Investment, Capital Structure and Default Risk

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Preliminary

Abstract

This paper studies how a firm's capital structure shapes the investment response during a sovereign debt crisis. To estimate the heterogeneous effect of capital structure on investment response to default risk, we use balance-sheet data for Italian firms during 2007-2015. We find that changes in default risk produce a negative response to investment, which changes with the capital structure. Specifically, the negative response of investment is amplified by at least 55% with higher leverage. However, investment sensitivity could be heightened or attenuated by about 15% with higher maturity, depending on whether firms are highly indebted. We build a partial equilibrium model of investment, short-term and long-term debt, and limited commitment to understanding the mechanisms that explain our empirical results. Our model shows that the effect of *debt overhang, rollover risk* and its interaction can qualitatively capture the empirical results obtained with Italian data for firms.

Keywords: Investment, debt overhang, rollover risk, sovereign debt crisis.

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1. Introduction

With the recent euro-zone crisis, much attention shifted to studying the role of investment in explaining the decline in aggregate activity during a sovereign debt crisis. A closely related topic explored the factors influencing firms' investment sensitivity to changes in default risk. This paper contributes to this literature by examining the links between investment, capital structure, and default risk. We are particularly interested in studying how firms' capital structure shapes the investment response during a sovereign debt crisis.

We will focus on the Italian economy during the euro-zone debt crisis of 2010-12. The particularities of Italy's aggregate investment and capital structure during this period motivate our choice. In particular, Italy, along with other euro countries (i.e., Greece, Ireland, Portugal, and Spain), experienced a historical increase in the spread of government bonds and a sharp decline in aggregate investment not observed for the rest of the euro area (Figures 1 and 2). However, relative to the other euro countries affected by the debt crisis, Italy's aggregate investment declined more smoothly and recovered more slowly. On the other hand, when comparing the Debt-to-Assets ratio and share of Long Term Debt for non-financial corporations (Figure 3 and 4). Non-financial corporations in Italy went through a more substantial deleveraging process while relocating liabilities toward long-term debt faster than other euro countries also affected by the debt crisis of 2010-12.

Thus far, the literature has primarily focused on the interaction of bank-sovereign linkages and the high level of corporate debt to explain the severe decline in economic activity during the last European crisis. However, using firm-level data for European countries Kalemli-Özcan et al. (2018) shows that small/medium and large firms report on average 36% and 64% of their liabilities in the form of long-term debt, respectively. The latter indicates that maturity is an essential dimension of the capital structure for European firms. The paper's primary objective is to understand the effect of maturity and leverage on the response of firms' investment during a sovereign debt crisis. We believe aggregate investment played a central role in understanding the severity of the last European crisis. Furthermore, the way capital structure shaped the response of firms' investment to changes in default risk is vital to explain the aggregate decline of investment observed in several European economies after the significant spike in the spread of government bonds during 2010-12

Our approach to studying the interactions between capital structure, investment, and default risk is primarily empirical. We employ balance-sheet data for Italian firms from 2007-2015. Our main variables for analysis are investment, leverage, and maturity. The first is the yearly change in tangible and intangible fixed assets. At the same time, the second and third are measured by the debt-to-capital ratio and share of long-term debts in the debt portfolio, respectively.

Our baseline specification uses investment as the left-hand side variable. As a right-hand side variable, we control for the spread of Italian sovereign bonds. Then we define dummy variables for leverage and maturity using the 2007 distribution of each variable. The categories above create four capital structure groups depending on leverage and maturity levels being high or low. Finally, our categorical capital structure groups will interact with the spread of Italian government bonds to control the potential heterogeneous investment response to changes in aggregate spread.

The empirical results in this paper can be classified into ones consistent with previous findings and new results that contribute to the empirical literature. On the one hand, consistent with previous findings, we find that higher levels of default risk reduce firm-level investment. Moreover, we find that capital structure induces significant heterogeneity in the negative response of investment to changes in default risk.

On the other hand, firms with high leverage and maturity are the most sensitive to default risk reducing their investment by 4.56 percentage points (pp) after a 100 basis points (bp) increase in aggregate spread. At the same time, firms with low leverage and high maturity are the least sensitive to changes in default risk, reducing their investment by 2.56 pp after an increase in aggregate spread by 100 basis points.

The main novelty of our paper is in terms of the results we report next. First, we find that higher leverage always amplifies the negative response of investment during a sovereign debt crisis. In particular, for low-maturity firms, a movement to a higher leverage group amplifies the negative response of investment by 55%. While for high-maturity firms, the negative response of investment is now 109 % higher. The case is different for maturity. In this case, higher maturity seems to shield investment for firms with low leverage but is detrimental for firms with high leverage. In particular, increasing maturity for high leverage firms makes the negative response of investment to default risk 15% higher. While increasing maturity attenuates the sensitivity of investment to changes in default risk by almost the same amount.

Finally, we build a partial equilibrium model of investment, capital structure, and default risk. The stylized model includes short-term and long-term debt, risky due to limited commitment problems on the firm size. The firm is affected by personal productivity and fixed costs shocks. Lenders are perfectly competitive and price new debt issuances using all relevant information about firms' decisions. Lenders discount future benefits using the interest rate of government bonds. In this model, default risk will be captured by exogenous changes in the interest rate for government bonds, used by lenders to discount future profits.

The characterization in the model serves to illustrate, motivate and provide some insights into the empirical setup presented earlier. In particular, our model shows that leverage and maturity induce heterogeneity in investment response to changes in sovereign spread through its effect on the marginal cost of an additional investment unit.

Moreover, the model can qualitatively capture the main empirical results obtained with firm-level Italian data. In particular, the model shows that *debt overhang* effect of leverage amplifies the negative response of investment. In contrast, for low-leverage firms, higher maturity attenuates the negative effect of investment to default risk due to lowe *rollover risk*. Finally, for high-leverage firms, the detrimental effect of higher maturity can be caused because lower rollover risk strengthens debt overhang as the probability of default for firms increases for several periods in the future. Therefore, increasing maturity for highly indebted firms raises the sensitivity of investment to default risk because the price of long-term debt in the future decline significantly, causing a significant jump in the marginal cost of investment.

Contribution to the Literature. This paper contributes to multiple strands of literature in Finance and Macroeconomics. On the one hand, our paper builds on the extensive empirical literature on corporate debt, capital structure, and firm investment that dates back to the study of corporate debt overhang in Myers (1977).

Within this literature, our paper is related to the recent work of Giroud and Mueller (2017),and Ottonello and Winberry (2020). These papers study how investments respond to different financial shocks and how this response is heterogeneous due to firm-level leverage differences. Compared to the previous papers, our paper provides a more comprehensive empirical approach because we study the combined role of maturity and leverage, tailoring the negative response of a firm's investment to financial shocks. Including the two dimensions that define firms' capital structure provides new evidence on how investment responds to financial shocks.

On the other hand, the empirical evidence in our paper is consistent with the results on Kalemli-

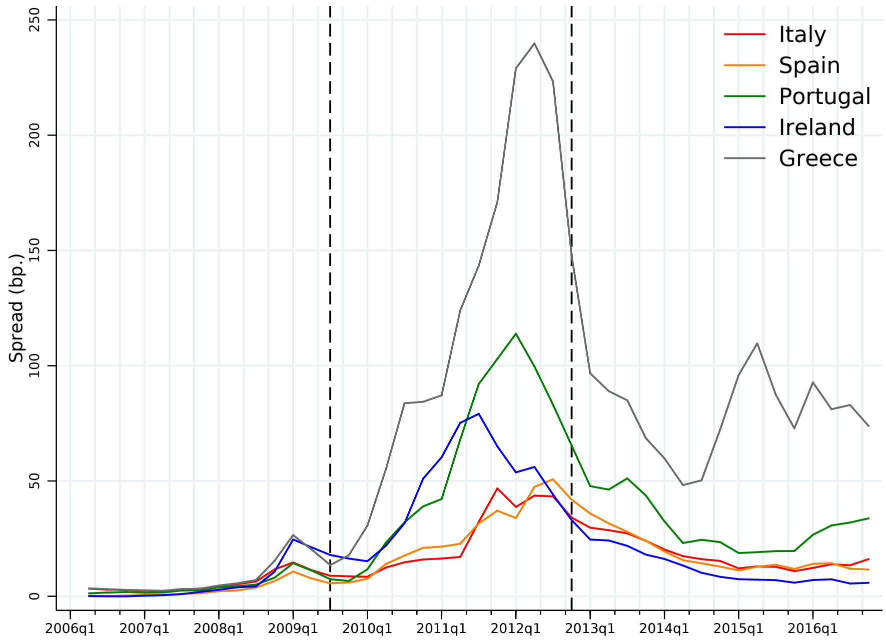
Özcan et al. (2018). They stress the importance of firm leverage in explaining loan changes in the euro area during the 2010-12 debt crisis. They find that excessive corporate debt accumulated during the boom years can be linked to weak investment in the aftermath of the crisis, which interacts with weak credit supply from banks. Our paper has many disadvantages from the previous one, especially additional data on firm links with banks and the number of European countries included in their analysis. Nevertheless, our empirical results in most cases complement the ones in Kalemli-Özcan et al. (2018). However, our paper provides novel evidence on the asymmetry of maturity for the investment response to financial shocks. As far as we know, this paper is the first to report these findings.

The second contribution of our paper is to the theoretical literature on corporate investment and debt. In particular, our paper is closely related to the quantitative models of Gomes et al. (2016) and Poeschl (2020). Both papers introduce long-term corporate debt into an investment model with firms affected by limited commitment problems.

Compared to Gomes et al. (2016), I provide a similar characterization for a firm's investment but in a model that includes both long-term and short-term debt. Moreover, the capital structure of a firm that has access to an additional type of corporate debt provides new layers of heterogeneity in investment.

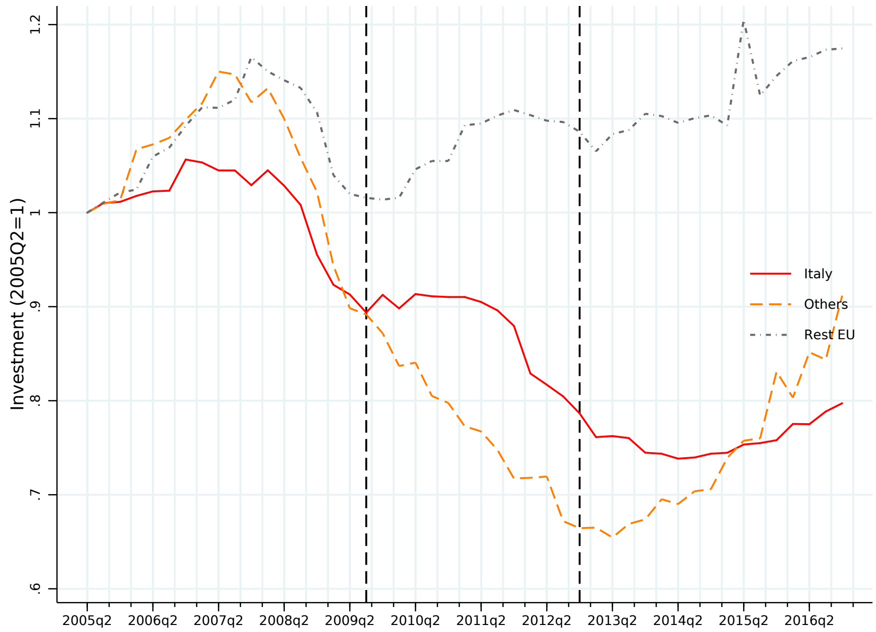
On the other hand, relative to Poeschl (2020), we present a more stylized model, which is used entirely to explain the results obtained with our empirical strategy. Compared to a full-blown quantitative model, our model limitations do not affect its power to provide critical insights about complicated interactions caused by the capital structure. The latter is usually to find in models with both types of debt as they are complicated to characterize and solve.

Layout. The paper is divided into five sections. Section 2 describes the firm balance sheet data for Italy during 2007-2015 used to estimate the interactions between maturity, leverage, investment, and default risk. Section 3 outlines our empirical strategy's parametric specification and provides a detailed discussion of the parameters of interest. Section 4 provides the baseline estimation results and examines the potential factors confounding our estimates. Section 5 builds the partial equilibrium model for firms' investment and capital structure and presents a detailed discussion on the qualitative predictions of the model and how this explains the results obtained in the empirical section. Finally 6 presents the conclusions of the paper.



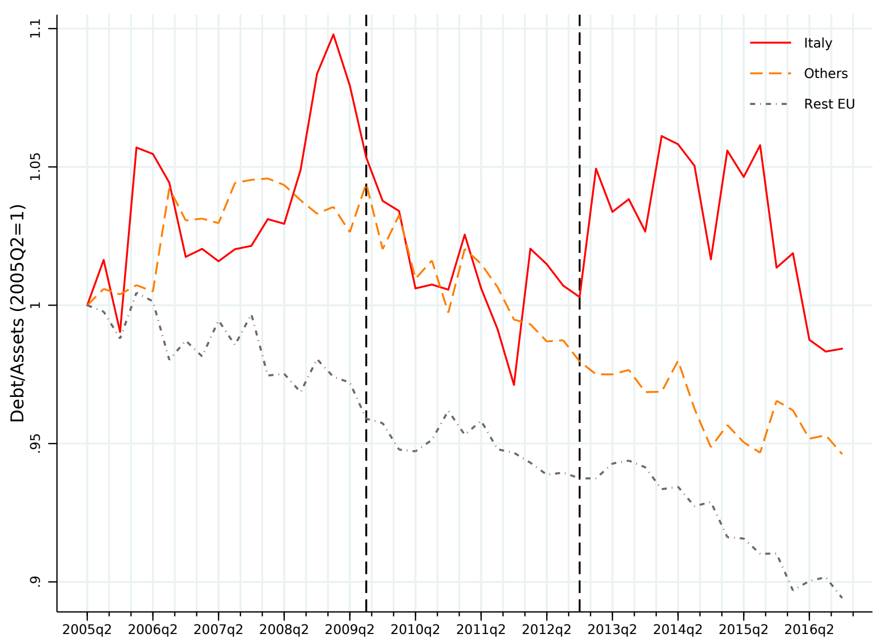
Note: The spread of sovereign bonds is measured as the excess yield of long-term government bonds relative to bonds for Germany.Source OCDE.

Figure 1: Sovereign Spread: Euro Countries



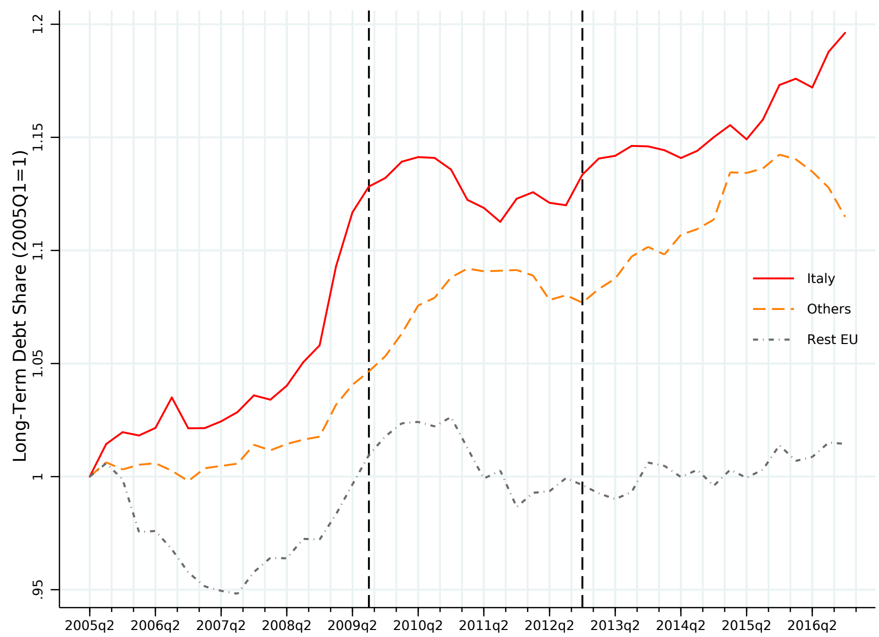
Note: Non-Financial Corporations Real Investment. Index 2005Q2=1. *Others* comprise the aggregate of Greece, Portugal, Ireland, and Spain, while *Rest EU* represents the aggregate for the rest of the EU countries. Source Eurostat.

Figure 2: Non-financial Corporations Investment



Note: Aggregate Debt-to-Assets ratio for Non-Financial Corporations. Index 2005Q2=1.Source Eurostat.

Figure 3: Non-financial Corporations Leverage



Note: Aggregate share of Long-Term liabilities for Non-Financial Corporations. Index 2005Q2=1.Source Eurostat.

Figure 4: Non-financial Corporations Maturity

2. Data

The analysis in this paper focuses on the Italian economy during 2007-2015. This section describes the details for constructing the data used in the regression analysis. This section begins with a short discussion of aggregate data sources and variables. Then we describe in detail the data source for firm balance-sheet data, the firm-level variables used in the empirical analysis, and the sample selection criteria used in this paper. Then, we present summary statistics for our selected sample for 2007 and during the period of analysis 2008-2015. Finally, we describe our approach to characterizing firms into capital structure groups in our data. This part will be vital once we detail the parametric specification in our empirical analysis.

2.1 Aggregate Data

All aggregate yearly data for Italy comes from Eurostat. The primary aggregate variable in this paper is the sovereign spread of Italian government bonds (spr_t), defined as the difference between the nominal interest rate of 10-year Italian government bonds and 10-year German government bonds. Additionally, we collect data on other aggregate variables for Italy, such as Gross Domestic Product in real terms (chain-linked volume 100=2010), real aggregate TFP, and Consumer Price Index (100=2010).

2.2 Firm-Level Data and Main variables of Interest

Firm-level data on Italian firms comes from Orbis global database from Bureau van Dijk (BvD). The Orbis dataset is the largest cross-country firm-level database providing detailed information on balance sheet variables for public and private firms. The main firm-level variables used are sales, operating revenue, employment, total assets, total fixed assets, tangible fixed assets, intangible fixed assets, loans, creditors, long-term liabilities, operating profits, net income (EBITDA), and total interest payments. Finally, we deflate all firm-level variables by the Italian Consumer Price Index (100=2010) so that these are expressed in euros for 2010.

Orbis classify any past commitment of firms into current and non-current liabilities. The former includes any firm's short-term obligations that are required to pay in one year. The latter captures all firm's obligations not due for settlement within one year. Therefore, we define as short-term liabilities the sum of non-current liability items *loans* and *creditors*. At the same time, the non-current liability item *long-term debt* will be our measure of long-term liabilities.

Following the previous discussion on short-term and long-term liabilities in our analysis, we move to define the two variables determining the capital structure of a firm. First, leverage (lev_{it}) will be the ratio of total liabilities over total assets, where total liabilities equal the sum of short-term and long-term liabilities. Second, maturity (mat_{it}) is the ratio of long-term liabilities over total liabilities.

On the other hand, we focus on items in the assets account to define investment. In particular, firm-level capital stock value(k_{it}) is defined as the sum of *tangible* and *intangible fixed assets*. While investment (Δk_{it}) is proxied by the log percentage change in the capital stock value.

Finally, other variables used in the empirical analysis are: (*i*) size of the firm ($log(A_{it})$) proxied by the log of total assets , (*ii*) profit ratio (π_{it}) defined as the ratio of operating profits over operating revenues, (*iii*) interest service rate (Int_{it}) measured as total interests paid over net income, and (*iv*) firm productivity (tfp_{it}) estimated following Wooldridge (2009), which is an extension of the 2-step TFP procedure proposed by Levinsohn and Petrin (2003).

2.3 About Sample Selection Procedure

In order to improve the quality of the Orbis data, we follow the cleaning procedure suggested by Gopinath et al. (2017). First, we drop firm-year observations with missing information on any firm-level variable defined in the previous section. Second, we eliminate any firm-year observation with negative values in operating revenues, total assets, and total fixed assets. Third, we drop firms in industries with strong government presence [1]. Fourth, to have a balanced panel, we only keep firms with complete information during 2007-2015. Finally, to reduce the influence of extreme values in the sample, we winsorized all the firm-level variables at the 1st and 99th percentile.

2.4 Summary Statistics

Table 1 reports the summary statistics for firm-level variables in 2007. The final sample comprises a balanced panel of $80,718$ privately held firms that operated continuously during $2007-2015$. For 2007, the median firm received $21,000$ euros in revenues, had eight employees, 1.432 million euros as assets, and 1.110 million euros as total liabilities. On the other hand, for the median firm, its total liabilities represent 83% of its total assets, while 16% of the liabilities represent long-term debt.

On the other hand, Figure 5 plots the average maturity and leverage for Italian firms during 2007-15. During this period, the average Italian firm deleverages continuously and moves its debt portfolio to long-term debt. This pattern is observed especially during the 2007-08 financial crisis and the 2010-12 eurozone debt crisis.

[1]These industries correspond to NACE codes 84 (Public Administrations and National Defense) 85 (Education) and 86-88 (Health Care)

Table 1: Summary Statistics - 2007 : Firm Level Variables

	Mean	S.D	P^{25}	P^{50}	P^{75}
Employment	12	27	4	8	15
Operating Revenue	33.5	33.8	10.2	21.3	44.1
Assets	2,202.5	2,165.4	677.6	1,432.9	2,965.2
Total Liabilities	1,735.6	1,802.5	514.5	1,110.2	2,296.1
Profit ratio	1.64	4.30	0.01	0.92	3.02
Interest Service	27.61	49.67	4.29	19.41	46.53
Maturity	0.216	0.190	0.067	0.163	0.314
Leverage	0.789	0.187	0.690	0.834	0.92

Notes: The table presents summary statistics for 80,718 firms during 2007. All monetary variables are expressed in hundreds of real euros for 2010.

2.5 Defining the Capital Structure Groups

Our empirical analysis relies on comparing firms across their capital structure. To facilitate this analysis, we classify firms into capital structure treatment groups using a single-year cross-section distribution of the continuous variables *maturity* and *leverage*.

However, as observed in Figure 5, the capital structure of Italian firms changed drastically during 2008-15. Therefore, to ease concerns related to endogeneity, we link the classification of firms into capital structure groups to the cross-section distribution of firms for 2007.

We know that the capital structure is summarized by the *maturity* and *leverage* choices. Then, we use these dimensions to classify firms into capital structure groups. In particular, a firm's *maturity* and *leverage* is considered high if its value is above the 75th percentile of the cross-section distribution for 2007 and low otherwise. The interaction between high/low choices for *maturity* and *leverage* should classify firms into four capital-structure groups: (i) high leverage-maturity (High-High), (i) high leverage-low maturity (High-Low), (i) low leverage-maturity (Low-Low), and (i) low leverage-high maturity (Low-High).

Finally, we provide some notation definitions for the capital structure groups, which will turn useful, especially when formulating the parametric specification. Let $D_{lev} = \mathbb{1}\{lev_i > p75\}$ and $D_{mat} =$

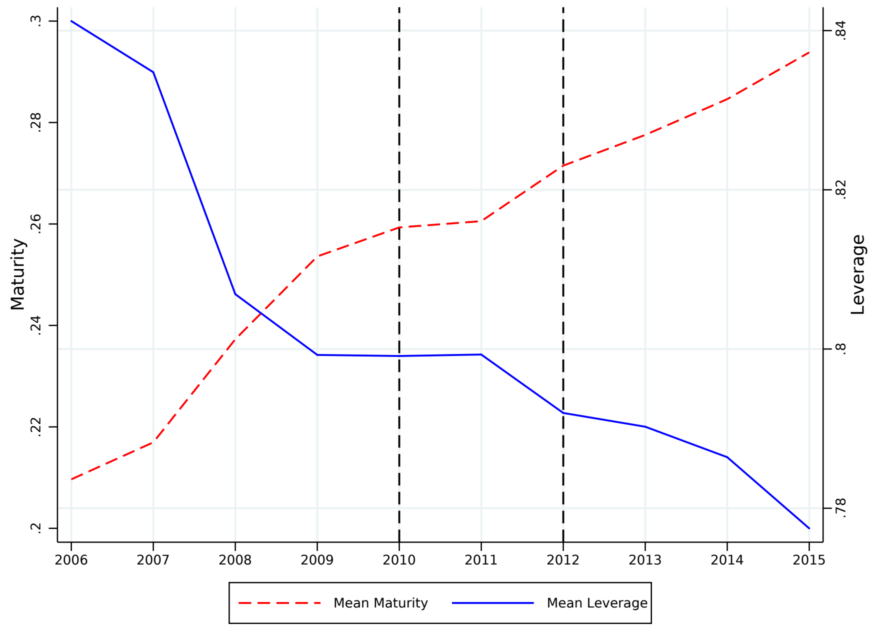


Figure 5: Average Leverage and Maturity for Italian Firms

$\mathbb{1}\{mat_i > p75\}$ represent a indicator variable taking the value of one whenever a firm is classified as having high leverage and maturity, respectively. Then our capital structure group is the set resulting from the interaction between D_{lev} and D_{mat}.

3. Empirical Strategy

This section proposes the econometric strategy using the previously defined capital structure groups. First, we present the baseline parametric specification. Then, we examine how to interpret the coefficients associated with the capital structure groups in our baseline specification. Lastly, we examine the assumptions needed for identification and the potential threats that may be present in our empirical strategy. Finally, we end this section by proposing some alternatives to deal with potential confounding factors in our analysis.

3.1 Parametric Specification

Equation (1) shows our baseline specification. For firm i, year t the main variable of interest is investment denoted as $\Delta k_{i,t}$. On the other hand, the main left-hand side variables include the spread of Italian government bonds (spr_t), the high *maturity* (D_{mat}) and high *leverage* (D_{lev}) indicators. We also include firm-level fixed effects FE_i to control for time-invariant unobserved firm characteristics determining investment. However, we do not include year-fixed effects as these will be perfectly collinear with spr_t. We will change this later when testing the robustness of our baseline results.

$$\Delta \log k_{it} = \text{FE}_i + \beta_0 spr_t + \beta_1 D_{lev} \times spr_t + \beta_2 D_{mat} \times spr_t + \beta_3 D_{lev} \times D_{mat} \times spr_t + \varepsilon_{i,t} \quad (1)$$

The coefficients of interest for the empirical strategy outlined (1) are $\{\beta_k\}_{k=0}^{3}$. In the next section, we use these coefficients to define the response to investment during a sovereign debt crisis.

3.2 Investment Response to Default Risk and Capital Structure

Table 2 define the structure we will use to summarize the main results of our empirical strategy. Each element in this table provides the links between the capital structure and investment response to changes in default risk using the coefficients of interest.

The coefficients of interest capture the potential layers of heterogeneity in the investment response to changes in default risk induced by different capital structures for firms. In particular, β_1 and β_2 represent the fraction of the investment response specific to firms with high leverage or high maturity, respectively. At the same time, β_0 and β_3 capture the component of the investment response for firms with low leverage-low maturity and high leverage-high maturity, respectively.

The inner elements of Table 2 combine these coefficients to define the average investment response to default risk for firms with different capital structures. On the other hand, the outer elements in row $\Delta lev \mid mat$ and column $\Delta mat \mid lev$ capture the effect of changing one dimension in the capital structure on the average response of investment to default risk.

Table 2: Response of Investment and Capital Structure

lev-mat	$D_{mat} = 1$	$D_{mat} = 0$	$\Delta\ mat \mid lev$
$D_{lev} = 1$	$\beta_0 + \beta_1 + \beta_2 + \beta_3$	$\beta_0 + \beta_1$	$\beta_2 + \beta_3$
$D_{lev} = 0$	$\beta_0 + \beta_2$	β_0	β_2
$\Delta lev \mid mat$	$\beta_1 + \beta_3$	β_1	

Before presenting the results of Table 2, it is useful to examine the implications of canceling some layers of heterogeneity induced by the capital structure. First consider the case in which $\beta_1 = \beta_2 = \beta_3 = 0$. In this scenario, the capital structure is irrelevant for investment decisions, and then β_0 defines the homogeneous response of investment to changes in default risk. Consider the case in which $\beta_3 = 0$. In this scenario, firms with high or low maturity and leverage should differ in their investment response to default risk. However, the change in investment response to reducing leverage and maturity will now equal β_1 and β_2, respectively. In this case, change in the investment response will be homogeneous across the dimension that was kept constant.

4. Estimation Results

This section reports the results for the baseline specification in (1). First, we present the results for Table 2. Next, we examine the potential confounding factors in our empirical strategy and how robust are the baseline estimates to changes in the parametric specifications.

4.1 Investment response and Capital Structure: Baseline Estimates

First, Table 3 presents the estimated results related to Table 2. The full set of coefficients of interest used to compute Table 3 can be found the Column (4) of Table 5. Notice that the inner elements

Table 3: Baseline Estimation Results

lev-mat	$D_{mat} = 1$	$D_{mat} = 0$	Δ *mat* | *lev*
$D_{lev} = 1$	-4.61**	-4.02**	-0.59**
$D_{lev} = 0$	- 2.20**	- 2.58**	0.38**
$\Delta lev \mid mat$	-2.41***	-1.44***	

of Table reftable:tab5 clearly show that investment for Italian firms is always negatively associated with changes in the spread of government bonds. In other words, we find a statistically significant negative sign across all capital structure groups of firms.

Even if the estimated results presented in Table 3 are similar qualitative terms. There are significant disparities in terms of the magnitude of the inner elements. That is to say, the average investment response to default risk changes differs significantly across firms with different capital structures. In particular, our baseline results predict that a 100 basis point increase in the spread for Italian bonds is associated with an upper bound and lower bound investment drop of 4.56 percentage points (high leverage-high maturity firms) and 2.56 percentage points (for low leverage-high maturity firms), respectively.

On the other hand, for the outer elements reported in Table 3, notice that all elements are statistically significant, which is expected given the results obtained for the inner elements. Furthermore, for elements in row $\Delta lev \mid mat$, we can see that higher leverage amplifies the negative response of investment to changes in default risk. In particular, for low-maturity firms, a movement to a higher leverage group amplifies the negative response of investment by 55%. While for high-maturity firms, the negative response of investment is now 109 % higher. Similarly, the results for elements in column $\Delta lev \mid mat$ provides additional evidence about the important links between the capital structure and investment response during a sovereign debt crisis. In this case, our results show that increasing maturity is detrimental for high leverage firms because the negative response of investment to changes in default risk is approximately 15% higher. While for firms with low leverage, increasing maturity reduces the sensitivity of investment to changes in default risk by almost the same amount.

We conclude this section by outlining the main empirical findings obtained with firm-level data for Italy during 2008-15. First, changes in default risk reduce firm-level investment. Second, the capital structure induces significant heterogeneity in the negative response of investment to changes in default risk. In particular, firms with high leverage and maturity are the most sensitive to default risk, while firms with low leverage and high maturity are the least sensitive to changes in default risk. Third, changes in the capital structure significantly affect the response of investment to default risk. In particular, higher leverage always amplifies the negative response of investment during a sovereign debt crisis, especially for firms with high maturity. In contrast, higher maturity seems to shield investment for firms with low leverage but is detrimental for firms with high leverage.

4.2 Identification and Potential Confounding Factors

Our empirical strategy relies on comparing firms across the four capital structure groups. Implicitly, specification (1) assumes that—after controlling for constant firm-specific characteristics—differences in capital structure across firms should materialize in observable differences for the investment response to default risk changes. However, if leverage and maturity are correlated with other observable and unobservable time-varying firm-level characteristics, then the results presented in Table 3 may be entirely spurious as they are contaminated by confounding factors unrelated to firms' capital structure.

In this section, we provide evidence about the correctness of our identification strategy, and we test for the robustness of our baseline results under alternative specifications.

4.3 Covariate-Balance and Capital Structure Groups

We first present evidence related to covariate balance across capital structure groups. This approach provides evidence of differences in capital structure groups related to other observable firm-level characteristics. The results from our covariate balance tests inform us about additional controls that need to be included in the specification to test for the robustness of the baseline results.

We perform a simple covariate-balance test for our capital structure groups of firms along five observable dimensions: revenues per worker, assets per worker, profit rate, investment rates, productivity, and interest service rate. We compute each observable characteristic's mean and standard deviation during 2008-15 across capital structure groups. Table 4 presents the results of our covariate balance test.

We observe that our capital structure groups are relatively balanced in terms of revenues per worker, assets per worker, and productivity. However, there seem to be significant differences for variables related to profit ratio, interest services rates, and investment rates. In particular, high-leverage firms have lower profits and higher interest service costs. On the other hand, high leverage-high maturity firms invest more in the capital.

Table 4: Balance across Capital Structure Groups

lev - mat	Revenues per worker	Assets per worker	Profit Rate	Investment Rate	Log TFP	Interest Service
$D_{lev} = 1, D_{mat} = 1$	3.3	317.9	-1.14	1.34	3.62	43.04
$D_{lev} = 1, D_{mat} = 0$	5.9	355.0	-0.40	0.87	4.00	39.86
$D_{lev} = 0, D_{mat} = 1$	3.2	304.9	2.34	0.78	3.70	27.01
$D_{lev} = 0, D_{mat} = 0$	5.5	333.1	2.40	0.76	4.00	22.00
S.D (All groups)	7.02	435.7	4.30	4.92	0.75	49.7

Notes: The table computes the 2007 averages for each firm-level variable across the four capital structure groups. All monetary variables are expressed in hundreds of real euros for 2010. Firm-level productivity is estimated by following Wooldridge (2009) extension of the two-step TFP procedure proposed in Levinsohn and Petrin (2003).

4.4 Testing Robustness of Baseline Results

We now change the specification to include additional controls to deal with the imbalance across capital structure groups reported by the previous test. The idea of this approach is that coefficient instability could be a significant sign of spurious results caused by confounding factors. Therefore, testing the robustness of our baseline results under different specifications provides evidence strengthening our identification strategy and the specific interpretation of our results.

First, we will test how the estimation results change as we include the interactions between D_{lev} and D_{mat} with spr_t sequentially. Evidence of heterogeneity should imply that the estimate for β_0 in (1) will drop as we add the interactions of spr_t with each dummy for our maturity and leverage categories.

On the other hand, as shown in Table 4, the capital structure groups differ in profit ratio and interest services rates. So, we will first add firm-level time-varying covariates to our baseline specification. However, we use the lag value of each firm level covariate to avoid further endogeneity issues.

On the other hand, the results we obtained with our baseline specification could capture the heterogeneous investment response to other aggregate shocks correlated to the spread of Italian government bonds. To rule out this, we will include interactions between dummy variables D_{lev}, D_{mat}, $D_{lev} \times D_{mat}$ and economy-wide aggregate variables. In particular, the aggregate variables we include are: (*i*) TFP growth, (*ii*) growth of final consumption expenditure for households, (*iii*) government expenditure growth, and (*iv*) manufacturing-retail and the employment ratio. Finally, we believe that the potential correlation between industry-specific firm factors and firms' capital structure could also explain the results related to the heterogeneous response of investment to default risk changes. In order to test for its influence, we control for industry-time fixed effects. The only caveat with the previous approach is that coefficient β_0 cannot be estimated anymore, given the high collinearity between the sovereign spread and the industry-year fixed effects.

Table 5 present the coefficients of interest under different specification discussed earlier. In Column (1), we present the results not controlling for control the interaction between spr_t and the capital structure groups. Columns (2)-(3) add the single interaction between leverage or maturity groups with spr_t. Column (4) adds the triple interaction between the capital structure dummies and spr_t. This column was used to compute our baseline results presented in Table 3. Columns (5) show the results for the specification that controls for the same firm-level covariates used in the covariate balance test of Table 4. Column (6) reports the regression estimates with interaction terms between capital structure groups and other aggregate variables. Finally, column (7) presents the results of adding industry-time fixed effects as additional controls. As we can see in Columns (2) and (4), the negative estimate for β_0 reduce once we control for $D_{\text{lev}} \times spr_t$ (column 2) or $D_{\text{lev}} \times D_{\text{mat}} \times spr_t$, the reason for this is that D_{lev} captures the amplification effect of leverage on the investment response to default risk, then its omission in Column (1) makes $\widehat{\beta}_0$ more negative. On the other hand, the estimate for β_0 is more negative once we control for $D_{\text{mat}} \times spr_t$ (column 4). This pattern is again related to D_{mat} capturing the mitigation effect of maturity on the investment response to default risk. In conclusion, the changes in the estimates for β_0 with a sequential introduction of the interactions defining the capital structure groups are consistent with the effect of leverage and maturity predicted later by our baseline results.

On the other hand, when we compare the coefficients of interest for the specifications in columns (5)-(7) and our baseline results in Column (4), we conclude that the latter is robust in different dimensions. First, across all specifications, there are no jump signs. Second, in terms of magnitude, the coefficients of interest remain relatively stable, with no notable change between the baseline results and the rest of the specifications. Finally, only when controlling for interactions with other aggregate variables do we observe a loss in significance for the coefficient associated with $D_{\text{mat}} \times spr_t$, but this seems to be produced by the loss of precision with the new specification than a dramatic change in the estimated coefficient. The results across columns (5)-(7) are clear evidence of coeffi-

Table 5: Baseline Results and Alternative Specifications

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
spr_t	-2.80***	-2.70***	-2.52***	-2.58***	-2.73***	-2.05***	
	(0.039)	(0.046)	(0.048)	(0.069)	(0.048)	(0.049)	
$D_{lev} \times spr_t$		-0.40***	-0.70***	-1.44***	-0.45**	-0.95***	-0.93***
		(0.083)	(0.158)	(0.195)	(0.192)	(0.189)	(0.191)
$D_{mat} \times spr_t$			0.42*	0.38**	0.57***	0.17	0.48***
			(0.21)	(2.07)	(3.04)	(0.93)	(2.63)
$D_{lev} \times D_{lev} \times spr_t$				-0.97***	-0.48*	-0.65**	-0.71***
				(-3.55)	(-1.73)	(-2.43)	(-2.65)
Firm FE	✓	✓	✓	✓	✓	✓	✓
Firm Controls					✓	✓	✓
Interactions						✓	✓
Industry-Year FE							✓
N	726,462	726,462	726,462	726,462	726,462	726,462	726,462
R^2	0.110	0.110	0.110	0.110	0.151	0.151	0.180

Notes: The table shows the estimates of the coefficients of interests in (1). The main dependent variable is a firm-level investment, measured as the log difference of fixed tangible and intangible assets. The high-leverage D_{lev} high-maturity D_{mat} where defined using the 2007 distribution for leverage and maturity across Italian firms. The main coefficients of interest are the ones associated to the interactions for D_{lev} and D_{mat} with the spread of Italian government bonds. Standard errors in parentheses are clustered at the two-digit industry level (NACE Rev.2), *, **, *** indicate significance at the 10% 5% and 1% respectively

cient stability in our baseline results.

5. Model

This section builds a partial equilibrium model of investment, capital structure, and default risk based on Poeschl (2020). The purpose of the model is to characterize the decisions of firms regarding maturity, leverage, and investment. The model will serve to illustrate, motivate and provide some insights into the empirical results presented earlier. The stylized model includes short-term and long-term debt, risky due to limited commitment problems on the firm size. The firm is affected by idiosyncratic productivity and fixed costs shocks. Lenders are perfectly competitive and price new debt issuances using all relevant information about firms' decisions. Lenders discount future benefits using the interest rate of government bonds. In this model, default risk will be captured by exogenous changes in the interest rate for government bonds, used by lenders to discount future profits.

5.1 Initial Setup

5.1.1 Firms

A continuum of firms produces a homogeneous good y_t sold in a perfectly competitive market at a price P_t. The price of the homogeneous good is normalized to one.

Production technology has constant returns to scale in capital k_t. Besides capital, output each period is altered by new realizations of a firm, specific TFP shock $z_t \in Z$ which is *iid* across time and has a cumulative distribution function $Phi(z) = P(z_t \leq z)$ defined over a bounded support $Z = [\underline{z}, \overline{z}]$ with $\underline{z} > 0$ Firms invest in capital stock which depreciates at a constant rate of δ. Let I_t represent; firm investment in period t, then (2) defines the law of motion for the capital stock of firms. Firms fund investment using operating profits or issuing corporate debt.

$$k_{t+1} = (1-\delta)k_t + I_t \tag{2}$$

Operating profits, denoted by $\pi(z_t, k_t)$, capture firm's internal fund sources available for investment. In terms of functional form, we can see that (3) is identical to the constant return to scale production function.

$$\pi(z_t, k_t) = z_t k_t + (1-\delta)k_t \tag{3}$$

Firms can also fund investment by selling corporate bonds to a lender through short-term and long-term debt. One-period non-contingent bonds represent the previous, while the latter is captured by zero-coupon bonds maturing each period with probability λ. Let $q_{S,t}$ and $q_{L,t}$ represent the price of each bond type, then issuances of short-term and long-term debt in period t are denoted by $q_{S,t} b_{S,t+1}$ and $q_{S,t}(b_{L,t+1} - (1-\lambda)b_{L,t})$, respectively.

Each period firms can default on their outstanding obligations. We assume that default in short-term debt leads to default for long-term debt default and vice-versa. A defaulting firm exits the market in the next period. Then it is replaced by a new firm that starts operations with zero liabilities, low capital, and the lowest possible realization for productivity.

After default, creditors with existing claims liquidate the firm and obtain a residual value that consists of the defaulting firm operating profits plus the capital that did not depreciate. However, to simplify our analysis, we assume that the liquidation process is costly and absorbs all the recovery value from the defaulting firm. Therefore, after the firm's default, its lenders do not receive any residual value.

Let D_t denote period-t dividends, which is defined formally in (4).

$$D_t = \pi(z_t, k_t) - b_{S,t} - \lambda b_{L,t} + q_{S,t} b_{S,t+1} + q_{L,t}\Big[b_{L,t+1} - (1-\lambda) b_{L,t}\Big] - I_t \tag{4}$$

In terms of the liabilities portfolio for firms, we introduce a slight change in notation. In particular, let $b_t = b_{S,t} + b_{L,t}$ denotes the total stock of debt that firm has in period t, and $m_t = b_{L,t}/b_t$ be the firm's share obligations in the form of long-term debt. The change in notation will affect our definition for dividends, which is now (5).

$$\begin{aligned} D_t = \pi(z_t, k_t) - (1-m_t) b_t - \lambda m_t b_t + q_{S,t}(1-m_t) b_{t+1} \\ + q_{L,t}\Big[m_{t+1} b_{t+1} - (1-\lambda) m_t b_t\Big] - I_t \end{aligned} \tag{5}$$

5.1.2 Lenders and the Sovereign Government

Loans are provided by a domestic financial sector which is comprised of a large pool of perfectly competitive intermediaries. The domestic financial sector also loans to a sovereign government.

To price new debt issuances, lenders use all the available information at their disposal. For the case of firms, this includes realizations of firms' idiosyncratic shocks and optimal policy functions determining future changes in capital structure. Therefore, lenders not only have perfect information on a firm's characteristics but also can correctly forecast its future behavior as they have complete information about the optimal policy function of firms.

Finally, let us discuss how we introduce sovereign risk in the model. Our approach is loosely based on **?**, which presents a reduced-form approach to include default risk in a model where the firms and sovereign government borrow from lenders. However, our case is more simplistic in that we assume lenders discount future profits using the interest rate for government bonds. Then if $r_{g,t}$ is the interest rate on government bonds, the discount factor of lenders will be $\frac{1}{1+r_{g,t}}$.

The variable $r_{g,t}$ is thought to be the result of an optimal decision involving a sovereign government. However, the problem of the sovereign government should not be influenced by individual decisions of firms and lenders. Then from the point of view of these agents, $r_{g,t}$ is exogenous. With that in mind, we can assume without loss of generality that $r_{g,t}$ is an exogenous aggregate variable. More importantly, this variable should capture any shock to default risk.

5.2 Timing of the Model

The inclusion of limited commitment on the firm side complicates the model because a firm will make several sequential decisions within a period. Definition 1 provides the details on the exact timing of our model.

Definition 1 (Timing and Firms' Sequential Decisions): *For any given period t, the decisions of firms will be spread over three different stages,*

- ***Production stage:*** *At the beginning of the period, firms that had not defaulted previously observed the realization of all the economic shocks. Then, the firm will produce and receives operating profits.*
- ***Repayment stage:*** *At this stage firm decides whether or not to default. If the choice is to default, the firm will exit the market and be replaced by a new firm at the start of the next period.*
- ***Continuation stage:*** *Only firms repaying their obligations move to this stage. In this last stage, firms adjust their capital structure by defining the optimal investment and debt issuance policy.*

5.3 Firms Problem at the Repayment and Continuation Stage

From now on, for any variable in the model, we use the notation Y no and Y' to denote current and future values, respectively. The state variables in our model are captured by a vector containing the endogenous states k, b, m, and exogenous state z.

5.3.1 Repayment Stage

Let V denote the present value of the firm's equity for its shareholders. On the other hand, we denote V_c and V_d as the firm's present value for its equity holders conditional on not defaulting and defaulting, respectively. Then, (6) captures the firm's problem at the repayment stage.

$$\mathbf{V}(k,b,m,z) = \max\left\{\mathbf{V}_c(k,b,m,z), \mathbf{V}_d\right\} \tag{6}$$

Due to limited liability, when firm defaults, its shareholders walk away with no residual value. Therefore, $\mathbf{V}_d = 0$. Shareholders default if the present values of the firm's equity conditional on continuing to the next stage are lower than zero. Notice that default in our model has a clear implication for the meaning of limited liability for shareholders.

5.3.2 Continuation Stage

Conditional on not defaulting in the previous stage, the firm moves to the continuation stage. At this stage the firm's problem is defined by (7), where D follows expression (5).

$$\mathbf{V}_c(k,b,m,z) = \max_{\{I,b',m'\}} \left\{ D + \beta\, \mathbf{E}[\mathbf{V}(k',b',m',z')] \right\} \tag{7a}$$

$$\text{subject to} \quad q_L = q_L(k',b',m',z') \tag{7b}$$

$$q_S = q_S(k',b',m',z') \tag{7c}$$

At the continuation stage, a firm can define its investment I and adjust its capital structure $(b'm')$. Notice that (7b) and (7c) represent the lenders optimal pricing functions for corporate debt. Therefore, firms internalize that investment and capital structure changes affect how lenders price new units of short-term and long-term debt.

subsectionInvestment, Capital Structure, and Corporate Default Risk Following Gomes et al. (2016), we will re-write (6) and (7). By changing the firm's problems in each stage, we can express the model in terms of variables equivalent to the ones used in the empirical analysis. Additionally, the adjusted version of each problem will simplify the characterization of the firm's optimality conditions for default, investment, and capital structure. The latter will be crucial to shed some light on the results found in the empirical part of the paper.

The adjusted version of the firm's problem at the repayment stage is presented in (8).

$$\mathbf{V}(k,b,m,z) = \max\left\{0, \pi(z,k) - (1-m)b - \lambda m b + \widetilde{\mathbf{V}}_c(k,b,m)\right\} \tag{8}$$

Notice that (9), employs a different continuation value denoted by $\widetilde{\mathbf{V}}_c$. However, as we show in (9), the value function $\widetilde{\mathbf{V}}_c$ is defined by an equivalent problem as the one in (7).

$$\begin{aligned}\widetilde{\mathbf{V}}_c(k,b,m) = \max_{\{k',b',m'\}} \Bigg\{ & q_S(1-m')b' + q_L\left[m'b' - (1-\lambda)mb\right] - k' + (1-\delta)k \\ & + \beta\left[\int_{\underline{z}}^{\bar{z}} \mathbf{V}(k',b',m',z')\right] d\Phi(z') \Bigg\}\end{aligned} \tag{9}$$

Notice that both $\mathbf{V}_c$ and $\widetilde{\mathbf{V}}_c$ include the present value of the firm's equity to shareholders in the next period. However, $\widetilde{\mathbf{V}}_c$ only captures the value of new debt issues, while $\widetilde{V}_c$ includes the previous term plus the current period dividends distributed to shareholders. By excluding the current value of dividend distributions, the continuation value $\widetilde{\mathbf{V}}_c$ will not depend on current productivity z. It then will have one fewer state variable as an implicit argument.

The latter also implies that $\widetilde{\mathbf{V}}_c$ provides a simpler way to characterize firms' default policy. In particular, using (8) we define firm's default policy in (10) as function of a cut-off productivity z^*.

$$d^f = \begin{cases} 1 & \text{if} \quad z < z^* \\ 0 & \text{if} \quad z \geq z^* \end{cases} \tag{10}$$

The cut-off productivity z^*, defined in (11), represents the lowest productivity realization that makes equity shareholders indifferent between defaulting or not.

$$\pi(z^*,k) - (1-m)b - \lambda m b + \widetilde{\mathbf{V}}_c(k,b,m) = 0 \tag{11}$$

Using the previous expression, we can solve for z^*, to provide a specific expression for the productivity cut-off—(12)—in terms of the rest of the states variables in the model.

$$z^*(k,b,m) = (1-m)\frac{b}{k} + \lambda m\frac{b}{k} - \widetilde{\mathbf{V}}_c(k,b,m)/k \tag{12}$$

Clearly, $z^*(k,b,m)$ in (12) separates firm's productivity support into a defaulting region and a continuation region. Finally, notice that (13) is the same continuation stage problem in (9), but the former includes the additional information on next-period default provided by the cut-off productivity.

$$\begin{aligned}\widetilde{\mathbf{V}}_c(k,b,m) = \max_{\{I,b',m'\}} \Bigg\{ & q_S(1-m')b' + q_L\Big[m'b' - (1-\lambda)mb\Big] - k' + (1-\delta)k \\ & + \beta \int_{z^{*\prime}}^{\bar{z}} \Bigg[z'k' - (1-m')b' - \lambda m' b' + \widetilde{\mathbf{V}}_c(k',b',m') \Bigg] d\Phi(z') \Bigg\}\end{aligned} \tag{13}$$

The final step before describing the optimality conditions for firms' investment and capital structure is to change the main variables to be equivalent to the ones used in the empirical analysis. This will be done by using the results of Proposition 1.

Proposition 1 (Homogeneity of $\widetilde{V}_c$): *If limited commitment for firms is present, firms produce using technology with constant returns to scale in capital. Then the continuation value function $\widetilde{V}_c(k,b,m)$ is homogeneous of degree one in k and b.*

A clear implication of Proposition 1 is that $z^*(k,b,m)$ will also be homogeneous of degree one on k and b.

Using the first result from Proposition 1, we can express the firm's problem at the continuation stage as one in which firms define their optimal investment, leverage, and maturity levels.

In particular, let $\ell = b/k$, $i = I/k$, $k'/k = i + 1 - \delta \equiv g(i)$, and $v_c = \widetilde{\mathbf{V}}_c/k$. Then continuation stage problem in (14) in terms of i, ℓ' and m' is presented as in (14).

$$\begin{aligned}v_c(\ell,m) = \max_{\{i,\ell',m'\}} \Bigg\{ & q_S(1-m')\ell' g(i) + q_L\Big(m'\ell' g(i) - (1-\lambda)m\ell\Big) - i \\ & + g(i)\,\beta \int_{z^{*\prime}}^{\bar{z}} \Bigg(z' - (1-m')\ell' - \lambda m' \ell' + v_c(\ell',m') \Bigg) d\Phi(z') \Bigg\}\end{aligned} \tag{14}$$

On the other hand, the cut-off productivity can be expressed in terms of ℓ' and m' applying the second result from Proposition 1 to the initial definition in (15).

$$z^*(\ell,m) = (1-m)\ell + \lambda m\ell - v_c(\ell,m) \tag{15}$$

Finally, with the information on the default policy defined by $z^*(\ell',m')$, the competitive lenders will price short-term and long-term corporate debt according to the zero expected profit rule. This pricing rules are presented in (16) and (17).

$$q_S(\ell',m') = \frac{1-\Phi\left(z^*(\ell',m')\right)}{1+r_g} \tag{16}$$

$$q_L(\ell',m') = \frac{1-\Phi\left(z^*(\ell',m')\right)}{1+r_g}\Big(\lambda+(1-\lambda)q_L'(\ell',m')\Big) \tag{17}$$

The full structure of our partial equilibrium model for firms decisions on investment and capital structure is captured by (14), (15), (10) ,(16), and (16). Appendix A provides a formal definition for the recursive competitive equilibrium in our model.

Using (14), we characterize firms' optimal decisions for investment, maturity and leverage in Proposition 2. Additionally, we can characterize the effect of capital structure adjustments on firms' default probability of default in Proposition 3. Both results will be key to discussing the empirical results obtained previously.

Proposition 2 (Optimality Conditions: Continuation Problem): *Assuming the continuation problem in (14), (15), (16), and (17) is differentiable. Then, firm's optimal decisions for investment, leverage and maturity are captured by (18), (19), and (20), respectively.*

$$1-q_S(1-m')\ell'-q_L m'\ell' = \beta\int_{z^{*\prime}}^{\bar{z}}\Big(z'-(1-m')\ell'-m'\ell'+v_c(\ell',m')\Big)d\Phi(z') \tag{18}$$

$$\begin{aligned}\Big[q_S(1-m')+q_L m'\Big]g(i)+\Big[\frac{\partial q_S}{\partial \ell'}(1-m')\ell' g(i)+\frac{\partial q_L}{\partial \ell'}\Big(m'\ell' g(i)-(1-\lambda)m\ell\Big)\Big]&\\ = g(i)\,\beta\left(1-\Phi\left(z^*(\ell',m')\right)\right)\frac{\partial z^*(\ell',m')}{\partial \ell'}&\end{aligned} \tag{19}$$

$$\begin{aligned}\Big[q_L-q_S\Big]\ell' g(i)+\Big[\frac{\partial q_S}{\partial m'}(1-m')\ell' g(i)+\frac{\partial q_L}{\partial m'}\Big(m'\ell' g(i)-(1-\lambda)m\ell\Big)\Big]&\\ = g(i)\,\beta\left(1-\Phi\left(z^*(\ell',m')\right)\right)\frac{\partial z^*(\ell',m')}{\partial m'}&\end{aligned} \tag{20}$$

Proposition 3 (Capital Structure Changes and Firms' Default Risk): *Assuming the continuation problem in (14), (15), (16), and (17) is differentiable. Then, the firm's probability of default in the* *next period increases with ℓ' and decreases with m'.*

5.4 Inspecting the Mechanism: *Debt overhang* and *Rollover Risk*

Using the first-order conditions of the model presented earlier, we will provide a detailed qualitative examination of the main mechanisms generating the results in the empirical part.

According to (18), firms' optimal investment equalizes the marginal benefits with its marginal cost. The marginal benefit, captured by the right-hand side of (18), represents the expected equity value net of debt payments within the continuation region (i.e., $z' > z^*(\ell', m,))$. On the other hand, the marginal cost, on the left-hand side of (18), represents a reduction in current equity cash flows net of funding using debt issuances.

To understand how default risk affects investment, we use the left-hand side of equation (18).

$$1 - q_S(1-m')\ell' - q_L m'\ell' = 1 - q_S\ell'\left(1 - \frac{(q_S - q_L)}{q_S}(1-\lambda)m'\right)$$

By replacing (16) and (17) in the previous equation we obtain an alternative expression for left-hand side of (18).

$$1 - \frac{1}{1+r_g}\left(\ell'\left[1 - \Phi\left(z^*(\ell', m')\right)\right]\right)\left(1 - m'(1-\lambda)\left(1 - q_L'(\ell', m')\right)\right) \tag{21}$$

Four main elements are captured by the left-hand side of the optimality condition for investment in (21). First, $1/(1+r_g)$ captures the investment lending channel of default risk changes. In particular, an increase in default risk will change the lending conditions unfavorably for firms. In particular, an increase in default risk increase the marginal cost, forcing firms to cut on investment.

The following three elements in (21) capture the interaction between the capital structure of a firm and the investment response to default risk.

On the one hand, $\left[1 - \Phi\left(z^*(\ell', m')\right)\right]$ will be related to the effect of *debt overhang* and *rollover risk* on investment. In particular, as shown in Proposition 3 higher leverage increases the probability of default next period, producing a larger drop in the prices for short-term and long-term debt due to changes in r_g. While higher maturity reduces the probability of default in the next period, a drop in the prices for short-term and long-term debt will be lower after higher values for r_g. In the first case, higher leverage amplifies the negative response of investment to changes in r_g due to a *debt overhang* effect. While for the latter, higher maturity attenuates the negative response of investment to default risk because lower rollover risk makes default next period less likely.

Finally, the second element $\left(1 - q_L'(\ell', m')\right)$ will be of particular importance for high-leverage firms. In this case, *debt overhang* will be intensified by *rollover risk* as higher maturity could impact not only the probability of default in the next period but also in the near future. In particular, increasing maturity could make *debt overhang* more detrimental for $q_L'(\ell', m')$ as rollover risk makes at high-leverage levels makes default more likely in all periods ahead.

Each element of (21) discussed earlier is part of the narrative we use to explain and illustrate the empirical results obtained earlier. First, our model predicts that it will reduce firm investment. Second, the response of investment will differ depending on a firm's capital structure. Third, consistent with our empirical results, investment of high leverage firms will always be more sensitive to changes in default risk due to the amplification effect of *debt overhang* on investment. Fourth, our model predicts that at relatively lower levels of leverage, increasing maturity attenuates the negative response of investment to default risk due to a *rollover risk* effect.

Lastly, for highly indebted firms, our model predictions are undetermined. However, the empirical results are still consistent with some scenarios predicted by our model. In particular, we found that higher maturity can be detrimental for firms with high leverage. This result can be generated by our model in case higher maturity at high levels of debt strengthens the negative effect of debt overhang, which in turn produces an increase in the probability of default for the firm in all future periods. Therefore, investment should reduce by more after default risk shock if high leverage firms increase their maturity leverage. On the other hand, we also found that higher maturity for low leverage firms attenuates the negative response of investment to default risk shocks. This again is consistent with higher maturity reducing the probability of firm default in the next due to the lower rollover risk effect. Furthermore, as firms are not highly indebted, rollover risk effects interact with *debt overhang* in the opposite direction as in the previous case.

6. Conclusions

The maturity and leverage decisions of the firm define its capital structure. If financial frictions are present, the capital structure will have a non-trivial role in the future investment plans of the firm. The paper studied how the capital structure can affect the response of investment to aggregate financial shocks, particularly in shocks to the sovereign spread. Using firm-level data for Italy during 2007-2015, we show that the higher levels of default risk reduce firm-level investment.

Moreover, we show that the response of firms' investment to changes in the default risk differs depending on the choices of leverage and maturity made by the firm. In particular, we find that firms with high leverage and maturity are the most sensitive to default risk, while firms with low leverage and high maturity are the least sensitive to changes in default risk. On the other hand, capital structure changes significantly affect investment response to default risk. In particular, higher leverage always amplifies the negative response of investment during a sovereign debt crisis, especially for firms with high maturity. In contrast, higher maturity seems to shield investment for firms with low leverage but is detrimental for firms with high leverage.

We build a partial equilibrium model of investment, capital structure, and default risk. The stylized model includes short-term and long-term debt, risky due to limited commitment problems on the firm size. The firm is affected by personal productivity and fixed costs shocks. Lenders are perfectly competitive and price new debt issuances using all relevant information about firms' decisions. Lenders discount future benefits using the interest rate of government bonds. In this model, default risk will be captured by exogenous changes in the interest rate for government bonds, used by lenders to discount future profits.

The characterization in the model serves to illustrate, motivate and provide some insights into the empirical setup presented earlier. In particular, our model shows that leverage and maturity induce heterogeneity in investment response to changes in sovereign spread through its effect on the marginal cost of an additional investment unit.

Moreover, the model can qualitatively capture the main empirical results obtained with firm-level Italian data. In particular, the model shows that *debt overhang* effect of leverage amplifies the negative response of investment. In contrast, higher maturity attenuates the negative effect of investment to default risk due to lower *rollover risk* for low-leverage firms. Finally, for high-leverage firms, the detrimental effect of higher maturity can be caused because lower rollover risk strengthens debt overhang as the probability of default for firms increases for several periods in the future. Therefore, increasing maturity for highly indebted firms raises the sensitivity of investment to default risk because the price of long-term debt in the future decline significantly, causing a significant jump in the marginal cost of investment.

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Appendix

A Competitive Equilibrium

Definition 2 (Recursive Competitive Equilibrium): *A recursive partial equilibrium for this economy will be defined a value function $v_c(\ell,m)$, policy functions $\{\mathbf{V}(x,f,s),\mathbf{V}_c(x,f,s)\}$, policy functions $\{i(\ell,m),\ell'(\ell,m),m'(\ell,m)\}$, price functions $\{q_S(\ell',m'),q_L(\ell',m')\}$ and cut-off rule $z^*(\ell',m')$ such that:*

- *Given $\{q_S(\ell',m'),q_L(\ell',m')\}$ and $z^*(\ell',m')$*

  1. *The value function $v_c(\ell,m)$ satisfies (14).*
  2. *The default policy $d^f(\ell',m')$ satisfies (10)*
  3. *The optimal policy for investment $i(\ell,m)$ and capital structure $\{\ell'(\ell,m),m'(\ell,m)\}$ are the solution from the continuation stage problem for firms in (14).*

- *Given $v_c(\ell,m)$ and $\{i(\ell,m),\ell'(\ell,m),m'(\ell,m)\}$, the pricing functions $\{q_S(\ell',m'),q_L(\ell',m')\}$ satisfy (16)), and (17), respectively.*

B Proofs Propositions

Proof Proposition 1 Using (11) and solving for $\widetilde{\mathbf{V}}_c$:

$$\widetilde{\mathbf{V}}_c(k,b,m) = (1-m)b + \lambda m b - z^* k +$$

Then for $\theta > 0$ be a constant

$$\widetilde{\mathbf{V}}_c(\theta k,\theta b,m) = \theta\Big((1-m)b + \lambda m b - z^* k\Big) = \theta\widetilde{\mathbf{V}}_c(k,b,m) \textbf{ QED.}$$

Proof Proposition 2 Using the continuation value function in (14), we can obtain optimality conditions for investment, leverage and maturity.

The first order condition for investment is presented below:

$$\{i\}: \; q_S(1-m')\ell' + q_L m'\ell' - 1 + \beta \int_{z^{*\prime}}^{\bar{\bar{z}}} \Big(z' - (1-m')\ell' - m'\ell' + v_c(\ell',m')\Big) d\Phi(z') \tag{1}$$

Rearranging terms in (1) we obtain (18). On the other hand, the first order condition for leverage:

$$\begin{aligned}\frac{\partial q_S}{\partial \ell'}(1-m')\ell' g(i) + q_S(1-m')g(i) + \frac{\partial q_L}{\partial \ell'}\Big(m'\ell' g(i) - (1-\lambda)m\ell\Big) + q_L m' g(i) \\ +g(i)\beta\Bigg[\Big(1-(1-\lambda)m' - \tfrac{\partial v_c(\ell',m')}{\partial \ell'}\Big)\Big(1-\Phi(z^{*\prime})\Big) \\ -\phi(z^{*\prime})\tfrac{\partial z^*(\ell',m')}{\partial \ell'}\Big(-z^{*\prime} + (1-m')\ell' + \lambda m'\ell' - v_c(\ell',m')\Big)\Bigg] = 0\end{aligned} \tag{2}$$

Notice that we can replace (5) on the second line. Additionally, using (15) to cancel out the term in the third line. Regrouping and rearranging the terms in (2) we arrive to equation (19). Finally, for maturity, the first order condition will be:

$$\begin{aligned}\frac{\partial q_S}{\partial m'}(1-m')\ell' g(i) + -q_S\ell' g(i) + \frac{\partial q_L}{\partial m'}\Big(m'\ell' g(i) - (1-\lambda)m\ell\Big) + q_L\ell' g(i) \\ +g(i)\beta\Bigg[-\Big((1-\lambda) + \tfrac{\partial v_c(\ell',m')}{\partial m'}\Big)\Big(1-\Phi(z^{*\prime})\Big) \\ +\phi(z^{*\prime})\tfrac{\partial z^*(\ell',m')}{\partial \ell'}\Big(-z^{*\prime} + (1-m')\ell' + \lambda m'\ell' - v_c(\ell',m')\Big)\Bigg] = 0\end{aligned} \tag{3}$$

Using the same arguments as with the first order condition for ℓ' and rearranging terms in (3) we will obtain (20)**QED**.

Proof Proposition 3 We focus on the effect of ℓ' and m' on $z^*(\ell', m')$ to show how default probabilities change. Then partially differentiating the cut-off productivity in (15) with respect to ℓ':

$$\frac{\partial z^*(\ell', m')}{\partial \ell'} = 1 - m'(1-\lambda) - \frac{\partial v_c}{\partial \ell'} \tag{4}$$

Using the continuation value in (14) to find $\partial v_c / \partial \ell'$ and replacing it in previous expression.

$$\frac{\partial z^*(\ell', m')}{\partial \ell'} = 1 - (1-\lambda)(1-q'_L)m' \tag{5}$$

Notice for (5) $(1-\lambda)(1-q'_L)m' < 1$ therefore $^*(\ell', m')/\partial \ell' > 0$, meaning that an increase in ell' increase the probability of default. The same procedure can be applied for m'. In this case, we obtain:

$$\frac{^*(\ell', m')}{\partial m'} = -(1-\lambda)(1-q'_L)l' \tag{6}$$

is negative, then the firm's probability of default reduces with m' **QED**.