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Corporate debt and investment: a firm level analysis for stressed euro area countries

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Abstract

This paper investigates the link between corporate debt and investment for a group of five peripheral euro area countries. Using firm-level data from 2005-2014, we postulate a non-linear corporate leverage-investment relationship and derive thresholds beyond which leverage has a negative and significant impact on investment. The investment sensitivity of debt increased after 2008 when financial distress intensified and firms had a lower capacity to finance investment from internal sources of funds. Our results also suggest that even moderate levels of debt can exert a negative influence on investment for smaller firms or when profitability is low.

JEL Classification: E22, F34, G31, G32

Keywords: Corporate debt, leverage, debt overhang, investment, threshold model

Non-Technical Summary

This paper investigates the relationship between corporate debt and investment. It uses firm-level data for five peripheral euro area countries (Italy, Spain, Greece, Portugal, and Slovenia) over the 2005-2014 period and explicitly accounts for non-linearities in the debt-investment link. Our paper builds on the existing literature which finds evidence that high debt distorts investment due to higher default risks and higher costs of financing, while low leverage levels do not negatively affect investment. One concern of this literature is that the threshold between high and low leverage has often been set exogenously and in an ad-hoc manner. In contrast, our empirical approach allows us to endogenously estimate debt thresholds.

Our estimations suggest that there are significant non-linearities in the debt-investment link: We identify leverage thresholds in the range of a debt-to-asset ratio of 80-85 percent. For firms with a leverage ratio above this threshold, we find strong evidence consistent with debt holding back investment.

The impact of leverage on investment is economically meaningful. In normal periods, the negative investment effect materialises only for high levels of debt. A firm with a debt-to-asset ratio of 90 percent (i.e. an overleveraged firm) has, ceteris paribus, 0.7 percentage point of forgone investment per year compared with a firm with a debt-to-asset ratio of 80 percent. For certain periods and subsamples the investment effects are, however, also significant for lower levels of debt. For example, during the post-2008 period, a firm with a debt-to-asset ratio of 30 percent had additional annual investment of 1.4 percentage points compared with a firm with a debt ratio of 60 percent, and 2.4 percentage points compared with a firm with a debt ratio of 80 percent.

Both the leverage threshold and the investment-dampening impact of high leverage are robust across various specifications. In particular, for highly leveraged firms we find a negative debt-investment relationship in all major sectors and for both profitable and unprofitable firms. There is, however, evidence for some heterogeneity across firm size. The negative investment impact of high debt is observed for micro, small and medium-sized firms (which amount to 99 percent of firms in our sample), but not for large firms. This suggests that financial constraints related to a debt overhang play a less important role for large firms.

For firms with debt levels below the threshold, the relationship between debt and investment is less robust and depends on a number of firm characteristics and the macroeconomic environ-

ment. While our full-sample estimation suggests a slight (and insignificant) positive effect of debt on investment, during the financial crisis period even low debt seems to constitute a drag on investment, though the negative investment effect is still smaller than for high-debt firms. Similarly, for smaller and less productive firms, even low levels of debt have a negative impact on investment.

Overall, these results suggest still substantial deleveraging needs in peripheral countries to support a stronger investment recovery. The economic environment in peripheral countries is characterised by a large number of small firms, low productivity and still relatively high financial uncertainty – factors which reduce the capacity to tolerate high levels of debt and lead to a more negative debt-investment relationship. Moreover, our results show that a debt overhang is not only reflected in a high stock of debt but also in a low capacity to service the debt (as measured by the EBITDA-to-debt ratio and the interest expenses-to-EBITDA ratio), which implies that even firms with a debt-to-asset ratio below the identified threshold may be in need of deleveraging if they face high debt service obligations.

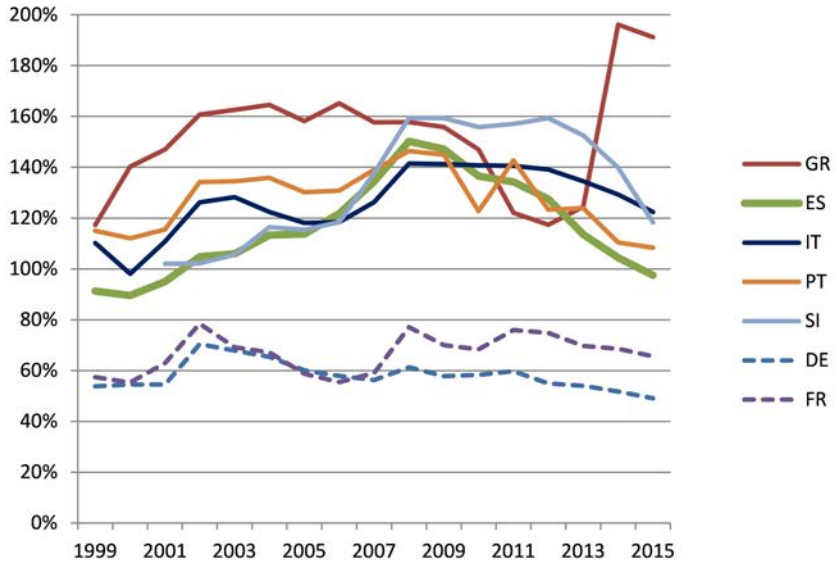
1 Introduction

Corporate debt increased rapidly in many peripheral euro area countries in the years preceding the financial crisis (Figure 1). The build-up of debt was largely driven by easy access to credit and coincided with strong increases in investment (Figure 2), but did little to create conditions for sustainable growth. As the financial crisis unfolded, a legacy of high debt remained on corporate balance sheets, rendering firms vulnerable to the shift in risk sentiment and the fall in asset prices and profits .

This paper builds on these considerations and investigates the link between indebtedness and investment at the firm level. In particular, we highlight the non-linear aspect of this relationship. The literature on corporate finance identifies both potentially positive and negative effects of debt on investment. On the positive side, debt financing may give rise to tax advantages compared to alternative forms of financing (Modigliani and Miller, 1963), and it can reduce agency costs between managers and shareholders (Ross, 1977; Grossman and Hart, 1982). On the negative side, high corporate indebtedness implies higher interest expenses and thus lowers funds available for investment. Firms with high debt also find it harder to obtain new funds from external finance sources due to higher default risk when only a small share of assets is financed with equity. The desire to repair weak balance sheets to lower external finance costs leads firms to increase savings and to forgo otherwise possibly profitable investment opportunities (Myers, 1977). In combination, these factors suggest a non-linear relationship between debt and investment, with debt levels below a certain threshold – if at all – positively affecting investment to the extent that the costs of holding debt are lower than marginal returns from further investment. However, high debt levels on firms' balance sheets presumably exert a negative effect on investment, as costs associated with high debt holdings increase significantly and thus reduce marginal returns on investment. Many economists have thus pointed out that corporate indebtedness in euro area countries inhibits investment spending and economic recovery whenever debt levels are "excessively" high (see e.g. Cecchetti et al., 2011; ECB, 2013; Kalemli-Özcan et al., 2015a).

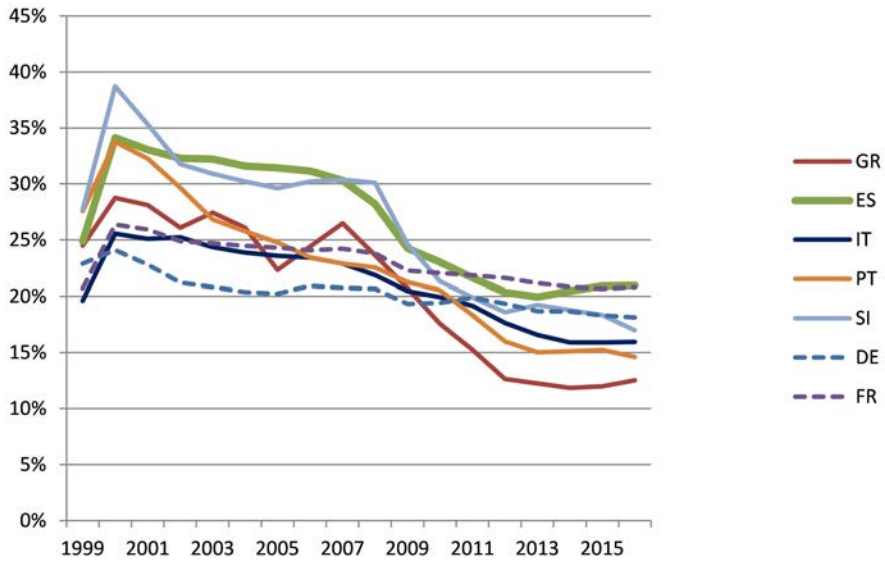
In our empirical approach, we exploit a large-scale panel data set to identify empirical threshold levels of leverage beyond which debt holdings pose a drag on corporate investment activity. Such estimated thresholds could be interpreted as midpoints of "vulnerability regions" around the estimated debt cut-off level (Reinhart and Rogoff, 2010) beyond which the structural relation

Figure 1: NFC debt, in percent of financial assets



Source: Eurostat.

Figure 2: Gross fixed capital formation, in percent of GDP



Source: Eurostat.

between debt and investment changes.[1] Our sample includes more than three million firm-year observations for five peripheral euro area countries (Italy, Spain, Greece, Portugal and Slovenia) over the 2005-2014 period. The choice of countries is motivated by data coverage and the strong increase in corporate indebtedness in these five countries during the pre-crisis period.[2] We explain firms' investment decision by leverage while controlling for other firm, sector, and macroeconomic characteristics.

In contrast to national account data, firm-level data provide added value to the analysis of the debt-investment nexus for the following reasons (ECB, 2013): First, the impact of debt on investment depends not on the aggregate leverage ratio of the corporate sector, but is subject to the distribution of debt across firms. This implies that if there are non-linearities in the debt-investment nexus, the analysis of national account data may not be possible due to aggregation bias. More precisely, if there are leverage thresholds, combined total investment of a high- and a low-indebted firm is different than the total investment in the case where the same level of debt is split equally across the two firms. Second, firm-level data allows for more specific statements regarding the required deleveraging needs, by taking into account additional firm characteristics (such as firm profitability) and evaluating their role in firms' investment decisions. Third, in particular for smaller and more open economies, macro data are often influenced by a few internationally exposed larger firms, while information on the large number of small firms is hidden. Firm-level data also adequately cover leverage and investment decisions of small firms and can thus provide a more representative picture of the heterogeneity of firms in the economy.

Whereas the notion of debt overhang is justified by theoretical work on corporate finances, there is no single, commonly agreed method to measure over-indebtedness and the size of deleveraging needs.[3] In our empirical analysis, we distinguish between two debt overhang concepts: a) the *leverage ratio*, which we define as the stock of debt in relation to firms' assets and for which we hypothesize negative effects on investment above a certain leverage threshold due to the higher costs of financing amid rising default risk; and b) *debt service obligations*, a con-

[1] As Reinhart and Rogoff (2010) put it in the context of their analysis on public debt and GDP growth: "We do not pretend to argue that growth will be normal at 89 percent and subpar ... at 91 percent debt/GDP any more than a car crash is unlikely at 54mph and near certain at 56mph. However, mapping the theoretical notion of 'vulnerability regions' to bad outcomes by necessity involves defining thresholds, just as traffic signs in the US specify 55mph."

[2] Insufficient availability of data prevented us from including further peripheral euro area countries such as Ireland and Cyprus.

[3] See Consolo et al. (2017), Cuerpo et al. (2013), and Bornhorst and Ruiz-Arranz (2015) for approaches put forward by the ECB, the European Commission, and the IMF, respectively.

cept emphasising liquidity risk and the capacity to serve outstanding debt with current income streams. For the latter, we assume a linear negative effect on investment, as, ceteris paribus, higher liquidity risk should dampen investment activity, independent from the current levels of debt holdings. We define liquidity risk in terms of the EBITDA-to-debt and the interest expenses-to-EBITDA ratio, where EBITDA stands for earnings before interest, taxes, depreciation and amortisation. In most of our specifications, we include both the leverage ratio and the debt service obligations to control for different aspects of the debt-investment link (see also Coluzzi et al., 2015; Kalemli-Özcan et al., 2015a or Antonecchia and Ferrari, 2016).

Our paper adds to the empirical literature on non-linear effects of corporate debt on investment (see, e.g., Jäger, 2003; Goretti and Souto, 2013). Leverage thresholds in these studies are typically determined in an exogenous and ad-hoc manner, instead of being derived from statistical inference. To the best of our knowledge, this study is the first to provide econometric evidence on the link between corporate indebtedness and investment in peripheral euro area countries by using panel threshold regression techniques (Hansen, 1999, 2000). We show that results are sensitive to the identified thresholds and that ad-hoc threshold specifications can lead to inconclusive results. With our model, we take an agnostic approach without any priors on potential thresholds and estimate threshold candidates directly from the data.

We find evidence of a non-linear relationship between leverage and investment. For highly indebted firms, i.e. firms above a debt-to-asset ratio of 80-85 percent (which account for 10 to 15 percent of our observations), we find a significantly negative leverage-investment link, suggesting that firms with weak balance sheets forgo some valuable investment opportunities. By contrast, leverage does not seem to depress investment for moderately indebted corporates implying a lower degree of financial constraints for these firms. However, for the financial crisis period, we find a negative effect of low debt on investment, suggesting that the capacity to tolerate even low levels of debt is negatively affected by stronger financial constraints and higher risk aversion. On top of the leverage channel of investment, we also identify an independent debt service channel, suggesting that not only the strength of the balance sheet but also the ratio of earnings relative to interest payments and amortisations has an impact on investment.

The remainder of the paper is organised as follows. Section 2 reviews the related empirical and theoretical literature. Section 3 provides some illustration of the data, followed by a description of the econometric model in section 4. In section 5, we report results of the baseline model estimations on the debt-investment nexus and then provide evidence on structural differences

according to firm size, sector, and profitability. Section 6 presents robustness tests, including an instrumental variable approach based on dynamic panel estimations. We conclude in section 7.

2 Related Literature

On the theoretical side, our study is linked to the branch of the finance literature investigating the determinants of corporate balance sheets and the link between corporate finance and investment. This literature has shown that, in the presence of financial market frictions, the Modigliani and Miller (1958) theorem does not hold and firms' net worth, largely determined by investment decisions, depends on their financial structure.

According to the trade-off theory of capital structure, firms set a target leverage ratio by balancing the costs and benefits of debt. The benefits of debt include, inter alia, the tax deductibility of interest (Modigliani and Miller, 1963), the disciplining effect of debt in case of agency problems between firm managers and shareholders (Jensen and Meckling, 1976; Grossman and Hart, 1982), and the signalling role of debt regarding firm productivity, for instance if managers possess inside information about the future productivity gains of the firm (Leland and Pyle, 1977; Ross, 1977). The costs of debt relate to potential bankruptcy costs. Increasing debt holdings compared to equity raises default probabilities as the fraction of asset holdings backed by equity is decreasing. Higher default probabilities lead to financial distress, which is reflected in higher external financing premia or the rationing of credit (Myers, 1977; Stiglitz and Weiss, 1981).

The key implication of the trade-off paradigm is that firms decide on an optimal leverage ratio that solves the trade-off.[4] If their actual financial structure deviates from the targeted leverage (e.g. due to shocks to firm value), balance sheet restructuring aims at gradually moving actual leverage back to target. A firm with a leverage ratio below the target will therefore follow a different investment decision rule than one with high leverage. While low-leveraged firms face low financial constraints and can draw on "reserves of untapped borrowing power" (Modigliani and Miller, 1963) if profitable investment opportunities arise, high-debt firms are more concerned about default risks and their financial status (e.g., due to the risk of losing investment grade status). They will focus on restoring leverage targets and may give up valuable investment opportunities when internal sources of funds are not sufficient (Myers, 1984), especially in times

[4]For survey studies on corporate debt targets and financing structures see for instance Graham and Harvey (2001), Bancel and Mittoo (2004), or Brounen et al. (2004).

of heightened uncertainty and financial distress.[5] In our empirical analysis, we therefore expect a non-linear debt-investment relation for firms operating below and above a leverage target or threshold.

The leverage target is influenced by several factors that have an impact on the costs and benefits of debt financing. For example, firms with a lower probability of being distressed, such as profitable or large (more diversified) firms, can be expected to be able to borrow more before the expected costs of financial distress offset the benefits of debt. Moreover, changes in general risk sentiment may impact on the leverage target through both the supply of and demand for funds (see e.g. Amador and Nagengast, 2016; Buca and Vermeulen, 2017; Cingano et al., 2016; Storz et al., 2017). We will come back to these aspects in the empirical section.

A number of empirical studies find evidence that high corporate leverage can have negative effects on investment (Vermeulen, 2002; Benito and Hernando, 2007; Martinez-Carrascal and Ferrando, 2008; Pal and Ferrando, 2010; Kalemli-Özcan et al., 2015a; Barbiero et al., 2016). These studies typically find that the investment impact of high corporate indebtedness is not uniform. Using industry level data, Vermeulen (2002) shows that leverage is more important in explaining investment during downturns and for small firms. Barbosa et al. (2007) find for Portuguese firms that the impact of corporate indebtedness on investment depends on firm size, the number of bank lending relationships, and credit default history. In contrast to Vermeulen (2002), they do not find different sensitivities of investment to debt between economic booms and busts.

In line with the trade-off theory, some studies have also argued that low leverage levels do not negatively impact on investment but that there is a threshold level of corporate debt beyond which leverage and investment are negatively associated. Using flow of funds data for the US and Germany, Jäger (2003) finds that the negative impact of corporate indebtedness on investment is stronger in years of above-average debt holdings than in years of below-average leverage. Hernando and Martinez-Carrascal (2008) provide firm-level evidence on threshold effects; their results for Spanish firms indicate that a negative impact of indebtedness on investment is only present for firms with high financial pressure, i.e. for firms above the 75^{th} percentile of indebtedness. This threshold is above the one identified by Goretti and Souto (2013) who find strongly negative effects of debt on investment once the debt to equity threshold exceeds the

[5] Bernanke et al. (1999) show that the sequence of events between firm net worth, collateral and investment can lead to larger and more persistent cyclical fluctuations in the economy ("financial accelerator mechanism").

25^{th} percentile of the firms in their sample of euro area firms. While these studies have assumed potential debt thresholds rather arbitrarily, Ferrando et al. (2017) estimate a leverage equation from which they calculate the target level of debt. They show that firms with a conservative leverage policy (defined by a negative deviation between the actual level of leverage and the target leverage) invest more in the years following the conservative financial policy.

We add to the literature by conducting threshold analyses applying the method by Hansen (1999, 2000) to a large firm level data set and analysing the investment sensitivity of leverage above and beyond these thresholds. The study coming closest to our approach in terms of method is Coricelli et al. (2012) who apply the panel threshold model by Hansen (1999) to a subsample of Orbis data for Eastern European countries. In their study, they focus on the effect of firm leverage on productivity and leave corporate investment aside.

3 Data

We rely on Bureau van Dijk's Amadeus database, which reports information on a large set of European nonfinancial corporates. Our dataset includes both listed and unlisted companies and contains information on financial data of about 920 thousand firms operating in five peripheral euro area countries (Italy, Spain, Portugal, Greece and Slovenia) for the 2005-2014 period. We pursue a standard cleaning procedure to account for data irregularities (Kalemli-Özcan et al., 2015b). In particular, we take care of double entries, firm-year observations with inconsistent balance sheet or income statement relations, including those with negative debt or asset holdings. Whenever available, we use consolidated annual accounts to account for potential cross-funding of investment activity among firms with subsidiaries. We furthermore exclude firms operating in specific sectors such as agriculture and mining, insurance services, public administration, as well as financial firms given their specific leverage characteristics. Furthermore, only firms with at least three consecutive years of reporting in the data set are included. Finally, we apply a trimming on all variables at the 1^{st} and 99^{th} percentile of the distribution to remove outliers.[6] Our final panel consists of 618 thousand firms and three million firm-year observations and includes firms from fifteen NACE sectors, with most firms operating in manufacturing, wholesale and retail trade, real estate and construction services, as well as food and accommodation services.

[6] This implies a maximum debt-to-asset ratio of 3.1. We also performed sensitivity tests with a threshold for the debt-asset ratio of 1.0, without implications for the main results.

Our key variables of interest are investment and leverage. We use both net and gross investment since they capture different dimensions of the debt-investment nexus. Net investment (defined as the annual percentage change in tangible fixed assets) is more relevant from a policy point of view given its close link to an economy's level of productivity (Kalemli-Özcan et al., 2015a). Gross investment (net investment plus depreciation) has a stronger theoretical motivation since financial constraints should affect both investment that replaces depreciated assets and new investment (Ferrando et al., 2017). We therefore show results both for net and gross investment. In our baseline regression, we define leverage as debt holdings relative to total assets, with debt including financial debt (loans and bonds) plus other current financial liabilities (mainly pension liabilities and accounts payable). We exclude trade credit as it typically serves for transaction purposes and not for financing. Tables 1 and 2 present the definitions and descriptive statistics of all variables, including our control variables. Note that all variables are expressed in real terms. Overall, there is significant heterogeneity in the variables of interest across firms. While the mean firm in our sample has a net investment rate of 12 percent, the median firms net investment rate is a negative six percent. On average, firms had debt holdings of about 48 percent of their assets. The firms in the highest decile of debt holdings reported 86 percent of debt relative to assets.

Table 1: Firm variable definition

Variable	**Definition**
Investment (net)	Annual change in net total fixed assets (in %)
Investment (gross)	Annual change in net total fixed assets plus depreciation (in %)
Leverage	Ratio of financial debt to total assets, with financial debt including loans, securities and other current liabilities.
Debt service capacity	Ratio of earnings before interest, taxes, depreciation and amortisations (EBITDA) to financial debt (defined as above)
Interest burden	Ratio of interest payments to earnings before interest, taxes, depreciation and amortisations (EBITDA)
Profitability	Ratio of earnings before interest, taxes, depreciation and amortisations (EBITDA) to total assets
Tangibility	Tangible fixed assets divided by total assets
Sales growth	Annual growth rate of sales
Size	Natural log of assets

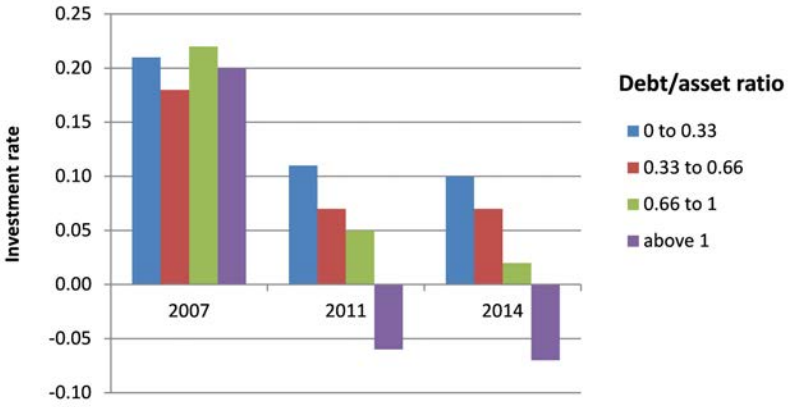
Table 2: Descriptive Statistics

	Total N = 3,006,374				
	Mean	*SD*	*p10*	*Median*	*p90*
Net Investment	0.12	1.09	-0.34	-0.06	0.46
Gross Investment	0.51	1.56	-0.01	0.09	1.12
Debt/Assets	0.48	0.3	0.12	0.45	0.86
ΔDebt/Assets	-0.01	0.16	-0.16	-0.01	0.14
EBITDA/Debt	0.37	0.73	-0.02	0.17	0.95
Interest Burden	0.18	0.43	-0.01	0.12	0.56
EBITDA/Assets	0.09	0.11	-0.01	0.07	0.21
Sales Growth	0.11	0.75	-0.32	0	0.47
Log(Assets)	13.58	1.45	11.76	13.51	15.55

	Pre-Crisis Period (2005-2008) N = 590,224					**Post-Crisis Period (2009-2014) N = 2,416,150**				
	Mean	*SD*	*p10*	*Median*	*p90*	*Mean*	*SD*	*p10*	*Median*	*p90*
Net Investment	0.34	1.46	-0.31	-0.04	1.09	0.06	0.97	-0.35	-0.06	0.32
Gross Investment	0.77	1.93	-0.01	0.21	1.85	0.45	1.45	-0.01	0.07	0.98
Debt/Assets	0.53	0.29	0.15	0.52	0.91	0.47	0.3	0.11	0.44	0.84
ΔDebt/Assets	-0.01	0.15	-0.14	-0.01	0.13	-0.01	0.16	-0.17	-0.01	0.15
EBITDA/Debt	0.38	0.66	0.03	0.19	0.89	0.37	0.74	-0.04	0.17	0.96
Interest Burden	0.2	0.39	0.01	0.142	0.54	0.18	0.44	-0.04	0.12	0.56
EBITDA/Assets	0.11	0.11	0.02	0.09	0.23	0.08	0.12	-0.02	0.07	0.2
Sales Growth	0.18	0.71	-0.21	0.05	0.54	0.1	0.75	-0.34	-0.02	0.45
Log(Assets)	13.78	1.38	12.04	13.71	15.67	13.53	1.46	11.7	13.46	15.51

Note: All variables are expressed in real terms (using the GDP deflator) and trimmed at the 1st and 99th percentile of the distribution (including net investment). The sample composition is only slightly different when the trimming procedure is applied with respect to gross rather than net investment. N is number of observations. EBITDA is earnings before interest, taxes, depreciations and amortisations.

Figure 3: Investment rate in 2007, 2011 and 2014,by leverage group



Source: Amadeus, own calculations.

We also report descriptive statistics for the periods before and after the outbreak of the global financial crisis in 2008.[7] Firms in our sample reported a substantially higher investment activity prior to the global financial crisis, with average net investment rates dropping from 34 percent in the pre-crisis years to only six percent thereafter. However, high average investment rates in the pre-crisis period appear to be driven by a subgroup of strongly investing firms, as the median investment rate is much lower. Even more, the collapse in investment rates after the outbreak of the financial crisis appears to be strongest for the formerly high-investment firms, as the median investment rate does not change significantly between the two periods. The substantial drop in investment is furthermore associated with a slight reduction in debt-to-asset ratios. However, as asset values dropped due to revaluations, the reduction in absolute debt holdings has been stronger in relative terms.

To elaborate further on the change in debt-investment behaviour over time, Figure 3 shows the net investment rate in 2007, 2011 and 2014 by leverage group. On the eve of the financial crisis there have not been strong differences in investment between high and low leveraged firms. However, during the crisis years, high-leveraged firms invested significantly less than their low-leveraged peers. This provides a first indication that leverage became more of a constraint for investment when risk aversion and financial uncertainty increased.

[7] We define the post-crisis period from 2009 onwards, as we expect potential changes in firm financing and investment decisions to be initiated shortly after the collapse of global financial markets. We also evaluated descriptive statistics with 2010 as the first crisis year, indicating the start of the European sovereign debt crisis. The main conclusions did not change by shifting the break point in such a way.

4 Estimation Design

To identify non-linearities in the relationship between corporate debt and investment activity, we estimate panel threshold regression models following Hansen (1999, 2000). These models allow for an endogenous identification of threshold levels that split the sample in two regimes for which the linear relationship between the dependent variable and one or more variables of interest is expected to differ. Furthermore, the procedure tests for the significance of the identified thresholds, relying on confidence intervals, derived with appropriately designed likelihood-ratio tests (Hansen, 1999, 2000).

Specifically, we estimate the following threshold model for different subsets of the data:

$$I_{it} = \beta_1 D_{it-1} I(D_{it-1} \leq \gamma) + \beta_2 D_{it-1} I(D_{it-1} > \gamma) + \phi z_{it-1} + \delta_1 I(D_{it-1} \leq \gamma) + \varepsilon_{it} \qquad (1)$$

with I_{it} referring to either net or gross investment, as defined above. The leverage measure D_{it} denotes the indicator variable for which the regime-separating threshold γ is estimated. Based on our theoretical motivation, we use the leverage ratio as both the regime-indicating variable and the regime-dependent regressor. The impact of leverage on investment is represented by the slope coefficients β_1 and β_2 which are allowed to differ in the two regimes. To do so, we interact D_{it} with the values of the binary indicator function $I(\bullet)$ for whether a firm has a debt-to-asset ratio above or below the estimated threshold in a certain year.

We add a vector of covariates z_{it} that includes lagged values of the debt servicing capacity ($\text{EBITDA}_{it}/\text{debt}_{it}$), the interest burden ($\text{interest expenses}_{it}/\text{EBITDA}_{it}$) to control for debt service obligations, profitability ($\text{EBITDA}_{it}/\text{assets}_{it}$), sales growth, the change in leverage, firm size (defined as the natural logarithm of total assets), and the share of tangible assets in total assets (Table 1).[8] We furthermore include controls for country-, sector-, and year-fixed effects to account for potential correlation between country- or sector-specific characteristics and regressors, and to take macroeconomic factors into account. In addition, we follow Bick (2010) and Kremer et al. (2013) in including a regime-specific intercept term (δ_1).[9] We assume the errors ε_{it} to be independent and identically distributed[10] and lag all right-hand-side variables by one

[8] See Kalemli-Özcan et al. (2015a), Goretti and Souto (2013), or Coricelli et al. (2012) for a discussion of firm-level control variables usually used in investment and productivity regression models.

[9] As Bick (2010) and Kremer et al. (2013) show, not controlling for differences in the intercept terms estimated for both regimes can cause estimation bias in both the slope coefficients and, as a consequence, the threshold.

[10] However, we allow for potential heteroscedasticity in the errors ε_{it} in the estimation of the slope coefficients conditional on the identified threshold by using clustered-robust standard errors for the estimation of slope

period to avoid endogeneity issues. We will discuss potential endogeneity concerns further in Section 6.

As regards the identification of the debt threshold, we follow Hansen (1999) and first estimate equation 1 over an array of threshold candidates. The selected threshold is then defined by the minimum of the resulting concentrated sum of squared errors function $S_n(\gamma)$. As the sum of squared errors depends on the threshold estimate only via the indicator function $I(\bullet)$, $S_n(\gamma)$ is not a linear but a step function, with steps occurring at distinct values of γ. For a given threshold candidate, however, $S_n(\gamma)$ becomes linear in the regression coefficients β_1, β_2, δ_1 and ϕ, whose estimated values in turn ultimately depend on the threshold estimate. Theoretically, the sample provides the full range of

$$\sum_{n=1}^{N} T_i$$

threshold candidates. However, to reduce the computational burden, we follow Hansen (1999) and others in solving the minimization problem by a grid search over 393 leverage ratio quantiles {1%, 1.25%, 1.50%,..., 98.75%, 99%}.[11]

After having derived the threshold estimate, a confidence interval has to be determined to evaluate the statistical significance of the derived estimate. Following Hansen (1999, 2000), we use the derived confidence interval to test the null hypothesis:

$$H_0 : \gamma = \gamma_0$$

where γ_0 depicts the true underlying threshold value. However, standard likelihood ratio test procedures cannot directly be applied, since, as Hansen (2000) has shown, the asymptotic distribution of the likelihood ratio statistic $LR_n(\gamma)$ is non-standard. We derive 'no-rejection regions' by computing the empirical likelihood ratio function

$$LR_i = \frac{S_n(\gamma_i) - S_n(\hat{\gamma})}{\hat{\sigma}^2(\gamma_i)}, i \in [1, 393] \tag{2}$$

where $S_n(\hat{\gamma})$ depicts the estimated threshold derived from the minimization procedure. One can then identify the respective confidence intervals by comparing the discrete values of the likelihood ratio distribution to the critical values which are, in accordance with Hansen (1999),

coefficients in a second step, and report these standard errors in the regression tables.

[11] We define the respective quantiles after ensuring that neither of the two regime samples covers less than 5 percent of total observations (Hansen, 1999).

computed using the inverse of the distribution function for a determined confidence level α:

$$c(\alpha) = -2log(1 - \sqrt{1 - \alpha}) \tag{3}$$

5 Estimation Results

5.1 Baseline Specification

Table 3 reports our baseline results for estimations with either net or gross investment as the dependent variable. The leverage thresholds γ are broadly in the same range for different versions of our baseline regression, with a debt-to-asset ratio of 80-85 percent. In 11-14 percent of the observations over our sample period, firms were operating above the leverage threshold. These firms are therefore classified as excessively leveraged for the period they operate above the threshold.[12]

As postulated by the trade-off theory, leverage above the threshold is associated with a negative and significant effect on investment in the following year as indicated by the significantly negative slope coefficient β_2. Conversely, there is a positive and statistically insignificant effect of debt on investment if the leverage ratio is below the threshold (β_1). These results support the view that a firm's leverage ratio affects its investment in a non-linear way. While firms with moderate debt levels potentially make use of unused borrowing capacities to engage in further investment, debt holdings beyond the threshold depress investment activity. This non-linearity in the debt-investment link holds for both the net and gross investment specification.

These results are economically non-negligible. A firm with a debt-to-asset ratio of 90 percent (i.e. an overleveraged firm) has, ceteris paribus, 0.7 percentage point of forgone investment per year compared with a firm with a debt-to-asset ratio of 80 percent. There are also significant differences across countries. Assuming an 80 percent threshold, Spain and Portugal have the highest share of excessively leveraged firms (Figure 4). One-fifth of Spanish firms operated above the leverage threshold at the end of our sample period in 2014. Our analysis also suggests significant deleveraging needs for Portugal, with 13 percent of firms recording leverage above the threshold. Excessive leverage seems to be lower in Italy, Slovenia and Greece.

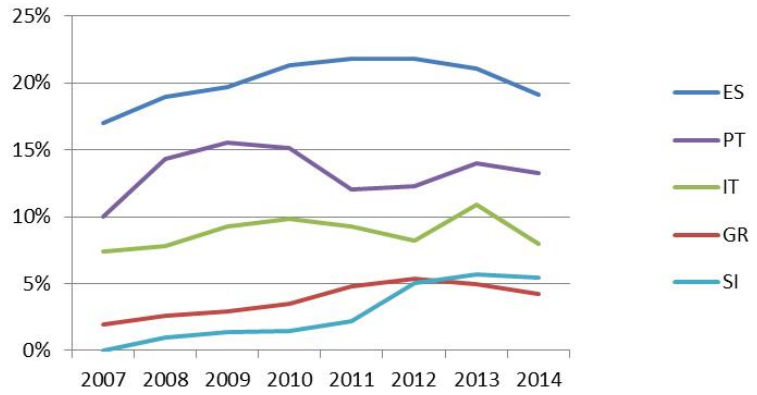
[12] Note that if a firm is above the leverage threshold, this is a sufficient but not a necessary condition for a firm to be excessively leveraged since excessive leverage may also be reflected in high debt servicing obligations.

Table 3: Add caption

	Net Investment			**Gross Investment**		
Threshold Estimate						
γ	0.852	0.803	0.803	0.813	0.813	0.813
95% Confidence Interval	(0.851 0.855)	(0.796 0.812)	(0.793 0.812)	(0.813 0.836)	(0.813 0.813)	(0.803 0.813)
Impact of Debt/Assets						
β_1 (Low-Debt Regime)	0.015	-0.034***	-0.036***	0.068	0.044	0.029
	(0.012)	(0.003)	(0.013)	(0.044)	(0.043)	(0.042)
β_2 (High-Debt Regime)	-0.143***	-0.109***	-0.108***	-0.086***	-0.080***	-0.072***
	(0.010)	(0.007)	(0.007)	(0.009)	(0.010)	(0.010)
Covariates						
EBITDA/Debt	0.014***	-	-	0.015***	-	-
	(0.002)			(0.005)		
Interest Rate Burden	-0.005***	-0.007***	-	-0.043***	-0.044***	-
	(0.002)	(0.001		(0.005)	(0.005)	
Sales Growth	0.062***	0.059***	0.059***	0.070***	0.070***	0.070***
	(0.010)	(0.001)	(0.009)	(0.013)	(0.013)	(0.013)
log(Assets)	-0.005**	-0.007***	-0.007**	-0.033***	-0.033***	-0.034***
	(0.003)	(0.000)	(0.004)	(0.009)	(0.009)	(0.009)
EBITDA/Assets	0.303***	0.301***	0.300***	0.553***	-0.600***	0.593***
	(0.047)	(0.006)	(0.046)	(0.056)	(0.067)	(0.062)
ΔDebt/Assets	0.012***	0.016***	0.017***	0.012	0.015	0.021*
	(0.005)	(0.004)	(0.004)	(0.014)	(0.013)	(0.012)
Tangibility	-0.456***	-0.450***	-0.450***	-1.469***	-1.469***	-1.469***
	(0.052)	(0.003)	(0.051)	(0.081)	(0.083)	(0.084)
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Regime-Dependent Intercept δ_1	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3.006.374	3.006.374	3.006.374	2.932.513	2.932.513	2.932.513
Percent of Obs. In Low-Debt Regime	89,31	85,87	85,87	86,78	86,78	86,78
Percent of Obs. In High-Debt Regime	10,69	14,13	14,13	13,22	13,22	13,22
No. Of Firms	618.174	618.174	618.174	605.589	605.589	605.589

Note: The threshold variable γ is the reported debt-to-asset ratio. Debt is defined as financial debt (short-and long-term loans plus other current financial liabilities). Net investment is defined as the annual percentage change in tangible fixed assets and gross investment as net investment plus depreciation. All independent variables are lagged by one period. Heteroskedasticity-robust standard errors of the covariates are reported in brackets. ***p-value < 0.01, **p-value < 0.05, *p-value < 0.1.

Figure 4: Share of firms above debt-to-asset ratio of 80 percent

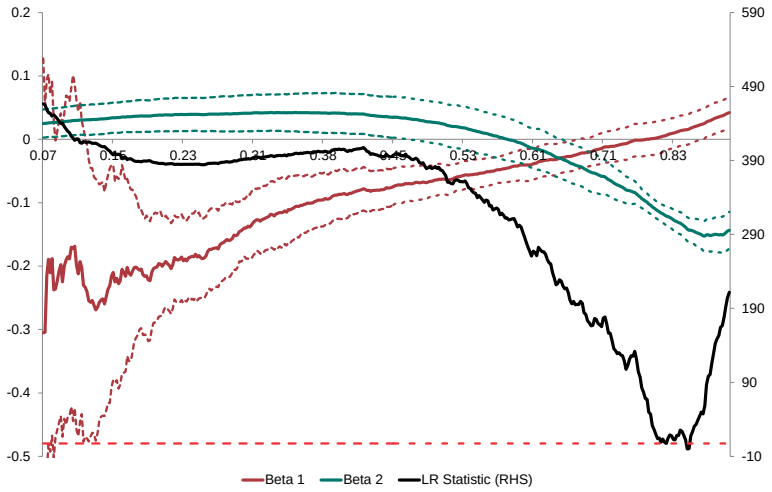


Source: Own estimations.

Our results also provide evidence for an independent debt-servicing channel. Low earnings relative to debt are negatively associated with investment activity, in line with the findings by Kalemli-Özcan et al. (2015a). To evaluate the degree of interdependence between the channels, we provide results for our baseline regression excluding the EBITDA-to-debt ratio (columns 2 and 5), and excluding the interest burden-to-EBITDA ratio (columns 3 and 6). Removing these variables hardly affects the debt-to-asset threshold, which remains slightly above 80 percent. The coefficient for the high-debt regime also remains strongly negative and significant, thereby confirming the negative sensitivity of firms' investment to high debt. The coefficient for the low-debt regime, however, decreases and even turns negative for the net investment equation. We take this finding as evidence that not controlling for the debt-servicing channel would imply underestimating the leverage channel of debt on investment.

Results for our additional explanatory variables are in line with expectations and previous empirical findings. An increase in sales revenues positively affects investment activity. The investment sensitivity with respect to profitability is significant and positive, suggesting that financial constraints play a role beyond the debt overhang effect. The negative coefficient on interest payments relative to earnings further reflects the importance of financial constraints for investment activity. Firm size is negatively associated with investment activity, potentially due to decreasing returns to scale (Gala and Brandon, 2016). When controlling for the stock of debt, an increase in leverage is positively related to investment, though not statistically significant in

Figure 5: Beta coefficients and likelihood ratio function of baseline model



The figure shows the estimated beta coefficients of the net investment baseline specification reported in column 1 of Table 3, as estimated for each of the potential 393 threshold candidates (primary axis). Furthermore, the respective likelihood-ratio statistic computed according to equation 2 are reported for each threshold candidate estimation. The critical value calculated according to equation 3 is also reported (red dashed line). Source: Own estimations.

all specifications.[13] Finally, tangible fixed assets enter negatively, indicating that firms' ability to pledge collateral did not lead to more investment. Again, these findings are robust to the use of net or gross investment as dependent variable.

For illustrative purposes, we evaluate for our baseline specification on net investment (column 1 in Table 3) the sensitivity of the high- and low-debt coefficients with respect to different thresholds. To do so, we plot the estimated coefficients β_1 and β_2, together with the respective confidence intervals, for the 393 quantiles of our debt-to-asset ratio in Figure 5.[14] We furthermore show the empirical likelihood ratio function of equation 2 and the critical value for the 95 percent confidence interval of the threshold variable (equation 3). The likelihood ratio has its minimum at our estimated threshold of a debt-to-asset ratio of 85 percent.

As can be seen, the correct identification of the threshold is crucial for the proper interpreta-

[13] The exclusion of the variable *change in leverage* does not affect our results in a qualitative way.

[14] We show this for the baseline result of column 1 exemplary. The implications are similar for results derived using gross investment.

tion of the debt-investment link. The relation between debt and investment differs substantially depending on the threshold. If, for instance, a leverage threshold had been set exogenously at 30 percent, high debt holdings would have been positively associated with investment activity, whereas the opposite would be true for only weakly indebted firms. Thus, relying on an ad-hoc threshold specification without econometric testing for its significance would have resulted in fundamentally different conclusions about debt-investment links. We take this finding as support for our claim that debt thresholds should be determined endogenously by the data, without taking an a priori stance on expected threshold levels.

In Table 4, we compare results for the periods before and after the global financial crisis of 2008 to discuss whether the crisis affected firm investment via balance sheet deteriorations.[15] Interestingly, while the leverage thresholds for both periods remain in the range of a debt-to-asset ratio of 80-85 percent, the negative debt-investment link is much stronger for the crisis years. First, the relationship between debt and investment is negative for both periods, but only significant in the post-crisis period. Second, there is even a negative effect of low debt on investment in the post-crisis years, compared to the significantly positive link in the pre-crisis years. This suggests a much larger need for deleveraging in crisis times. As indicated above, firms were benefitting from favourable financing conditions in the boom years preceding the global financial crisis, whereas the debt overhang accumulated over the boom phase depicts an investment-dampening factor in post-crisis years.

We also report subsample estimations for firms being assigned to different profitability groups. We therefore split the sample by mean profitability (which corresponds to an EBITDA-to-asset ratio of six percent). A single firm might be included in both subsamples if it has been operating above and below mean profitability over the sample period. As discussed in the previous section, profitable firms are expected to be less financially constrained, implying a lower investment sensitivity of debt. The empirical results point to a noticeable impact of profitability on the debt-investment nexus. Whereas the strongly negative effect of high leverage on investment occurs for both types of firms, even low debt holdings depress investment when a firm is unprofitable. These results suggest that high profitability in combination with low debt is most likely to spur investment.

[15] In line with the treatment of the period definitions in Section 3, we evaluated different cut-off points for the pre- and post-crisis periods. However, the basic results described here were not affected.

Table 4: Sample split across time and firm profitability

	Pre-Crisis	**Post-Crisis**	**Profitable**	**Unprofitable**
Threshold Estimate				
γ	0.857	0.808	0.809	0.853
95% Confidence Interval	(0.852 0.864)	(0.782 0.855)	(0.793 0.809)	(0.850 0.856)
Impact of Debt/Assets				
β_1 (Low-Debt Regime)	0.099***	-0.047***	0.026**	-0.015
	(0.020)	(0.010)	(0.012)	(0.011)
β_2 (High-Debt Regime)	-0.064	-0.099***	-0.181***	-0.086***
	(0.041)	(0.007)	(0.015)	(0.008)
Covariates				
EBITDA/Debt	0.017	0.010***	0.015***	0.018***
	(0.012)	(0.003)	(0.002)	(0.003)
Interest Rate Burden	-0.002	-0.002	-0.029***	-0.002
	(0.005)	(0.002)	(0.004)	(0.003)
Sales Growth	0.037**	0.059***	0.074***	0.043***
	(0.014)	(0.009)	(0.006)	(0.011)
log(Assets)	-0.005	-0.007***	-0.008***	-0.007
	(0.008)	(0.002)	(0.003)	(0.005)
EBITDA/Assets	0.374***	0.208***	0.156***	0.291***
	(0.065)	(0.034)	(0.040)	(0.026)
ΔDebt/Assets	-0.004	0.029***	0.005	0.015
	(0.014)	(0.006)	(0.006)	(0.010)
Tangibility	-0.930***	-0.319***	-0.599***	-0.316***
	(0.013)	(0.027)	(0.059)	(0.034)
Sector FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Regime-Dependent Intercept δ_1	Yes	Yes	Yes	Yes
Observations	646.944	2.551.982	1.702.366	1.304.008
Percent of Obs. In Low-Debt Regime	85,14	87,72	89,54	85,60
Percent of Obs. In High-Debt Regime	14,86	12,28	10,46	14,40
No. Of Firms	323.472	624.004	336.374	281.800

Note: The threshold variable γ is the reported debt-to-asset ratio. Debt is defined as financial debt (short-and long-term loans plus other current financial liabilities). The dependent variable net investment is defined as the annual percentage change in tangible fixed. Pre-crisis period covers years 2006-2008, the prost-crisis period the years 2009-2014. Firms are defined as (un-)profitable, if their EBITDA-to-asset ratio has been below sample mean (six percent) in the previous year. All independent variables are lagged by one period. Heteroskedasticity-robust standard errors of the covariates are reported in brackets. ***p-value < 0.01, **p-value < 0.05, *p-value < 0.1.

5.2 The Role of Firm Size and Sectors

In this section, we conduct further subgroup regressions along firm size and operating sector. We begin by evaluating whether we find structural differences across firm size and follow the European Commission's firm size classification. According to this definition, firms are categorized based on employee headcount, turnover and balance sheet size.[16] Results are reported in Table 5 and can be summarized as follows: First, while leverage thresholds decrease with firm size, the non-linearity in the debt-investment link is less pronounced for large firms, as the significance of the regime-dependent coefficients decreases with firm size. Second, for all size categories, we find a negative impact of high leverage on investment, though not statistically significant for large firms. Third, for micro and small firms, which account for 96 percent of all firms in our sample, we find evidence of a negative sensitivity of investment to debt service as measured in terms of the EBITDA-to-debt ratio. Overall, these results are in line with empirical findings by Vermeulen (2002) and the literature on the financial propagation mechanism, which states that large firms tend to be better diversified and are likely to face lower financial constraints (Gertler and Gilchrist, 1994). The results, therefore, provide some preliminary evidence for the importance of bank credit supply restrictions, thereby supporting earlier studies which find that investment by borrowers that are more dependent on banks drops significantly relative to that of borrowers less dependent on banks (Buca and Vermeulen, 2017).

Next, we discuss whether the link between leverage and investment differs across sectors. We show results for the largest four NACE sectors, namely manufacturing, wholesale and retail trade, food and accommodation services, and construction and real estate activities. These sectors account for some 80 percent of firm-year observations in our sample. Interestingly, and in line with the findings by ECB (2013), heterogeneity across sectors is relatively limited (Table 6). Leverage threshold estimates for all sectors remain within the interval identified in our baseline estimation in Table 3, ranging from 80 percent for construction and real estate to 86 percent for food and accommodation services. For all sectors, we find evidence of a non-

[16] The classification is based on the following ceilings: Micro firms have less than ten employees and a turnover or assets of less than €2 million. Small firms are those with fewer than 50 employees and a turnover or assets of less than €10 million, whereas medium-sized firms have fewer than 250 employees, a turnover of less than €50 million and assets of less than €43 million. Above these cut-off points, firms are classified as large. See European Commission (2015) for details. Whereas firm size is almost time-invariant in the sample, some changes in size status within single firms can occur over time. Similar to the approach with respect to profitability, we separate the firm-year observations accordingly if a firm changes status. For instance, if we have data for a specific firm for six consecutive years, and the size classification changes after three years, the firm will appear in both class size regressions with the data for the respective three-year period.

Table 5: Sample split across firm size

	Micro	**Small**	**Medium**	**Large**
Threshold Estimate				
γ	0.854	0.848	0.666	0.540
95% Confidence Interval	(0.854 0.854)	(0.812 0.853)	(0.658 0.727)	(0.137 0.837)
Impact of Debt/Assets				
β_1 (Low-Debt Regime)	-0.030***	0.070***	0.006	-0.080
	(0.011)	(0.016)	(0.024)	(0.126)
β_2 (High-Debt Regime)	-0.122***	-0.201***	-0.106***	-0.014
	(0.011)	(0.021)	(0.049)	(0.089)
Covariates				
EBITDA/Debt	0.016***	0.009**	-0.011***	-0.019
	(0.003)	(0.005)	(0.002)	(0.030)
Interest Rate Burden	-0.005	-0.004	0.007	-0.029
	(0.003)	(0.003)	(0.004)	(0.026)
Sales Growth	0.053***	0.072***	0.083***	0.144*
	(0.010)	(0.007)	(0.008)	(0.076)
log(Assets)	-0.010***	-0.031***	-0.046***	-0.107***
	(0.004)	(0.009)	(0.008)	(0.027)
EBITDA/Assets	0.235***	0.305***	0.276***	0.370*
	(0.043)	(0.054)	(0.040)	(0.196)
ΔDebt/Assets	0.020***	-0.014***	0.021	-0.233**
	(0.004)	(0.006)	(0.033)	(0.110)
Tangibility	-0.406***	-0.557***	-0.496***	-0.515***
	(0.051)	(0.046)	(0.032)	(0.084)
Sector FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Regime-Dependent Intercept δ_1	Yes	Yes	Yes	Yes
Observations	1.915.596	672.958	130.110	6.496
Percent of Obs. In Low-Debt Regime	86,75	93,63	88,81	64,66
Percent of Obs. In High-Debt Regime	13,25	6,37	11,19	35,34
No. Of Firms	450.259	146.674	26.541	1.550

Note: The threshold variable γ is the reported debt-to-asset ratio. Debt is defined as financial debt (short-and long-term loans plus other current financial liabilities). The dependent variable net investment is defined as the annual percentage change in tangible fixed. Micro firms have less than ten employees and a turnover or assets of less than €2 million. Small firms are those with fewer than 50 employees and a turnover or assets of less than €10 million, whereas medium-sized firms have fewer than 250 employees, a turnover of less than €50 million and assets of less than €43 million. Above these cut-off points, firms are classified as large. See European Commission (2015) for details. All independent variables are lagged by one period. Heteroskedasticity-robust standard errors of the covariates are reported in brackets. ***p-value < 0.01, **p-value < 0.05, *p-value < 0.1.

linear relationship between debt and investment, including a strongly negative and statistically significant relation between highly-leveraged firms' debt-to-asset ratios and investment. For firms in food and accommodation services as well as firms in construction and real estate, we even find a negative (though not significant) debt-investment relationship for low-debt firms, possibly due to the smaller size of these firms and therefore a higher likelihood of financial constraints.

6 Robustness Checks

6.1 Instrumental Variable Approaches for the Leverage Ratio

A well-known problem of panel threshold models as well as panel estimation in general arises from potential endogeneity concerns. In particular, the assumption of the error terms ε_{it} being i.i.d. is crucial when applying the framework of Hansen (1999), and thus exogeneity of the threshold variable and the regressors is required.[17] However, the strict exogeneity assumption can be challenged by the fact that a firm's decisions on investment and liabilities are taken contemporaneously, and the direction of causality in the debt-investment link might not be clear. In our baseline estimation, we use lags to deal with these concerns. In line with the literature on panel estimation, in this section, we further address possible endogeneity concerns by proposing two alternative instrumental variable candidates for our leverage ratio. Suitable instruments need to be closely correlated with the endogenous regressors but uncorrelated with the error term ε_{it}.

Following Coricelli et al. (2012), we first use two-period lags of the regressors. This turns out to be a suitable instrument candidate given the high correlation of consecutive leverage ratios (the correlation between the one- and two-year lag of the leverage ratio is 0.87 in our sample), and the assumption that debt reported two years before the investment decision does not affect current investment decisions. (The correlation between the two-year lag of the leverage ratio and the residuals from the baseline regression of Table 4 is -0.001).

We furthermore undertake a more structural two-step approach and instrumentalise the debt-to-asset ratio by building on dynamic panel estimation techniques. In doing so, we first es-

[17] Recent studies have developed estimation procedures that directly take endogeneity in regressors and threshold variables in threshold models into account. See Caner and Hansen (2004) or Kourtellos et al. (2008) for static as well as Seo and Shin (2016) for dynamic panel threshold models. However, these approaches are not suitable for the use of large unbalanced panels as the one in this paper.

Table 6: Sample split across sector

	Manufact.	**Trade**	**Food/ Accommod.**	**Constr./ Real Estate**
Threshold Estimate				
γ	0.816	0.850	0.858	0.796
95% Confidence Interval	(0.812 0.816)	(0.834 0.854)	(0.615 1.097)	(0.796 0.802)
Impact of Debt/Assets				
β_1 (Low-Debt Regime)	0.011	0.014	-0.052	-0.071
	(0.069)	(0.060)	(0.045)	(0.051)
β_2 (High-Debt Regime)	-0.140***	-0.139***	-0.095***	-0.089***
	(0.032)	(0.006)	(0.019)	(0.032)
Covariates				
EBITDA/Debt	0.005***	0.016***	-0.005	0.009***
	(0.001)	(0.002)	(0.005)	(0.002)
Interest Rate Burden	0.000	-0.010***	0.004	-0.008***
	(0.002)	(0.002)	(0.003)	(0.002)
Sales Growth	0.084***	0.081***	0.034***	0.038***
	(0.007)	(0.005)	(0.001)	(0.004)
log(Assets)	-0.007***	-0.004***	0.018***	-0.015***
	(0.001)	(0.001)	(0.001)	(0.001)
EBITDA/Assets	0.273**	0.395***	0.104***	0.254**
	(0.109)	(0.047)	(0.016)	(0.115)
ΔDebt/Assets	0.010	0.003	0.024	0.014
	(0.009)	(0.012)	(0.025)	(0.021)
Tangibility	-0.554***	-0.532***	-0.347***	-0.297***
	(0.023)	(0.023)	(0.045)	(0.062)
Sector FE	-	-	-	-
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Regime-Dependent Intercept δ_1	Yes	Yes	Yes	Yes
Observations	549.638	914.038	193.452	736.269
Percent of Obs. In Low-Debt Regime	92,49	90,65	82,16	82,61
Percent of Obs. In High-Debt Regime	7,51	9,35	17,84	17,39
No. Of Firms	97.058	183.613	43.260	162.502

Note: The threshold variable γ is the reported debt-to-asset ratio. Debt is defined as financial debt (short-and long-term loans plus other current financial liabilities). The dependent variable net investment is defined as the annual percentage change in tangible fixed. Sectors are defined according to the NACE-2 broad sector classification. All independent variables are lagged by one period. Heteroskedasticity-robust standard errors of the covariates are reported in brackets. ***p-value < 0.01, **p-value < 0.05, *p-value < 0.1.

timate a leverage equation including firm-specific characteristics as well as instruments related to lagged observations. We then replace the actual debt-to-asset values in our baseline specification (equation 1) with the fitted values of the estimated leverage model. Due to the persistence in leverage ratios, we estimate the leverage model by applying a dynamic panel system generalized method-of-moments (GMM) estimation following Arellano and Bover (1995) and Blundell and Bond (1998).[18] Such specifications allow for lagged values as well as differences of the dependent variable as instruments.

As regards our leverage equation, we follow the existing literature and use a variety of firm characteristics identified to affect firm leverage (Rajan and Zingales, 1995; Coricelli et al., 2012; ECB, 2013; Ferrando et al., 2017) as controls.

In stage one, we estimate the following model using the system GMM approach:

$$Leverage_{it} = \vartheta_0 Leverage_{it-1} + \vartheta_1 X_{it} + \mu_i + \varrho_t + \nu_{it} \tag{4}$$

Vector X_{it} contains a set of control variables previously identified as leverage determinants by the literature[19]: sales growth, size (defined as log of assets), tangible fixed assets as a share of total assets, profits (EBITDA/assets), and cash holdings to total assets. We furthermore allow for firm and time fixed effects μ_i and ϱ_t in the specification to control for macroeconomic and institutional factors affecting leverage decisions.

In our system GMM, we use both lagged levels and first differences of the regressors as instruments. This assumes that first differences of our instruments are uncorrelated to firm-specific fixed effects. Even though firm-specific fixed effects are a source of heterogeneity in our leverage estimation, we expect leverage changes to be independent of the initial size of leverage attributed to firm fixed effects. Whether factors captured by the fixed effects such as location or operating sector may account for a large share of debt holdings or not, we assume that these factors do not have a structural impact on the magnitude and direction of leverage changes. Indeed, we use a system GMM instead of the Arellano and Bond (1991) difference GMM as we expect previous changes in debt-to-asset ratios to be good predictors for current leverage positions, but not vice versa. We estimate model 4 using the Blundell and Bond (1998) two-step

[18] We decided to use the more demanding system-GMM estimator instead of the standard Arellano and Bond (1991) difference-GMM model as results drawn from this approach indicated a severe weak-instrument problem (Blundell and Bond, 1998). The coefficient on the lagged dependent variable turned out to be substantially lower in respective specifications.

[19] See for instance ECB (2013) or Ferrando et al. (2017).

system GMM specification where we use both lagged values of the endogenous variables for the first-difference equation and lagged values of the first differences of the instruments in the level equation. Our endogenous variables consist of the lagged leverage variable and the controls contained in vector X_{it} and we use, based on results from sequential Arellano-Bond tests for autocorrelation, the set of available lags starting at lag order two for respective instruments. Results for the leverage equation are reported in Table 7.

Persistence in the leverage ratio is substantial, as indicated by the large coefficient on lagged leverage. However, the coefficient is still below one, indicating stationarity in the data generating process, thus not violating the stationarity assumption necessary for system-GMM (Arellano and Bover, 1995).

In line with our expectations, sales growth negatively affects leverage. Similarly, both increasing profits and cash holdings negatively affect leverage, in line findings on pecking-order behaviour in investment-finance Myers (1984) according to which firms rely on internally generated sources of funding before turning to external finance. Leverage decreases with firm size, as in ECB (2013). Tangible fixed assets have a weak negative impact on leverage.

Finally, results for the Sargan-test of instrument validity indicate an issue already discussed in Ferrando et al. (2017), who also report test results indicating strong rejection of the instrument set. Several studies have discussed the reliance on Sargan-test results in panels with dimensions similar to ours, and highlighted a tendency of strong over-rejection by the Sargan-test.[20] We thus treat the results on the Sargan-test with caution and still use the described set of instruments.

The fitted values from the system-GMM estimation are highly correlated with the actual leverage ratio (0.86), but show basically zero correlation with the baseline model residuals (-0.001). In total, we derive about 2.3 million fitted firm-year observations.

6.2 Results of Robustness Checks

We present all our robustness test results in Table 8. Due to space limitations, we report only estimations using net investment as the dependent variable.[21] For convenience, results for the baseline regression from Table 3 are reported in the first column. In addition to the instrumental variable approaches discussed above (using two-year lags and fitted values), we report results for further subsample specifications on which we estimated the standard model, using our baseline

[20] See Ding et al. (2013), Benito (2003), or Blundell et al. (1998).

[21] The main results did not change when gross investment was used. Respective results are available upon request.

Table 7: Results leverage regression

	System-GMM
Covariates	
Leverage (t-1)	0.944***
	(0.010)
Sales Growth	-0.052***
	(0.010)
log(Assets)	-0.005***
	(0.001)
EBITDA/Assets	-0.084**
	(0.033)
Tangibility	-0.007*
	(0.004)
Cash Holdings	-0.048**
	(0.021)
Constant	0.119***
	(0.019)
Firm FE	Yes
Year FE	Yes
Observations	2.325.353
No. Of Firms	609.409
AR(1) Test	-105.56
P-Value	0.000
AR(2) Test	-0.092
P-Value	0.927
Sargan-Test	364.781
P-Value	0.000
No. Of Instruments	55
Fitted Values	
Correlation Leverage	0.861
Correlation Baseline Residuals	-0.001
No. Of Fitted Values	2.325.353

Note: Results for a leverage equation estimation using a two-step system-GMM dynamic panel model are reported. We include both lagged values of the endogenous variables for the first-difference equation and lagged values of the frst differences of the instruments in the level equation. Windmeijer (2005) WC-robust standard errors are reported in parentheses. ***p-value < 0.01, **p-value < 0.05, *p-value < 0.1.

leverage ratio as the regime-dependent regressor.

Both of our instrumental variable regressions confirm the non-linear relationship between debt and investment. When two-year lags of the right-hand side variables are used, the estimated threshold is almost identical to the baseline estimate, and results for the covariates are similar to our baseline model.

In the estimation using the fitted values from the dynamic panel instrument estimation, the non-linearity in investment behaviour above and below a certain threshold level of debt is confirmed. Even though the estimated threshold is lower than in the baseline regression, results for the regime-dependent debt coefficients and the regime-independent covariates are comparable with the baseline results. We take these results as confirmation for our model setup and as evidence for an adequate treatment of endogeneity concerns in our framework.

As a significant proportion of firms report zero financial debt, we estimate our baseline model for the subset of observations with positive financial debt only. Threshold estimates are not substantially affected, even though roughly one quarter of observations are excluded. High-debt firms still tend to be associated with negative debt-investment linkages, while the corresponding coefficient for low debt firms is positive, but insignificant. We then exclude observations, one at a time, for firms reporting less than three employees and observations with investment above 1000 percent. Furthermore, we report results for an estimation of the baseline model where we define a finer grid than the 393 bins we use in the baseline estimations. Results show that we did not distort threshold and confidence interval estimates simply because of excessively wide bins. Finally, we re-estimate the baseline model by excluding Greek firms from our sample as further investigation of the sample for Greece in Amadeus revealed that the distribution of firms with respect to our key variables is significantly influenced by outliers, whereas we did not find evidence for outlier dominance in the other country subsamples. The estimation results, however, are only marginally affected, confirming our main results with respect to the leverage threshold and the differences in terms of investment sensitivity for low- and high-debt firms.

Table 8: Robustness checks

	Net Investment (baseline)	**Two-Year Lags**	**Fitted Values**	**Excl. Firms with Zero Fin. Debt**	**Excl. Firms with Inv. Rate > 10**	**500 Bins in Grid Search**	**Excl. Greece**
Threshold Estimate							
γ	0.852	0.846	0.746	0.854	0.825	0.854	0.854
95% Confidence Interval	(0.851 0.855)	(0.839 0.858)	(0.743 0.769)	(0.854 0.854)	(0.812 0.855)	(0.812 0.854)	(0.799 0.854)
Impact of Debt/Assets							
β_1 (Low-Debt Regime)	0.015	0.009***	0.614***	0.011	-0.008	0.016	-0.002
	(0.012)	(0.004)	(0.186)	(0.014)	(0.009)	(0.012)	(0.012)
β_2 (High-Debt Regime)	-0.143***	-0.009	-0.021	-0.147***	-0.101***	-0.143***	-0.135***
	(0.010)	(0.008)	(0.017)	(0.011)	(0.007)	(0.010)	(0.009)
Covariates							
EBITDA/Debt	0.014***	0.013***	0.014***	0.038***	0.010***	0.013***	0.014***
	(0.002)	(0.001)	(0.003)	(0.006)	(0.002)	(0.003)	(0.002)
Interest Rate Burden	-0.005***	-0.005***	-0.006***	-0.009***	-0.005***	-0.005**	-0.006***
	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Sales Growth	0.062***	0.028***	0.051***	0.054***	0.049***	0.062***	0.059***
	(0.010)	(0.009)	(0.015)	(0.010)	(0.008)	(0.010)	(0.009)
log(Assets)	-0.005**	0.011***	0.001	-0.010***	0.001	-0.005	-0.007*
	(0.003)	(0.000)	(0.002)	(0.004)	(0.003)	(0.003)	(0.004)
EBITDA/Assets	0.303***	0.193***	0.238***	0.245***	0.239***	0.307***	0.259***
	(0.047)	(0.008)	(0.042)	(0.045)	(0.039)	(0.047)	(0.004)
ΔDebt/Assets	0.012***	-0.002	0.008	0.009*	0.020***	0.012***	0.013***
	(0.005)	(0.004)	(0.006)	(0.005)	(0.004)	(0.005)	(0.005)
Tangibility	-0.456***	-0.347***	-0.376***	-0.463***	-0.311***	-0.456***	-0.452***
	(0.052)	(0.003)	(0.040)	(0.050)	(0.042)	(0.052)	(0.051)
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Regime-Dependent Intercept δ_1	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3.006.374	2.540.697	2.164.796	2,204,851	2.971.742	3.006.374	2.955.380
Percent of Obs. In Low-Debt Regime	89,31	88,70	85,17	87,96	87,48	89,46	89,31
Percent of Obs. In High-Debt Regime	10,69	11,30	14,83	12,04	12,52	10,54	10,69
No. Of Firms	618.174	571.783	477.494	485.779	612.729	618.174	609.174

Note: The threshold variable γ is the debt-to-asset ratio. Debt is defined as financial debt (short-and long-term loans plus other current financial liabilities). The dependent variable net investment is defined as the annual percentage change in tangible fixed. Fitted values are generated from the system-GMM estimation outlined in Chapter 6.1. All independent variables are lagged by one period. Heteroskedasticity-robust standard errors of the covariates are reported in brackets.

7 Conclusion

This paper aims to provide new evidence on the relationship between corporate debt and investment. We use firm-level data for five peripheral euro area countries and explicitly account for non-linearities in the debt-investment link. Our empirical analysis allows us to endogenously estimate debt thresholds, instead of relying on a priori assumptions about potential threshold levels.

The estimations suggest that there is a threshold in the debt-investment link: when debt is too high, debt overhang distorts investment due to higher default risks and higher costs of financing. We identify this threshold in the region of a debt-to-asset ratio of 80-85 percent. For firms with a leverage ratio above this threshold, we find evidence consistent with debt holding back investment. Both the leverage threshold and the negative relation between debt and investment for high-debt firms is highly robust across various specifications. In particular, for highly leveraged firms we find a negative debt-investment relationship in all major sectors and for both profitable and unprofitable firms. There is, however, evidence for some heterogeneity across firm size. The negative investment impact of high debt is observed for micro, small and medium-sized firms (which amount to 99 percent of firms in our sample), but not for large firms, and the role of earnings relative to debt becomes less relevant as firm size increases. This suggests that financial constraints related to debt overhang play a less important role for large firms. The latter result also provides some tentative evidence for the importance of loan supply restrictions, though further work, e.g. by matching firm and bank balance sheet data, would be needed to disentangle the relative contribution of supply and demand effects.

For firms with debt levels below the threshold, the relationship between debt and investment is less robust and depends on a number of firm characteristics and the macroeconomic environment. While our baseline regression suggests a slight (and insignificant) positive effect of debt on investment, during the financial crisis period even low debt seems to constitute a drag on investment, though the negative investment effect is still smaller than for high debt firms. Similarly, for smaller firms or when profitability is low, even low levels of debt have a negative impact on investment. Our analysis does not take a stance on whether the negative impact of debt on investment is due to demand or supply effects. The literature identifying the role of credit conditions on firm investment suggests that banking shocks to the supply of credit can have large effects on corporate investment.

Overall, these results suggest still substantial deleveraging needs in peripheral countries to support a stronger investment recovery. The economic environment in peripheral countries is characterised by a large number of small firms, low productivity and high financial uncertainty – factors which reduce the capacity to tolerate high levels of debt and lead to a more negative debt-investment relationship. Moreover, our results show that debt overhang is not only reflected in a high stock of debt but also in a low capacity to service the debt (as measured by the EBITDA-to-debt ratio and the interest expenses-to-EBITDA ratio), which implies that even firms with a debt-to-asset ratio below the threshold may be in need of deleveraging if they face high debt service obligations.

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