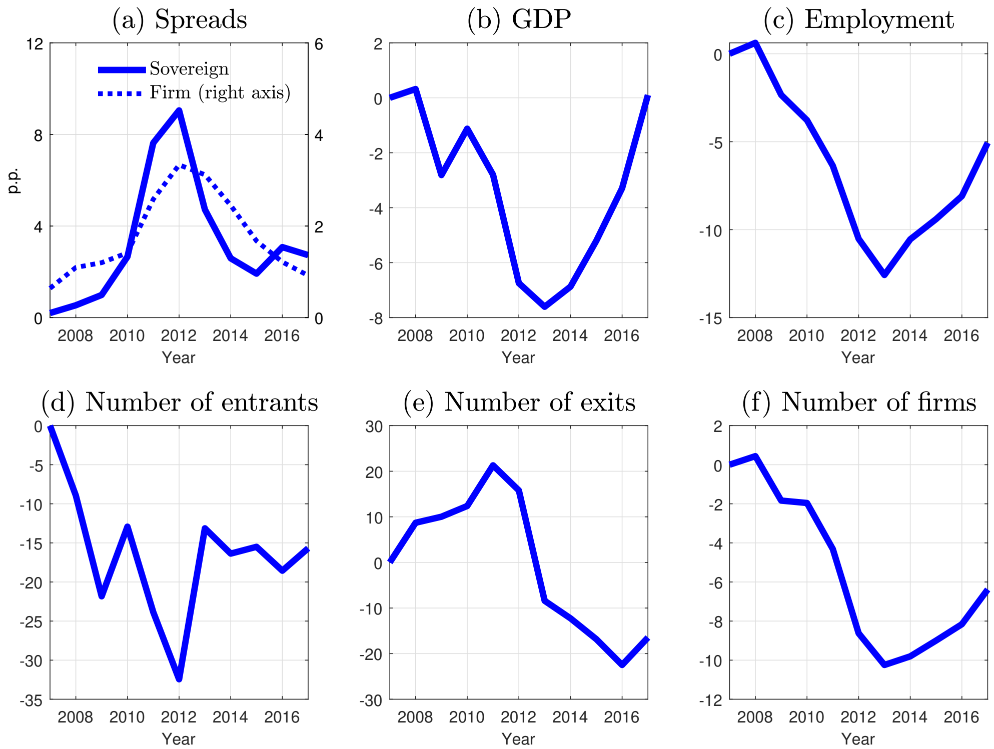
We focus on Portugal for several reasons. Portugal is one of the most severely affected countries by the European sovereign debt crisis. Unlike Spain and Ireland, who also experienced a deep recession, Portugal did not suffer from housing market boom and bust neither was it subject to severe political 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 2007-2017. 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 14%. 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 the 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 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 early in their lifecycle. Within this group we further distinguish between the '2010' and '2011-2012' cohorts since the latter group was, in addition, particularly

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

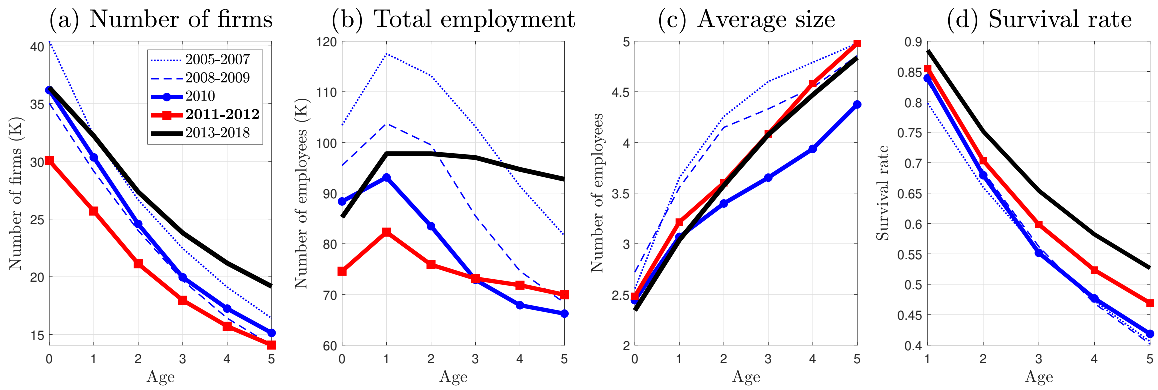


Note: Sovereign spread is a percentage point difference between yields on 10-year domestic government bonds and German bonds. The firms' spreads measure the percentage point difference between the annual (average) interest rates charged on bank loans to new businesses in Portugal and Germany. All other variables are shown in terms of percent deviations relative to the year 2007. Data sources: OECD, ECB, Eurostat.

exposed to the heightened sovereign risk *at entry*, as seen in Figure 1. We treat cohorts that started operating after 2013 (the '2013-2018' cohorts) as a group of firms not exposed to high sovereign default risk.

Figure 2 plots average life cycle characteristics of the '2010', '2011-2012', and '2013-2018' cohorts. Panel (a) displays average employment (number of workers) in each cohort by age. It shows that '2011-2012' cohorts employ 12% fewer workers at entry compared to the '2013-2018' cohorts; this difference in the cohort-level employment persists and further increases over time reaching 25% by age 5. Panels (b)-(d) provide evidence that the extensive margin of adjustment is primarily responsible for these differences in cohort-level employments. In particular, the average number of firms in '2011-2012' cohorts is significantly and persistently lower than in the '2013-2018' cohorts (Panel (b)), while the average size of firms by age is very similar across

Figure 2: Cohorts' Post-entry Dynamics



Note: The figure displays average life-cycle dynamics of cohorts born over different periods of time. For example, '2011-2012' describes average characteristics of cohorts born in 2011 and 2012. Panel (b) plots average total employment of cohorts by age. Panel (a) has the average number of firms within each cohort by age. Panels (c) and (d) plot average firm size and survival rate of cohorts by age.

the cohorts (Panel (c)). The difference in the number of firms, in turn, is due the sharp decline in the number of start-ups during the sovereign crisis resulting in persistently lower number of firms in '2011-2012' cohorts relative to non-crisis '2013-2018' cohorts.[17]

Next we compare the life cycle dynamics of firms born in 2010 to the other two groups of firms discussed above. As mentioned earlier, one of key differences between the '2010' and '2011-2012' cohorts is that the latter group of firms was exposed to severe sovereign stress at the time of entry and saw a substantial reduction in the number of entrants while the '2010' cohort did not. As can be seen in Figure 2, the number of firms, employment, and average firm-size of age 0 and 1 firms in the '2010' cohort are quite similar to that of non-crisis cohorts (2013-2018). The sizable differences between the two groups start to appear at age 2 and above. At age 2 the firms born in 2010 employ 10% less workers than the average of '2013-2018' cohorts, and by age 5 the difference goes up to 27%. Panel (c) shows that the average size of firms of age 2 and above are lower in the '2010' than in the '2013-2018' cohorts. In addition, the survival rates of firms born in 2010 are much lower which leads to the smaller number of firms in this cohort over life-cycle.

[17] As can be seen in Figure 2, Panel (b), at entry the '2011-2012' cohort consists of about 17% fewer firms compared to the '2013-2018' cohorts, and this difference further increases to 26% by age 5 partly because of the lower survival rates of the '2011-2012' cohort.

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

In this subsection, we use Portuguese enterprise-level data to evaluate the 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:

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

where N_t denotes aggregate employment and $n_{g,t}$ refers to employment of a cohort of age g at time t, $g = 0, 1, 2, 3, 4, 5$.[18] Res_t describes the rest of the employment.[19]

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:

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

where $\hat{n}_{g,t}$ refers to a counterfactual employment level of a cohort of age g at time t. Using equations (4) and (5) we can decompose changes in the aggregate employment as a sum of the changes in the cohorts' employment by age,

$$\Delta\hat{N}_t = \Delta\hat{n}_{0,t} + \Delta\hat{n}_{1,t} + \Delta\hat{n}_{2,t} + \Delta\hat{n}_{3,t} + \Delta\hat{n}_{4,t} + \Delta\hat{n}_{5,t} + ... + \Delta\widehat{Res}_t, \tag{6}$$

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.[20]

Using equation (6) 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

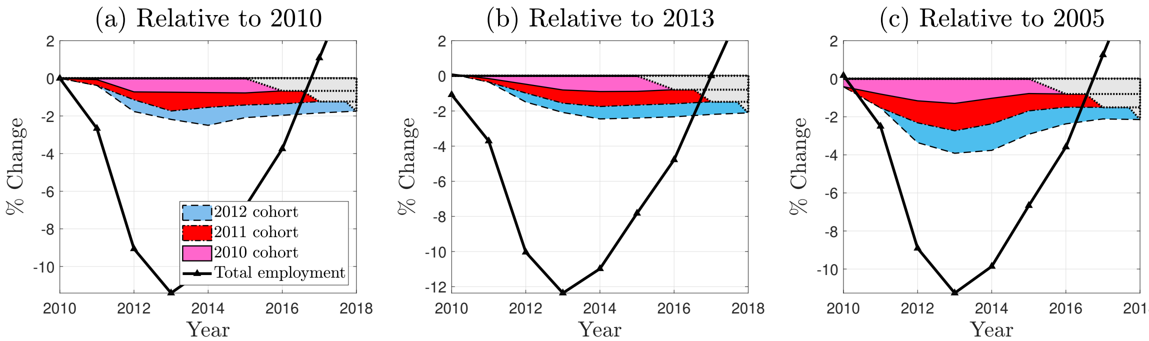
[18] The Eurostat dataset provides information about enterprises only up to 5 years of operation.

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

[20] 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:

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

Figure 3: Changes in aggregate employment accounted by cohorts born over 2010-2012



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 3 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.

3 The Model

We consider an infinite horizon closed-economy model populated by households, firms, financial intermediaries (banks) and a government. Time is discrete and indexed by $t = 1, 2, ...$ Households consume, supply labor and own firms.

At the core of our model are heterogeneous firms – incumbents and potential entrants – that rely on bank credit to finance their investment and production. The incumbent firms are heterogeneous across productivity and capital. In each period, the incumbents decide on production and investment and whether to exit the market. The potential entrants make entry decisions as well as how much capital to operate upon entry. Interest rates are a major determinant of firms decisions and are affected by sovereign default risk. Endogenous firm dynamics, and its extensive margin, in particular, affect how the entire economy responds to an increase in sovereign risk.

The government borrows from banks by issuing long-term default-risky 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. In response to heightened sovereign default risk, banks' restrict credit supply and increase the lending rate to non-financial firms. The reduced-form technology that 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 and financial repression.[21]

The remainder of this section describes each agent's problem.

[21] 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 reduction in banks lending capacity. For micro-founded models of the banks' balance sheet channel see, for example, Bocola (2016), Sosa-Padilla (2018) or Arellano et al. (2020). 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).

3.1 Firms

Firms consist of incumbent firms and new entrants. There is a mutual fund, fully owned by households, that collects profits from all active firms in the market and allocates these profits to the households in a lump-sum manner.

At time t, a positive mass of price-taking firms produce a homogeneous good by means of the production technology, $y_t = z_t(k_t^{\alpha} l_t^{1-\alpha})^{\theta}$ with $\alpha, \theta \in (0, 1)$. k_t denotes physical capital owned by an individual firm and l_t is the labor input hired by the firm at the beginning of the period. Idiosyncratic productivity, z_t, follows an AR(1) process given by

$$\log(z_{t+1}) = \rho_z \log(z_t) + \sigma_z \varepsilon_{z,t+1} \tag{7}$$

with $\varepsilon_{z,t} \sim \mathcal{N}(0, 1)$ for all $t \geq 0$. Denote the conditional distribution of z_t by $F_I(z_{t+1}|z_t)$.

At the end of 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.

Firms that quit producing cannot re-enter the market at a later stage. At the time of exit, they can recoup a fraction of their undepreciated capital stock as we assume that capital adjustment is costly. Additionally, at the end of the period each firm may exit with an exogenous probability $\gamma \in (0, 1)$.

3.1.1 Incumbent Firm's Problem

We formulate the firms' problem recursively. Given today's aggregate state s, capital in place k, and idiosyncratic productivity z, firms are making production, investment and continuation decisions. In the beginning of the period, each firm starts with predetermined capital stock, k. After observing an idiosyncratic productivity shock, z, they make hiring decision, undertake production and decide how much to invest in tomorrow's capital stock, k'. Firms take wage rate, w, as given and are subject to an ad-valorem tax to value added with tax rate τ. We assume that the firms have to pay a fraction ϕ of their investment and labor cost before production takes place.[22] To do so, they rely on intra-period working capital loans from banks. A firm borrows from

[22]We assume that these working capital needs are time-invariant and common across firms.

financial intermediaries by issuing bonds b at interest rate R.[23] Individual capital evolves according to $k' = (1-\delta)k + i$, where i is investment.

While making investment decision a firm takes into account expected fixed cost of production c_f. The firm optimally decides to exit the market if expected continuation value after investment, loan repayment and fixed cost of production is less than a recovery value of capital. Upon exit, a value of an incumbent, $V_x(k)$, equals to an undepreciated portion of its capital k, net of the adjustment cost it incurs in order to dismantle it, i.e., $V_x(k) = (1-\delta)k - g(-k(1-\delta), k)$, where the function for capital adjustment cost, $g(i,k)$, is defined below.

Denote by $V^I(z,k;s)$ the value of an incumbent firm at the beginning of the period. Then the dynamic programming problem faced by the incumbent is:

$$\begin{aligned} V^I(z,k,s) = \max_{l,i,k'} & (1-\tau) z (k^\alpha l^{1-\alpha})^\theta - (1-\phi)\left[wl + i + g(k,k')\right] - R(s)b + \\ & + \int_{c_f} \max\left\{V_x(k), \beta(1-\gamma)\mathbb{E}\left[V^I(z',k',s')|z,s\right] - c_f\right\} dF_{c_f}(c_f), \end{aligned} \tag{8}$$

subject to the capital accumulation equation,

$$k' = (1-\delta)k + i, \tag{9}$$

and the working capital constraint,

$$b = \phi\left[wl + i + g(k,k')\right]. \tag{10}$$

Following the real business cycles literature we assume quadratic investment adjustment cost function both for incumbents and entrants,

$$g(i,k) = c_k \left(\frac{i}{k}\right)^2 k,$$

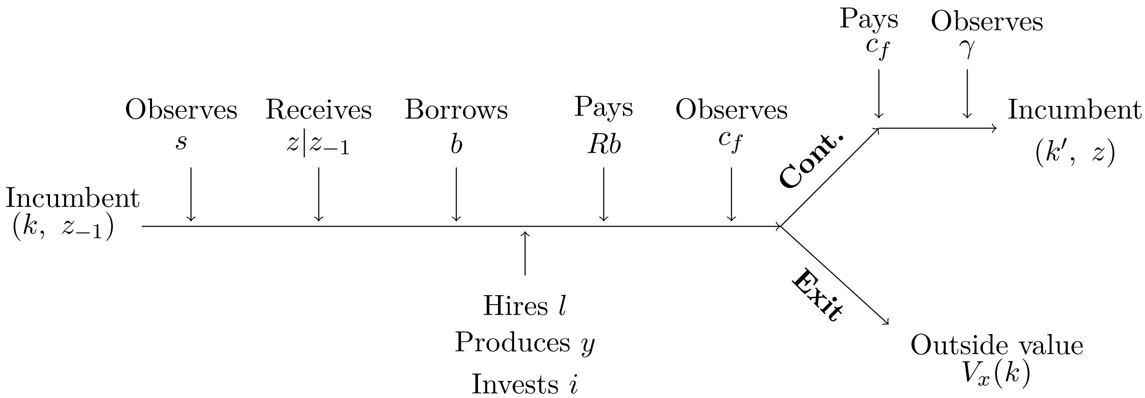
where the parameter $c_k \geq 0$ controls the cost of adjusting capital.

3.1.2 Entrant's Problem

Every period there is a constant mass $M > 0$ of prospective entrants, with each receiving a signal $p \sim F_p(p)$ about its productivity. Conditional on entry, the distribution of the idiosyncratic shock in the first period of operation is $F(z|p)$. To

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

Figure 4: **Incumbent Firm's Timing**



enter the market entrepreneurs need to pay the fixed entry cost $c_e \geq 0$, after which they observe the first period productivity, receive initial capital level k_0 and make production and investment decisions.

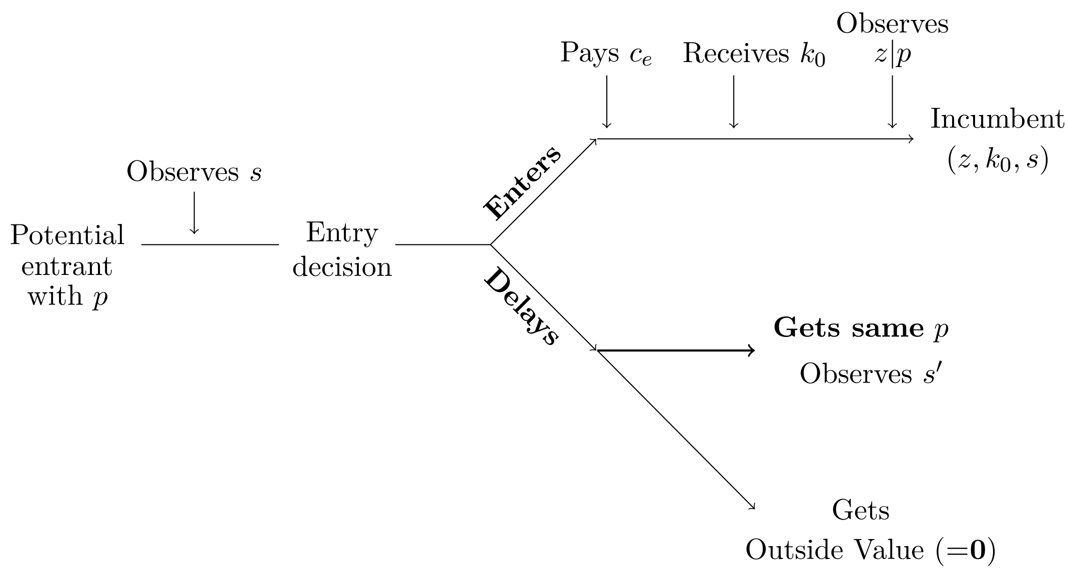
We assume that the distribution of the signal $F_p(p)$ is Pareto with location parameter $\underline{p}$ and Pareto exponent $\xi > 0$. For a given signal, p, the idiosyncratic shock in the first period of operation is Normally distributed and follows the process $log(z) = \rho_z log(p) + \sigma_z \epsilon_z$, where $\epsilon_z \sim N(0, 1)$. We denote the conditional distribution for entrants productivity by $F_E(z|p)$.

Potential Entrant's Timing At the beginning of every period, each potential entrant with a signal p observes an aggregate state of the economy s and makes an entry decision. We follow Vardishvili (2022) and allow potential entrants to keep their productivity signals over time if they decide to postpone starting a business today. By entering the market, the potential entrant gives up the value associated with exercising the signal in the future. Thus, since starting a business today or tomorrow are mutually exclusive alternatives, the feature leads to the option value of delay in firms' entry decisions.

Entry into the market is subject to a fixed entry cost c_e. We assume that the firm needs to externally finance the fraction ϕ of the fixed cost.[24] If a firm decides

[24]In other versions of the model we also allowed the initial investment of a firm to be subject to the working capital constraint. The latter mechanism seem to have a negligible effect on the firms' entry decisions. Please see Appendix C.1 for more details about this version.

Figure 5: **Potential Entrant's Timing**



to enter the market today, the firm starts next period with productivity drawn from $F_E(z|p)$ and becomes an incumbent with the state variables (z, k_0, s). Therefore, the firm's expected gross value of entry today before paying the fixed entry cost equals the expected value of being an incumbent with state variables (z, k_0, s)

$$V^g(p, s) = \mathbb{E}\left[V^I(z, k_0, s)|p\right] \tag{11}$$

If the firm waits, it starts the next period with the same signal p, but observes a new aggregate state s'. Therefore the value of waiting equals to

$$V^w(p, s) = \beta\mathbb{E}\left[V^E(p, s')|s\right]$$

Thus, a firm prefers to enter the market if the expected value from being an incumbent with (p, k_0, s) net of the fixed cost is more than the value of waiting. Finally, a potential entrant with signal p makes entry decision according to the following rule,

$$V^E(p, s) = \max\left\{V^w(p, s), V^g(p, s) - (1-\phi)c_e - R\phi c_e\right\}. \tag{12}$$

3.2 Households

There is a continuum of identical households of unit measure. Each household consists of a worker who supplies labor to non-financial firms. Households receive labor income 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

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[C_t - \nu L_t \right], \tag{13}$$

subject to the budget constraint

$$C_t = \Pi_t + w_t L_t, \tag{14}$$

where $\beta \in (0, 1)$ is the discount factor, $\nu > 0$ is the labor disutility parameter, and w_t denotes wages per labor hour. Given the simplicity of the household's problem in the model, we assume that households are hand-to-mouth. The infinitely elastic labor supply then implies that wages are also fixed, $w_t = \nu$, $\forall t$. Therefore, equilibrium labor hours in our model are 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. The default process D_{t+1} then evolves according to

$$D_{t+1} = \begin{cases} 1 & \text{if } \ \varepsilon_{d,t+1} - d_t \geq 0 \\ 0 & \text{otherwise} \end{cases} \tag{15}$$

where d_t is an AR(1) process

$$d_{t+1} = (1 - \rho_d)\overline{d} + \rho_d d_t + \sigma_d \varepsilon_{d,t+1}, \qquad \varepsilon_{d,t+1} \sim \mathcal{N}(0,\, 1). \tag{16}$$

Then the conditional probability that the sovereign is in default state tomorrow is given by

$$\pi^d \equiv \text{Prob}(D_{t+1} = 1) = \frac{e^{d_t}}{1 + e^{d_t}}. \tag{17}$$

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

$$R_t = \chi_1 R_{g,t}^{\chi_2} \tag{18}$$

where

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

is the 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 financial repression during the European debt crisis see Becker and Ivashina (2018), who find 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,

$$q_t(d_t) = \mathbb{E}_t \left[\beta(1 - D_{t+1})(\vartheta + q_{t+1}(d_{t+1})(1 - \vartheta))\right], \tag{19}$$

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

4 Credit Supply Channel

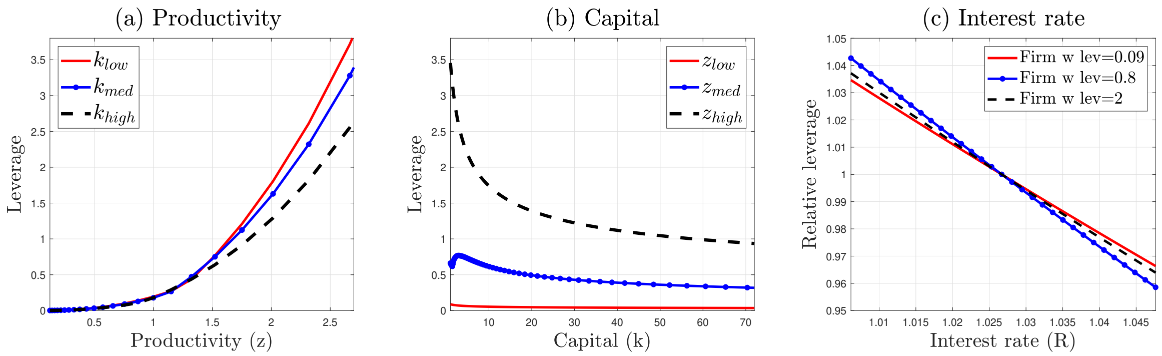
In the model, the only source of transmission of sovereign risk to the real economy is through its effect on firms' borrowing rates. Thus, the assumption about the firms' reliance on any type of external finance is vital for the credit supply channel to work. We use the working capital constraint to model firms' dependence on external finance. This section investigates firms' optimal borrowing decisions and their implications for the response of the extensive and intensive margin to sovereign risk.[25] In the next section, we show that despite its simplicity, the working capital constraint enables the model to closely match the distribution and life cycle dynamics of leverage observed in the data – the features essential to account for and quantify the effect of the sovereign risk on the life cycle dynamics of cohorts.

Leverage Dynamics First, we explore the model's predictions about firms' external finance needs, proxied by leverage dynamics. We measure leverage as the ratio of firms' total borrowing over the existing capital stock, $\frac{b}{k}$. Figure 6 illustrates policy functions for leverage across productivity, capital, and interest rate. Panel (a) of Figure 6 displays how the optimal level of leverage varies with productivity for different levels of capital. The figure shows that leverage increases with productivity irrespective of the existing capital stock of a firm. Panel (b) illustrates that the shape of the policy function of leverage concerning capital depends on the firms' idiosyncratic productivity level. For a firm with *high* productivity, leverage decreases with capital, while for example, a *medium* productivity firm chooses to increase leverage for low levels of capital. Finally, Panel (c) shows that firms' optimal leverage decreases with the interest rate. We plot three types of firms with *low*, *medium*, and *high* steady-state leverage level. For the sake of comparison, we display leverage relative to its steady-state level.

Next, we explore how firm leverage varies with firm size and age using the cross-sectional distribution of firms in the stationary steady state. Figure 7, Panels (a) and (b) illustrate that there is a positive association between firm leverage and size measured by either labor or capital, respectively. The panels display scatter plots of cross-sectional distribution of firms in the stationary steady state together with the OLS fitted lines. The size of dots representing observations on each scatter plot are proportional to the mass of firms with a given combination of labor (or capital) and leverage. Panel (c) of Figure 7 further shows that there is a negative association

[25] 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 6: Policy functions for leverage



between firm leverage and age in the cross-section of firms.[26]

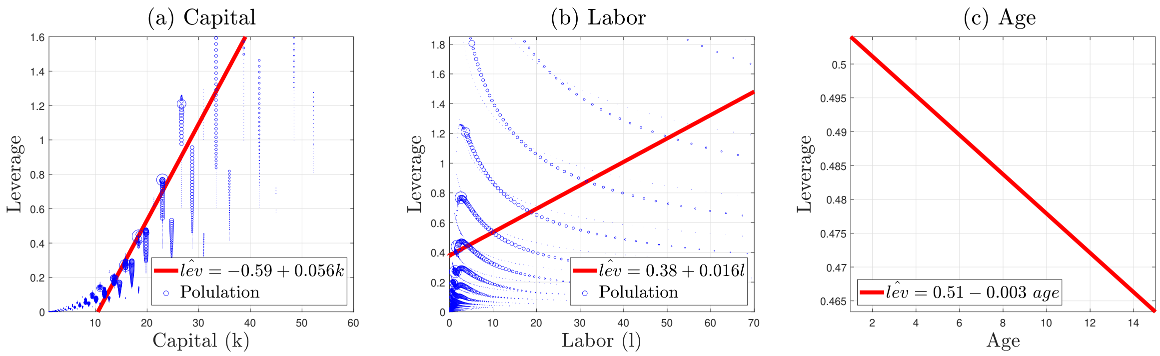
It is worth emphasizing key features that lead to the heterogeneous leverage dynamics over the firm life cycle. First, heterogeneity in firm-level productivity and decreasing returns to scale production technology imply that firms have an optimal size. Second, working capital constraint and investment adjustment costs prevent firms from immediately getting to their optimal size of production. Therefore, firms can only reach their optimal size over time. As a result, on average older firms are closer to the optimal scale of their activity and have less incentives to borrow more, 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.

The life-cycle dynamics in firms' financing needs implies that the increase in the interest rate through the credit-channel can lead to heterogeneous responses of firms at *intensive* margin (production, hiring, and investment) and *extensive* margin (entry and exit). We explore the mechanism next.

Hiring, Investment & Exit Decisions This section explores how firms with differing degrees of leverage adjust their production, investment, hiring, and exit decisions in response to an increase in sovereign risk. We divide firms into high- and low-leverage groups based on the stationary distribution of leverage. Specifically,

[26] As we show in Section 5.3, not only are these facts about leverage dynamics qualitatively consistent with the data, but also the regression coefficients from Figure 7 are close their empirical counterparts.

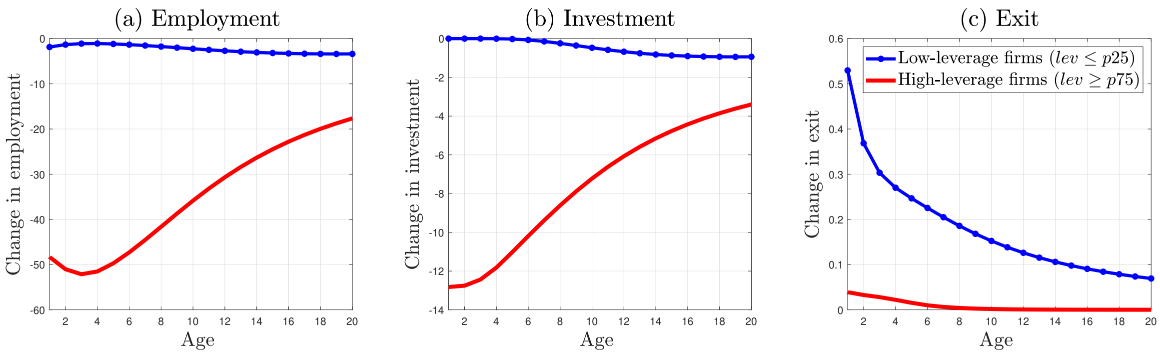
Figure 7: Leverage and firm size and age: Cross-sectional relationships



we consider high-leverage all those firms with leverage above the $75th$ percentile. Low-leverage firms are those with leverage below the $25th$ percentile.

Figure 8 illustrates the responses of the high- and low-leverage firms to an increase in the interest rate triggered by higher sovereign risk. In this exercise, we consider changes in the variable of interest during the crisis period relative to their normal (steady-state) levels. Additionally, we differentiate the responses of high- and low-leverage firms within different age groups. Panel (a) shows that during the crisis high-leverage firms decrease employment significantly more compared to their low-leverage counterparts. Moreover, the figure shows that high-leverage young firms are the ones that are harmed most during the crisis. Panel (b) shows analogous results for investment. Again, the high-leverage young firms are the ones that adjust investment the most. The slower capital accumulation also dampens hiring decisions, lowers revenues and profits in the upcoming periods. Accounting for firms' intertemporal decisions, absent in Arellano, Bai, and Bocola (2020), could provide additional propagation mechanism for the sovereign default shocks. Panel (c) compares the responses in the number of firm exits across high- and low-leverage groups during the crisis period. The higher interest rate increases the number of firm exits and more so among young firms. However, it is interesting to see that the firms with low-leverage exit more from the market than their high-leverage counterparts. The intuition is that, in the model, high-leverage firms are usually the ones with high growth potential, i.e., the firms that experience favorable productivity shocks and are relatively far away from their optimal size. Such firms, therefore, have relatively high continuation values and choose to continue operating, even with higher interest rates. That is, the

Figure 8: Credit supply channel and firms' hiring, investment and exit decisions: High- vs low-leverage firms



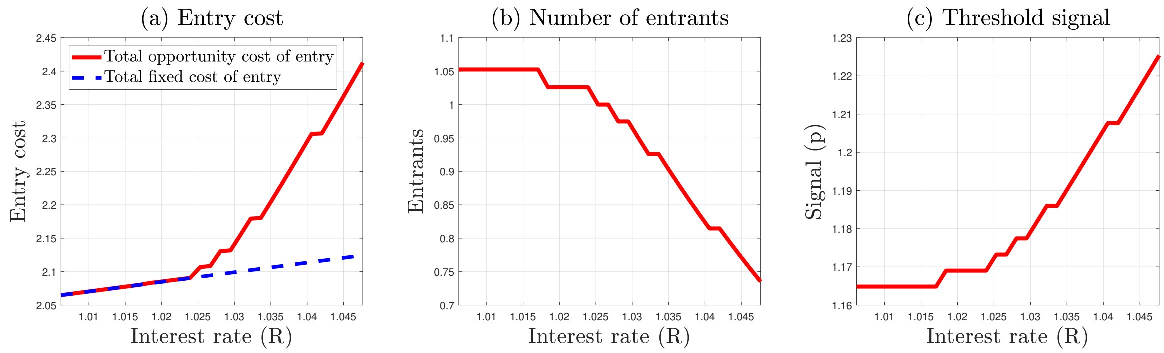
level of external finance dependence cannot fully account for the negative effect of sovereign crisis on firm exits. This result is in line with our empirical finding from Section 2 showing that a higher sovereign risk is associated with a significant increase in firm exits but that the level of external finance plays a minor role in explaining this relationships.

Entry Finally, we discuss the effect of an increase in interest rate on firms' decisions to enter the market. Figure 9 summarizes the underlying mechanisms. Panel (a) displays two components of the total cost of entry across different aggregate states. First, it plots the total fixed cost of entry – the total value of internal and external funds needed to cover the fixed entry cost. Second, the figure displays the total opportunity cost of entry, which, in addition to the fixed entry cost, includes the option value of delay. The figure shows that the total opportunity cost of entry significantly increases with the interest rate. The increased cost of entry in turn leads to a lower number of entrants during the crisis periods as shown on Panel (b).

There are two reasons for why the entry cost rises with the interest rate. First, the higher interest rate directly increases the total fixed cost of entry because entrants need to externally finance a fraction of their fixed entry cost. Moreover, the higher interest rate indirectly increases the value of waiting due to a higher risk of post-entry failure. Note that with the severity of the crisis, the latter channel presents an important barrier to entry.[27] During the non-crisis periods, marked as periods with

[27] See Vardishvili (2022) for more details about the option-to-delay entry channel.

Figure 9: The response of entry to changes in interest rate



low-interest rates, the value of waiting is zero; thus, financing the fixed entry cost is the only barrier to entry. All potential firms whose expected life time value exceeds the cost choose to enter the market.

Lastly, we characterize the selection of entrants across different aggregate conditions. First, note that firms make entry decisions based on the information about their signal and aggregate state. Since aggregate state s is the same for all potential entrants, we can characterize the selection of firms at entry based only on the signal level. Let $\underline{p}(s)$ be a threshold signal which satisfies the following property: every potential entrant with $p > \underline{p}(s)$ enters the market, the rest decide to stay outside the market. Panel (c) of Figure 9 shows that the threshold signal is positively correlated with the interest rate. Due to the countercyclical entry cost the group of firms that enters the market during high-sovereign default risk episodes holds a relatively higher range of signals than the group of firms that enter during low-risk periods. The endogenous variation of the threshold signal in response to changes in the aggregate state result in endogenous changes in the composition of entrants. For example, in times of high private borrowing costs, the high threshold signal leads to fewer but relatively high productivity firms entering the market. This is in line with Ates and Saffie (2021), who document that entrants during the sudden stops are fewer but better.[28] Using the ORBIS dataset, we also find that cohorts of firms born during the European sovereign debt crisis are on average more productive relative to their

[28] Using the US Business Dynamics Statistics dataset Lee and Mukoyama (2015), and Moreira (2016) also find that firms that are born during recessionary periods are, on average, more productive at entry and over time.

non-crisis counterparts (see Figure 16 in Appendix C.2).

5 Calibration and Model Performance

In this section, we explore the behavior of the model economy. First, we calibrate the model to Portuguese data and show that the model can closely replicate the main characteristic of firm dynamics in Portugal. Second, we evaluate the model's performance in various dimensions and inspect the mechanism.

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 other parameters to match some features of firm dynamics at the extensive and intensive margin in Portugal. Table 5 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.[29] The parameters describing the process for default risk are taken from Bocola (2016).

Next, we describe the calibration of the second set of 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 margin. 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. This set of parameters includes $\{c_e,\ \underline{p},\ \xi,\ k_0,\ \mu_f,\ \sigma_f,\ \gamma,\ \sigma_z,\ \rho_z,\ c_k,\ \phi\}$. To capture 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

[29] 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 5: 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
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
ϕ	Working capital constraint	0.50	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	Elasticity of entry to interest rate
ξ	Pareto exponent	4.00	Elasticity of entry to interest rate
c_e	Entry cost	3.98	Entry rate
k_0	Initial level of capital	2.15	Firm size at entry
$\bar{d}$	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)
χ_1	Average corporate rate	1.0216	Own calculation
χ_2	Elasticity to sovereign yields	0.42	Own calculation

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. In addition, we target the distribution of leverage. Table 6 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 identify this parameter, we use the entry rate in Portugal. Parameters that shape potential entrants distribution are $\underline{p}$ and ξ. The shape of the potential entrants' distribution determines the elasticity of the number of entrants with respect to corporate spreads. We use the combination of the Eurostat and the ORBIS datasets to identify the elasticity of entrants with respect to interest rate and sovereign default spread. Finally, we calibrate the initial level of capital (k_0) by matching the average size of entrants in the data.

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

Table 6: Calibration targets and model-implied moments

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
Average leverage (%)	0.43	0.40
SD of leverage	0.25	0.35

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.

rates at age 1, age 3, and age 5.[30]

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. In addition, we use the working capital constraint parameter (ϕ) to match the distribution of leverage. 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. We target the mean and standard deviation of leverage.

Finally, the process for the corporate interest rate is estimated running the following regression

$$log(R_t) = log(\chi_1) + \chi_2 log(R_{g,t})$$

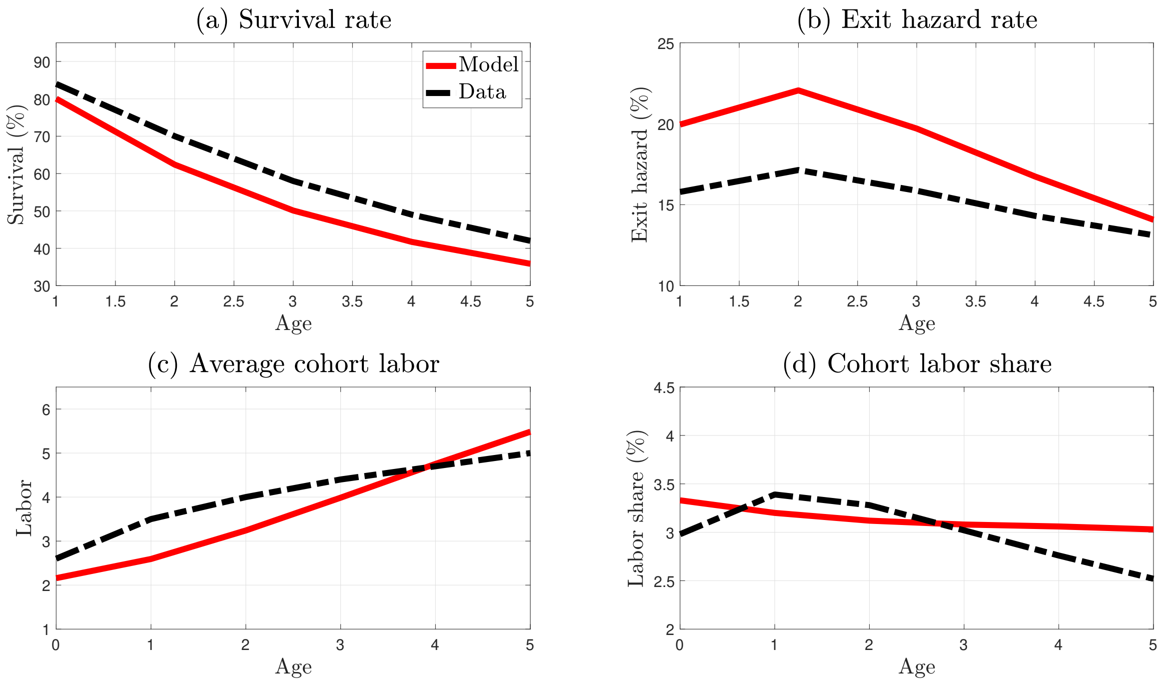
using monthly interest rate for firms and sovereign bonds from January 2000 to August 2021.

5.2 Firm Dynamics in Portugal: Model vs Data

Table 6 reports the calibration results (Column 2) comparing the model-implied moments with their empirical counterparts. The model does a good job at replicating

[30]The Euorostat dataset does not provide information about firms with age 6 and more.

Figure 10: 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.

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 replicating 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, that is 2 workers less than in the data. 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 in the data.

Figure 10 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 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

As we discussed in Section 4 the firms' reliance on external finances is vital to explain the response of the extensive and intensive margin to sovereign risk. Thus, matching firms' borrowing needs over the life cycle is paramount to correctly account for and quantify the effect of sovereign risk on the life cycle dynamics of cohorts. This section documents the dynamics of leverage by age and size for the Portuguese economy and shows that the simple working capital constraint, alongside firms' life-cycle demographics, endogenously leads to data-consistent leverage dynamics in our model.

We use the ORBIS dataset for Portugal. The time series are at annual frequency and cover the period 2005-2015. We follow Dinlersoz et al. (2019) to estimate the following standard leverage regression:

$$lev_{i,s,t} = \alpha + \omega_{s,t} + \underset{(0.000)}{0.019} \cdot log(emp_{i,s,t}) - \underset{(0.000)}{0.002} \cdot age_{i,s,t} + controls + \hat{\varepsilon}_{i,s,t} \tag{20}$$

where i is a firm, s is a sector that firm operates, and t is time, measured in years. $\omega_{s,t}$ is an industry$\times$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. 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). The dependent variable is defined as firm's debt-to-assets ratio, where we choose our baseline specification to measure debt as the sum of short-term loans, long-term loans, and accounts receivable. In the Appendix, we also consider alternative measures of leverage.

Regression equation (20) 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 the regression specifications. We also find a strong positive relationship between leverage and productivity. The results are consistent with findings by Dinlersoz et al. (2019). They document that large firms are more leveraged in the cross-section of private firms in the United

States. In addition, they show that a firm's leverage declines with age. Additionally, Dinlersoz et al. (2019) show that while small private firms are least leveraged, young private firms are the most leveraged. Using Italian firm-level data from ORBIS over 2005-2015, Arellano et al. (2020) also find that high leverage firms are on average larger, more productive, and more profitable.

6 Quantitative Evaluation

This section uses the calibrated model to quantify the importance of the entry and exit margins in propagating sovereign default risk to the economy. We first study the transmission of an increased sovereign risk on the aggregate economy using an event analysis of the Portuguese 2011-2012 sovereign debt crisis. Then, to assess the role of the extensive margin, we perform a counterfactual exercise in which we shut down firm entry and exit in our model. Finally, we explore the relevance of firm heterogeneity and selection at entry for the effects of the extensive margin.

6.1 Sovereign Risk, Firm Entry and Exit

To study the transmission of sovereign default risk we perform a crisis event-study by focusing on the Portuguese sovereign debt crisis of 2011-2012 and its aftermath. It is worthwhile to emphasize that in our model sovereign risk affects non-financial firms only through the increase in interest rates (i.e., bank credit supply channel). Our quantitative exercise thus assesses the transmission of sovereign risk through this particular channel, abstracting from other potential transmission mechanisms.[31]

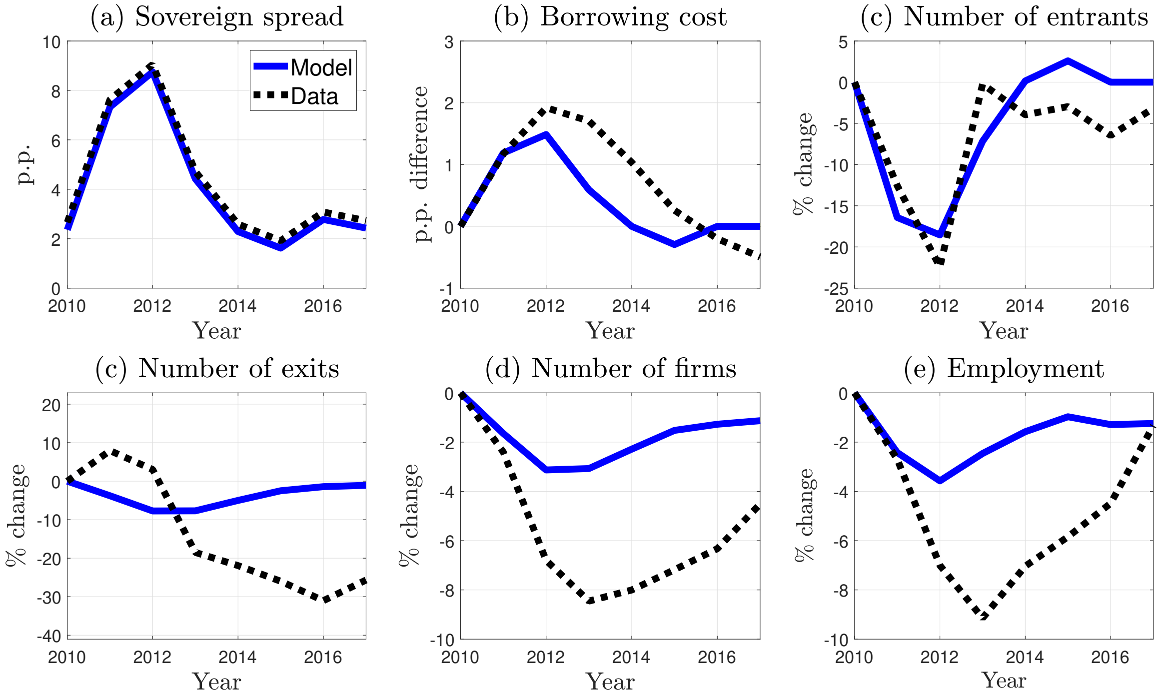
We consider the following exercise: We feed our model economy with the sequence of shocks to sovereign default risk so that the model-implied sovereign spread dynamics matches that of Portugal during the period 2010-2017. Figure 11 plots the model's endogenous responses to these sovereign risk shocks (solid lines) together with the data from Portugal (dashed lines) over the period 2010-2017.

Figure 11, Panel (b) shows that the dynamics of firms' borrowing interest rate in the model closely matches that in the data.[32] Panels (c) to (e) of Figure 11 illustrate

[31]Other channels include disruptions in international trade (Rose 2005, Mendoza and Yue 2012) or distortionary fiscal policies (Aguiar et al. 2009, de Ferra 2018) during sovereign debt crisis.

[32]The increase in lending rates is somewhat more persistent in the data than in the model which

Figure 11: Sovereign risk and macro dynamics



the endogenous propagation of sovereign risk to the economy through the increased corporate interest rates. Panel (c) shows that the model successfully replicates firm entry dynamics during the sovereign crisis. In 2012 the fall in the number of entrants is about 22% in the data versus 18% in the model. The result points that the heightened sovereign risk affected firm entry primarily through tightening in credit conditions. Panel (d) shows that the model, specifically the credit-supply channel, does not account for the observed exit dynamics in Portugal.

To externally validate the model's prediction about the transmission of sovereign risk to extensive margin, in Table 7 we re-estimate the regressions from Section 2 for Portugal. Table 7 shows that on average, one percentage point increase in the sovereign spread is associated with 2.2% drop in entry. Columns (2) and (3) of Panel A show that the effect of sovereign risk is fully driven by the fall in entry in high-EFD sectors. As seen in Figure 11, during the crisis, sovereign spreads increased by about 7 percentage points. Then, a back-of-the-envelope calculation and the estimated

is largely due to the fact that we abstract from modelling endogenous movements in banks' net worth and leverage constraints. In this sense, equation (18) is estimating a lower bound of the transmission of an increased sovereign spreads into the lending rates charged by banks during the crisis.

Table 7: Sovereign risk, firm entry and exit in Portugal

	Panel A. Entry			Panel B. Exit		
	(1)	(2)	(3)	(1)	(2)	(3)
Sovereign spread	-.022***	-.012		.073***	.074***	
	(.008)	(.008)		(.008)	(.008)	
Sovereign spread×high-EFD		-.027***	-.029***		-.002	-0.002
		(.008)	(.006)		(.008)	(.007)
Controls	✓	✓	–	✓	✓	–
Industry FE	✓	✓	✓	✓	✓	✓
Year FE	–	–	✓	–	–	✓
Observations	658	658	611	611	611	611
R^2	0.988	0.988	0.979	0.988	0.988	0.985

Note: 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, current account, inflation and industry-specific linear time trends. When the outcome variable is exit we also control lagged entry. We report robust standard errors. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

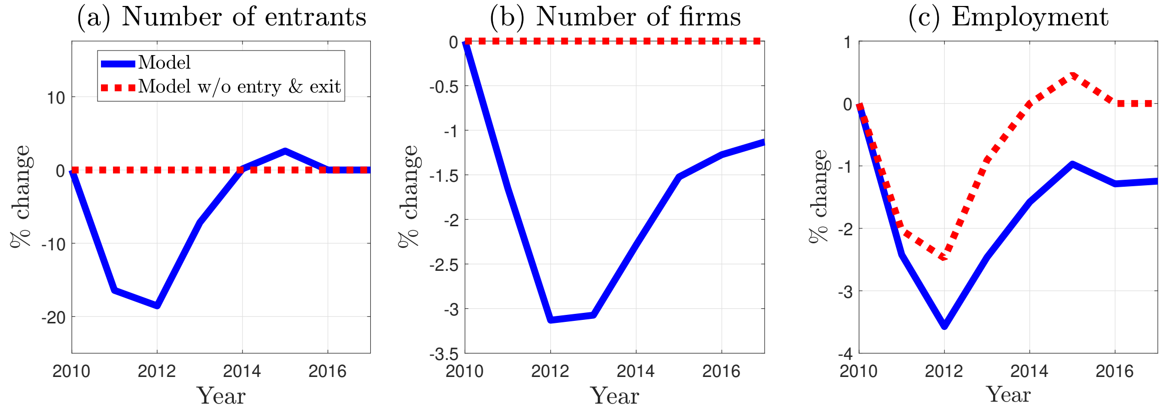
coefficient from column (2) implies that sovereign crisis accounts for around 19% out of total 22% drop in entry, reassuringly close to our model's prediction.[33]

Panel B of Table 7 repeats the exercise for the exit dynamics. Column (1) shows that an average percentage point increase in the sovereign spread is associated with a 7.4% increase in firm exits. However, consistent with the model predictions above, Columns (2) and (3) show that the effect does not work through high-EFD sectors.

Finally, we evaluate the effect of the sovereign crisis on the real economy. On Figure 11, Panels (d) and (e) show the dynamics of the number of firms and aggregate employment. The credit channel explains about 50% of the observed fall in these aggregates over the crisis period 2011-2012. Importantly, the model generates a persistent drop in aggregate employment as in the data. By 2017, long after the sovereign spread starts declining towards its pre-crisis levels, employment remains about 1.7% below its 2010 level. As we show next, the entry dynamics plays a critical role in generating the persistent effects of the sovereign crisis.

[33] Moreover, in Appendix C.2 we also show that the life cycle characteristics of cohorts born during the crisis and non-crisis periods are consistent with the empirical findings described on Figure 2. Specifically, the model simulated crisis cohorts also consists of fewer firms at entry and over time, and employ persistently fewer workers. At the same time, we see that the average size and survival rates are not very different across the crisis vs non-crisis cohorts.

Figure 12: Sovereign risk and macro dynamics: The role of the extensive margin



Note: This figure shows the dynamics of the selected endogenous variables in response to the same sovereign default shocks as in Figure 11. Blue solid lines are from our baseline model; Red dotted lines show the dynamics of the model-economy in which entry and exit are set at the steady-state level and do not respond to shocks.

The Role of the Extensive Margin To investigate the role of the entry and exit margins, we consider a counterfactual scenario without the extensive margin. Figure 12 compares the dynamics of the key aggregates from our baseline model (blue solid lines) to the version of the model without entry and exit margins (red dotted lines). We feed both models with the same sequence of shocks as in Figure 11. The two models are thus subject to the same path of corporate interest rates.

Panels (a) and (b) of Figure 12 plot the dynamics of the number of entrants and the number of operating firms. In the model without entry and exit, the number of firms and entrants are fixed at their steady-state levels. Thus, any changes in the employment, output, or investment in response to changes in the interest rate come from the adjustments at the intensive margin. Panel (c) shows the implications for aggregate employment. The economy with only the intensive margin of adjustment fully recovers by 2017 while our baseline model with entry and exit margins predicts that employment stays persistently below the pre-crisis trend.

Inspecting the Mechanism: The 'Missing Generation' Effect How does the transitory decline in the number of startups generate the persistent fall in aggregate employment? We show that the variation in the composition of entrants at the time of entry plays a crucial role: it is not a decline in the *number* per se, but the variation in the share of high productivity-high survival rate entrants in an entrant cohort that determines the propagation.

Toward the goal, we perform the following experiment. We generate the same drop in the number of entrants during the crisis period as in our baseline economy but vary the composition of entrants based on their productivity. Specifically, in one scenario we cut the lowest productivity firms from the steady-state distribution of entrants, while in the other scenario we instead lower the number of firms at entry by dropping the highest productivity entrants. Figure 13 plots the entrants' productivity distributions during the crisis year under different selection scenarios together with the stationary (non-crisis) distribution. Figure 13 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.

Figure 14 then compares the crisis-event dynamics under these different scenarios of entrants' selection. Figure 14(a) shows the dynamics of the number of entrants in the baseline and counterfactual scenarios are the same by construction. Thus, the only difference between the counterfactual economies and the baseline come from the variation in the composition of entrants. Figure 14(b) shows that the number of firms drops more in the economy where the high-productive firms get hurt the most. The baseline economy is in between these two scenarios. Figure 14(c) shows that the economy where the only low productivity firms suffer at entry does not exhibit persistent fall in aggregate employment, while losing the high-productivity firms significantly propagates the sovereign crisis. Therefore, accounting for variations in entrant cohorts' productivity composition over the cycle is critical for properly quantifying the effects of sovereign crisis. Appendix C, confirm that the baseline selection of entrants during the sovereign crisis implied by our model is consistent with the Portuguese experience (see Figure 16).

The mechanism above is similar with the "missing generation" effect studied by Gourio et al. (2016) and Sedláček (2020) in the context of the United States during the Great Recession. A current fall in entry reduces the number of firms in later years. As cohorts of firms that survive and age over time create a significant fraction of employment, this 'missing generation' of startups has a persistent negative impact on employment and economic activity.

Figure 13: Selection of entrants during crisis: Baseline and counterfactual scenarios

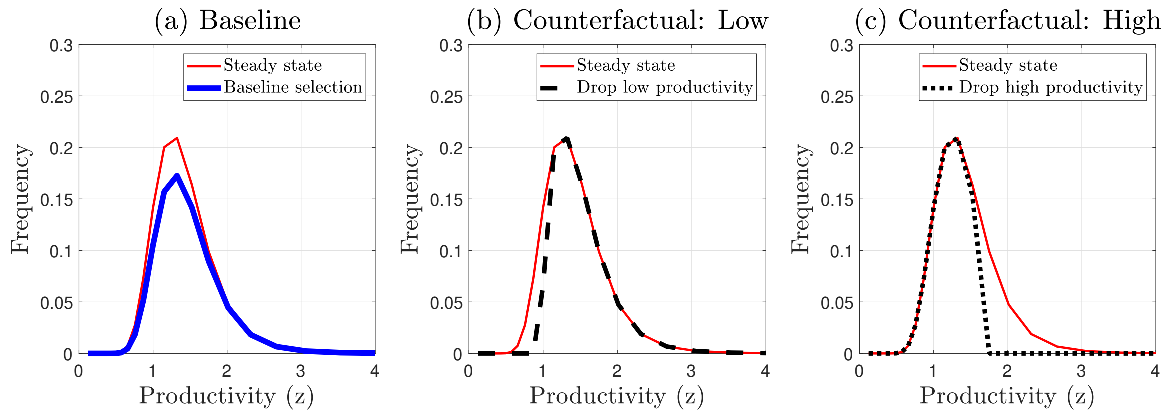
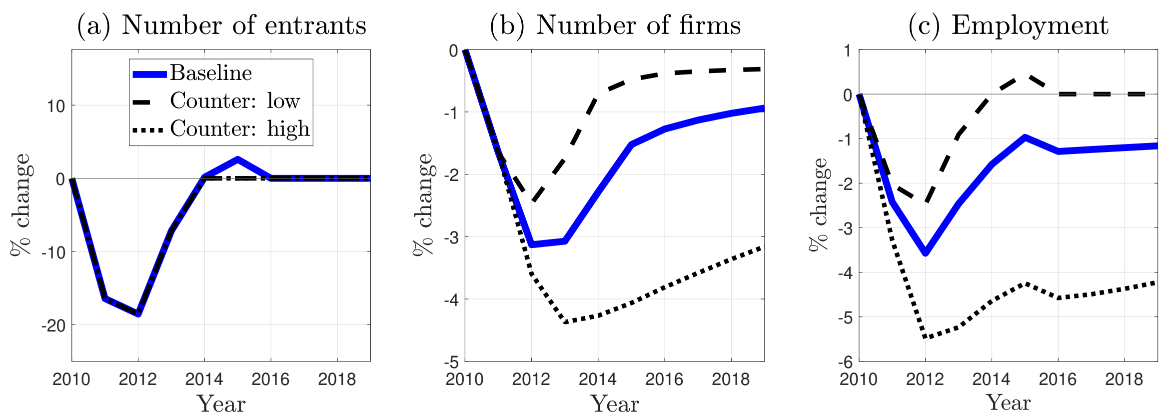


Figure 14: Persistent effects of entry: The role of selection



7 Conclusion

In this paper, we document that an increased sovereign default risk is associated with a decline in firm entry and increase in firm exits. To evaluate the relevance of sovereign risk-bank lending channel we exploit variation in entry and exit dynamics across industries with varying degrees of external financial dependence and across countries with different levels of banks' exposures to domestic sovereign debt. We find strong evidence in favor of the bank lending channel in explaining the observed negative relationship between sovereign risk and firm entry. However, this channel plays a minor role in sovereign risk - exit relationship. Using the firm-level data from Portugal, we also document the persistent effects of the sovereign crisis on the entrant cohorts' life-cycle dynamics.

Motivated by the above facts, we develop a heterogeneous firm dynamics model with endogenous firm entry and exit, sovereign default risk, and financial frictions. The calibrated model generates a close match to firms' life-cycle dynamics in Portugal. Notably, the model endogenously leads to the documented rich heterogeneous dynamics in firms' borrowing needs over the life cycle - an important feature to correctly account for the effect of the sovereign–bank lending channel on the real economy. Specifically, in the model, as in the data, firms' leverage increases on average with firm size, productivity, and decreases with age.

To study the transmission of sovereign default risk we perform a crisis event-study by focusing on the Portuguese sovereign debt crisis of 2011-2012 and its aftermath. Consistent with the empirical facts, we find that the sovereign-bank lending channel plays an important role in the observed dynamics of entry, but does not account for the dynamics of firm exits. Importantly, the model generates a persistent drop in aggregate employment consistent with the data. Then, using a counterfactual exercise, we show that the persistent effect of the entry is due to the drop in the share of high-growth/high-survival firms – in line with the well-known 'missing generation' channel in firm dynamics literature. Therefore, policies that support young business operations during the sovereign crisis could mitigate its negative long-run effects.

Our paper focuses on one important channel through which changes in sovereign risk affects the real economy - a bank lending channel. We therefore abstracted from other potential transmission channels of sovereign crisis such as distortionary taxation, disruptions in international trade or uncertainty about future fiscal policies. These channels might be particularly relevant for firm exit dynamics and we leave this for future research.

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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".[34]

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";[35]

[34]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.

[35]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.[36] See Table A1 for more details.

[36] 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 Robustness

This section provides robustness checks for our empirical results, described in the Empirical Evidence (Section 2) . Specifically, Appendix B.1 provides robustness checks for the Sovereign Risk, Firm Entry and Exit (Section 2.1). Appendix B.2 provides robustness checks for the Evidence on Credit Supply Channel (Section 2.2). Appendix B.2.1 provides robustness checks for the Evidence from the Sovereign Debt Crisis. Finally, Appendix B.2.2 provides robustness checks on the Alternative Measures of External Finance Dependence.

B.1 Sovereign risk, firm entry and exit

Table B1: 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***	-0.033***	-0.033***	0.037***	0.034***	0.029***
	(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	2,898	2,898
R^2	0.986	0.986	0.989	0.977	0.985	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, the current account to GDP ratio, and country-specific linear time trends. When the outcome variable are (log) exit and net entry we also control for lagged (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 B2: 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***	-0.052***	-0.052***	0.039***	0.016**	0.012*
	(0.004)	(0.008)	(0.007)	(0.004)	(0.007)	(0.006)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	–	✓	✓	–	✓	✓
Industry×Year FE	–	–	✓	–	–	✓
Controls	–	✓	✓	–	✓	✓
Observations	4,496	4,449	4,449	3,938	3,789	3,742
R^2	0.977	0.979	0.984	0.976	0.983	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, the current account to GDP ratio, and country-specific linear time trends. When the outcome variable are (log) exit and net entry we also control for lagged (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 B3: Sovereign risk, firm entry and exit: All countries

	Panel A. Entry			Panel B. Exit		
	(1)	(2)	(3)	(1)	(2)	(3)
Sovereign spread	-0.010***	-0.015***	-0.015***	0.038***	0.049***	0.049***
	(0.003)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	–	✓	✓	–	✓	✓
Industry×Year FE	–	–	✓	–	–	✓
Controls	–	✓	✓	–	✓	✓
Observations	10,510	9,758	9,758	10,327	8,174	8,127
R^2	0.977	0.979	0.983	0.9770	0.982	0.984

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, and country-specific linear time trends time trends. When the outcome variable are (log) exit and net entry we also control for lagged (log) entry. For the list of all countries see Table A1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table B4: 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***	-0.018***	-0.018***	0.051***	0.054***	0.054***
	(0.004)	(0.006)	(0.005)	(0.004)	(0.006)	(0.008)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	–	✓	✓	–	✓	✓
Industry×Year FE	–	–	✓	–	–	✓
Controls	–	✓	✓	–	✓	✓
Observations	8,121	7,651	7,651	8,543	7,048	7,048
R^2	0.981	0.983	0.985	0.976	0.983	0.984

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, and country-specific linear time trends time trends. When the outcome variable are (log) exit and net entry we also control for lagged (log) entry. For the list of all countries see Table A1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

B.2 Evidence on Credit Supply Channel

Table B5: 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***		0.992		-0.084***	
	(0.021)		(0.014)		(0.023)	
Sovereign spread×periphery	0.051***		0.017		0.048**	
	(0.019)		(0.015)		(0.021)	
Sovereign spread×high-EFD	0.038	0.038	0.002	0.001	0.032	0.030
	(0.034)	(0.020)	(0.017)	(0.017)	(0.030)	(0.029)
Sovereign spread×high-EFD×periphery	-0.068**	-0.068**	0.013	0.014	-0.075***	-0.071***
	(0.033)	(0.033)	(0.018)	(0.017)	(0.029)	(0.028)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Industry×Year FE	✓	✓	✓	✓	✓	✓
Country×Year FE	–	✓	–	✓	–	✓
Controls	✓	–	✓	✓	✓	✓
Observations	3,276	3,323	3,225	3,272	3,217	3,264
R^2	0.990	0.992	0.987	0.993	0.576	0.722

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, and country-specific linear time trends. When the outcome variable are (log) exit and net entry we also control for lagged (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 B6: 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	-0.008		0.097***		-0.116***	
	(0.007)		(0.010)		(0.015)	
Sovereign spread×periphery	0.031***		-0.063***		0.063***	
	(0.008)		(0.009)		(0.013)	
Sovereign spread×high-EFD	0.006	0.013	0.002	-0.002	0.028*	0.034**
	(0.009)	(0.009)	(0.014)	(0.013)	(0.016)	(0.015)
Sovereign spread×high-EFD×periphery	-0.031**	-0.034***	-0.007	-0.005	-0.043**	-0.044***
	(0.013)	(0.012)	(0.014)	(0.013)	(0.017)	(0.017)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Industry×Year FE	✓	✓	✓	✓	✓	✓
Country×Year FE	–	✓	–	✓	–	✓
Controls	✓	–	✓	✓	✓	✓
Observations	9,758	10,510	8,127	8,550	8,109	8,532
R^2	0.990	0.987	0.984	0.991	0.912	0.936

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, and country-specific linear time trends. When the outcome variable are (log) exit and net entry we also control for lagged (log) entry. For the list of all countries see Table A1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table B7: 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	-0.008		0.096***		-0.132***	
	(0.010)		(0.012)		(0.017)	
Sovereign spread×periphery	-0.017		-0.078***		0.066***	
	(0.010)		(0.013)		(0.015)	
Sovereign spread×high-EFD	0.024*	0.034***	0.009	0.001	0.020	0.033**
	(0.012)	(0.012)	(0.013)	(0.012)	(0.016)	(0.015)
Sovereign spread×high-EFD×periphery	-0.049****	-0.055***	0.004	0.008	-0.056***	-0.058***
	(0.017)	(0.016)	(0.015)	(0.014)	(0.021)	(0.019)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Industry×Year FE	✓	✓	✓	✓	✓	✓
Country×Year FE	–	✓	–	✓	–	✓
Controls	✓	–	✓	✓	✓	✓
Observations	7,651	8,121	8,127	7,471	7,030	7,453
R^2	0.985	0.989	0.984	0.992	0.921	0.942

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, and country-specific linear time trends. When the outcome variable are (log) exit and net entry we also control for lagged (log) entry. For the list of all countries see Table A1. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

Table B8: 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	-0.008	0.031
	(0.030)	(0.016)	(0.020)
Sovereign spread×Low-EFD	-0.039	-0.008	-0.028
	(0.033)	(0.020)	(0.034)
Sovereign spread×High-EFD×Periphery	-0.054*	0.006	-0.059**
	(0.031)	(0.019)	(0.029)
Sovereign spread×Low-EFD×Periphery	0.031	0.012	0.013
	(0.033)	(0.020)	(0.034)
Country FE	✓	✓	✓
Industry FE	✓	✓	✓
Country×Industry FE	✓	✓	✓
Year FE	✓	✓	✓
Industry×Year FE	✓	✓	✓
Country×Year FE	✓	✓	✓
Controls	–	✓	✓
Observations	5,197	4,163	4,155
R^2	0.987	0.993	0.720

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 are (log) exit and net entry we also control for lagged (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. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

B.2.1 Evidence from the European Sovereign Debt Crisis

Table B9: 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**	0.061	-0.150***			
	(0.045)	(0.039)	(0.053)			
Sov. crisis×high-EFD×periphery×spread				-0.021**	0.013	-0.032***
				(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	3,272	3,319	3,323	3,272	3,319
R^2	0.992	0.993	0.714	0.992	0.993	0.720

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 are (log) exit and net entry we also control for lagged (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 B10: 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**	-0.000	-0.067			
	(0.038)	(0.033)	(0.051)			
Sov. crisis×high-EFD×periphery×spread				-0.020***	0.000	-0.018**
				(0.008)	(0.006)	(0.011)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Industry×Year FE	✓	✓	✓	✓	✓	✓
Country×Year FE	✓	✓	✓	✓	✓	✓
Controls	–	✓	✓	–	✓	✓
Observations	10,510	8,550	8,532	10,510	8,550	9,326
R^2	0.987	0.991	0.936	0.987	0.991	0.933

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 are (log) exit and net entry we also control for lagged (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 B11: 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**	0.019	-0.085			
	(0.039)	(0.036)	(0.053)			
Sov. crisis×high-EFD×periphery×spread				-0.018**	0.006	-0.022**
				(0.007)	(0.007)	(0.010)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Industry×Year FE	✓	✓	✓	✓	✓	✓
Country×Year FE	✓	✓	✓	✓	✓	✓
Controls	–	✓	✓	–	✓	✓
Observations	8,121	7,471	7,453	8,121	7,471	7,965
R^2	0.989	0.992	0.942	0.989	0.992	0.937

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 are (log) exit and net entry we also control for lagged (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 B12: The European sovereign debt crisis, firm entry and exit: Credit supply channel (High, medium and low-EFD sectors)

	Panel A			Panel B		
	Entry (1)	Exit (2)	Net entry (3)	Entry (1)	Exit (2)	Net entry (3)
Sov. crisis×high-EFD×periphery	-0.087*	0.049	-0.141**			
	(0.048)	(0.041)	(0.056)			
Sov. crisis×low-EFD×periphery	-0.015	0.020	-0.030			
	(0.044)	(0.035)	(0.050)			
Sov. crisis×high-EFD×periphery×spread				-0.026***	0.008	-0.030***
				(0.007)	(0.009)	(0.011)
Sov. crisis×low-EFD×periphery×spread				-0.006	0.003	-0.009
				(0.008)	(0.007)	(0.010)
Country FE	✓	✓	✓	✓	✓	✓
Industry FE	✓	✓	✓	✓	✓	✓
Country×Industry FE	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓
Industry×Year FE	✓	✓	✓	✓	✓	✓
Country×Year FE	✓	✓	✓	✓	✓	✓
Controls	–	✓	✓	–	✓	✓
Observations	5,197	4,163	4,398	5,197	7,471	4,398
R^2	0.987	0.993	0.714	0.987	0.992	0.714

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 are (log) exit and net entry we also control for lagged (log) entry. See Appendix A for a detailed description of our sample and data coverage. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

B.2.2 Alternative Measures of External Finance Dependence

Table B13: Sovereign risk, entry, and exit: Credit supply channel (Leverage-based measure of external finance dependence)

	Panel A Dependent Variable			Panel B Dependent Variable		
	Entry	Exit	Net Entry	Entry	Exit	Net Entry
Crisis× Lev 2-high	0.008	0.001	-0.013			
	(0.048)	(0.061)	(0.058)			
Crisis× Lev 2-high ×periphery	-0.029***	0.007	-0.022*			
	(0.010)	(0.08)	(0.012)			
Crisis× Lev 3-high				0.055	0.029	-0.018
				(0.035)	(0.036)	(0.045)
Crisis× Lev 3-high ×periphery				-0.026**	-0.002	-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	3,037	3,227	3,695	3,037	3,227
R^2	0.993	0.994	0.7478	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 $75th$-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 $50th$-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 are (log) exit and net entry we also control for lagged (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 Model Appendix

C.1 Model Extensions: Entry Decision with the Choice of Initial Capital Level

In this section, we present an alternative version of the entry phase, where entrants' have the option to choose initial capital level subject to the working capital constraint.

Entry into the market is again subject to a fixed entry cost c_e. We assume that the firm needs to externally finance the fraction ϕ of the fixed cost. However, if a firm decides to enter the market today, the firm observes actual idiosyncratic productivity (z) and behaves like an incumbent with state variables (z, k, s). The value of the firm after paying the entry cost but before observing the productivity reads

$$\tilde{V}^E(p, s) = \max_{i^e} \Big\{ -(1-\phi)(i^e + g^e(i, k_0)) - Rb_i^e + \beta \mathbb{E}[V^I(z', k', s')|p, s] \Big\} \tag{21}$$

subject to

$$k'^e = k_0 + i^e, \tag{22}$$

$$b_i^e = \phi \left[i^e + g^e(i, k_0) \right], \tag{23}$$

where $g^e(i, k_0)$ is an entrant's adjustment cost function which may not coincide with the incumbent's adjustment cost function.

If the firm waits, it starts the next period with the same signal p, but observes a new aggregate state s'. Therefore the value of waiting equals to

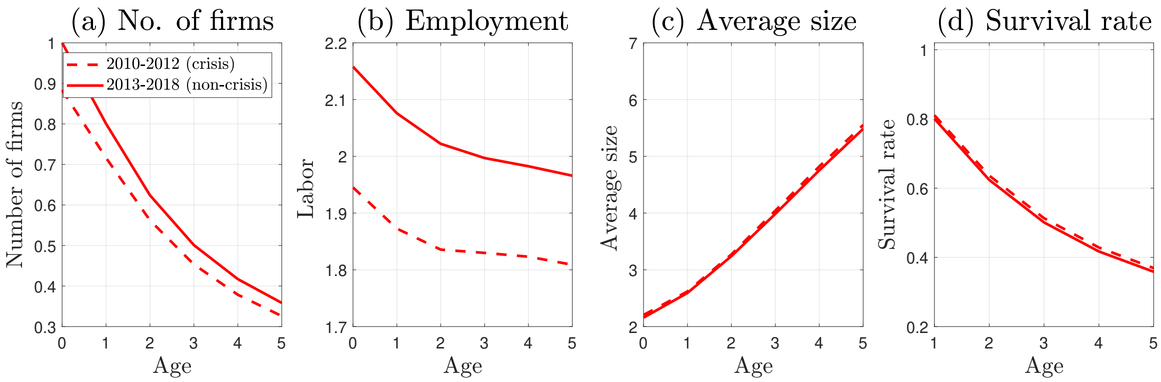
$$V^w(p, s) = \beta \int_{s'} V^E(p, s') dF(s'|s)$$

Thus, the firm is going to decide to enter the market if the expected value from being an incumbent with (p, k_0, s) is more than the value of waiting. A potential entrant with signal p makes entry decision according to the following rule,

$$V^E(p, s) = \max \Big\{ V^w(p, s), \quad \tilde{V}^E(p, s) - (1-\phi)c_e - R\phi c_e \Big\} \tag{24}$$

C.2 Quantitative Exercise: Persistent Cohort Effects

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



Crisis vs Non-Crisis Cohorts' Post-Entry Dynamics Figure 15 investigates the model's predictions about the dynamics of the 2010-2012 cohorts over the life-cycle compared to the non-crisis cohorts. Specifically, '2010-2012', and '2013-2018' describe average characteristics of cohorts born during the periods 2010-2012, and 2013-2018, respectively. Panel (a) plots average total number of firms of cohorts by age. Panel (b) displays total employment, Panels (c) and (d) illustrates the average firm size and survival rates of cohorts by age. Consistent with the empirical findings described on Figure 2, the crisis cohorts consists of fewer firms at entry and over time, and employ persistently fewer workers. At the same time, we see that the average size and survival rates are not very different across the crisis vs non-crisis cohorts.

Figure 15(e) additionally compares productivity distribution of crisis and non-crisis entrants. Note that the increase in the interest rate due to the heightened sovereign risks has two type effects on the selection of entrants. First, it directly decreases number of entrants. Second, the productivity composition of entrants changes as a response of the shock. Moreover, Figure 15(f) shows that the latter effect also leads to on average more productive entrants during the crisis compared to non-crisis entrants. The latter is consistent with the facts documented in Section 2.3, Figure 16.

Figure 16: Crisis vs non-crisis cohorts' productivity distribution (kernel density estimate)