When Leverage Matters: Investment in Portugal

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Abstract

Debt and investment are two fundamental topics in the corporate world. This research investigates the relationship of these two concepts in Portuguese firms over the time window of 2011 and 2022 using a fixed-effect panel threshold model. Studying 6,857 firms, the results suggest that the sensitivity between leverage and investment decreases as firms indebt themselves more. In this scenario, firms are often highly constrained and already operating at minimal investment levels, leaving little room for further reductions in investment. The results across industries and firm sizes are also presented, reaffirming the non-linear relationship and emphasising the primary usage of internal funds to invest, aligned with the pecking order theory. Surprisingly, the relationship between leverage and investment is positive at the 90^{th} percentile of the investment distribution, which might suggest that Portuguese firms often use leverage to finance working capital, daily operations or to benefit from tax shields rather than invest in long-term projects.

Keywords: Debt, Investment, Leverage Threshold Analysis, Portugal

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Resumo

A dívida e o investimento constituem dois temas fundamentais no mundo empresarial. Este estudo investiga a relação entre estes dois conceitos em empresas portuguesas, no período de 2011 a 2022, recorrendo a um modelo de painel de efeitos fixos que segmenta os resultados consoante determinados níveis de endividamento. Com base na análise de 6.857 empresas, os resultados indicam que a sensibilidade entre alavancagem e investimento diminui à medida que as empresas se endividam mais. Nesse contexto, as empresas encontram-se frequentemente muito condicionadas, operando em níveis mínimos de investimento, o que reduz a possibilidade de cortes adicionais. São igualmente apresentados resultados por setor de atividade e dimensão das empresas, reforçando a natureza não linear desta relação e evidenciando o papel fundamental dos fundos internos para o investimento, em linha com a *pecking order theory*. Surpreendentemente, a relação entre alavancagem e investimento torna-se positiva no percentil 90 da distribuição do investimento, possivelmente sugerindo que as empresas portuguesas recorrem à dívida sobretudo para financiar fundo de maneio, operações do dia a dia ou tirar proveito de benefícios fiscais, em vez de a canalizarem para projetos de longo prazo.

Palavras-Chave: Dívida, Investimento, Limiar de Endividamento, Portugal

Título: Quando a alavancagem é relevante: Investimento em Portugal

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Contents

1. Introduction

Corporate investment represents a fundamental role in promoting economic growth, boosting firms' productivity, and fostering innovation. As firms expand their production capacities, adopt innovative technologies, and enter new markets, they generate employment and improve competitiveness, contributing to a country's long-term prosperity. However, achieving this investment often requires external financing, especially when internal funds are insufficient. The early theoretical model presented by Modigliani & Miller (1958), suggests that capital structure is irrelevant in perfect capital markets, in spite of that subsequent research recognises that real-world imperfections, such as taxes, agency costs, and asymmetric information, make external financing costly and influence the relationship between leverage and investment.

This relationship is far from linear. On the one hand, excessive debt can produce a "debt overhang" problem (Myers, 1977), discouraging firms from undertaking positive net present value projects as the gains primarily accrue to debtholders. On the other hand, moderate leverage can impose managerial discipline and discourage inefficient spending, as suggested by Jensen's (1986) free cash flow hypothesis. Furthermore, recent studies highlight that leverage's effect on investment may depend on a firm's debt level, size, or investment intensity, where non-linear approaches (Martinez-Carrascal & Ferrando, 2008; Gebauer et al., 2017; Serrasqueiro, 2016; Mendes et al., 2014) show that the marginal impact of debt changes not only as leverage crosses a certain threshold, but also across the investment distribution.

Portugal presents an interesting case for such an analysis. Despite the use of loans for fixed investment for Portuguese firms is around 26% (compared to 43% in Germany), according to the European Central Bank's survey on the access to finance of enterprises (*Data and Surveys - SAFE*, 2023), 61% of firms answered that they would prefer to finance investments with bank loans. The demand exists, although only 55% received the full amount.

This research applies a fixed-effects threshold model (Hansen, 1999) following the practical guidance of Wang (2015), focusing exclusively on Portuguese firms. Identifying leverage thresholds has practical implications for firms seeking sustainable growth or for financial institutions that aim to calibrate their lending strategies. The decision to study Portuguese firms instead of US firms stems from the inclusion of both private and public firms in the Portuguese case, which allow to fully characterise the economy. The aim is to add into what was studied before regarding the negative relationship between leverage and investment of Portuguese firms (Farinha & Prego, 2013; Serrasqueiro 2016; Mendes et al., 2014), while

studying other variables that might be related with investment such as debt service, liquidity, sales growth, firm size, cash flow, collateral and changes in leverage.

The results suggest that the sensitivity of investment to leverage decreases as firms increase their debt beyond a certain threshold. While taking on some debt may initially support investment, pushing leverage too far might impose constraints, making additional borrowing less effective, or even detrimental. In the baseline model, leverage as a positive relationship with net investment for firms with debt ratios below 5.4%. Interestingly, the threshold effects are not uniform across sectors. For instance, manufacturing firms display a positive and statistically significant relationship between leverage and investment at lower and moderate debt levels. Moreover, the results suggest that micro and small enterprises, which dominate the Portuguese economy, are more dependent on internal financing and are expected to be more financially constrained. Dividing the sample into distinct macroeconomic periods reaffirm the non-linear relationship. Although, when only "low profit" firms are considered, the relationship between leverage and investment is positive, where leverage might play as an alternative to scarce internal funds.

Managers can use these thresholds as guidelines, avoiding excessive debt that will probably decrease investment as financial obligations rise. Considering that policymakers and regulators, aware of these non-linearities, could design support mechanisms or incentives that push firms towards dynamic leverage ratios, potentially improving credit allocation and reducing financial costs.

2. Literature Review

The understanding of capital structure and its implications on how firms finance their investments has evolved considerably over time. The modern debate on capital structure began with Modigliani and Miller's seminal paper published in 1958. Modigliani & Miller (1958) argued that under the assumptions of perfect capital markets, no taxes, no transaction costs, and symmetric information, a firm's financing decisions are irrelevant to its value or investment choices. Consequently, a firm's value is determined solely by its underlying profitability and risk, revealing the irrelevance of capital structure to investment performance.

However, the assumptions of perfect capital markets do not hold in reality, leading subsequent researchers to explore the effects of market imperfections on capital structure decisions. Myers (1977) extended the discussion by introducing the concept of "debt overhang problem". He argued that firms with significant growth opportunities and high levels of risky

debt may face conflicts of interest between shareholders and debtholders. Specifically, managers acting on behalf of shareholders might forego positive net present value (NPV) projects as benefits would primarily accrue to debtholders rather than shareholders, leading to underinvestment problems. To address this, firms with significant growth prospects tend to minimize leverage, either by negotiating conditions or shortening debt maturity. In contrast, Jensen (1986) introduced the "free cash flow hypothesis," emphasising the agency conflicts between managers and shareholders over the use of excess cash flow. Additionally, he assumed that managers might invest free cash flow in projects with negative NPV rather than distributing it to shareholders, leading to inefficient investment. Jensen (1986) suggested that debt can serve as a disciplinary mechanism by committing the firm to fixed interest payments, thereby reducing the free cash flow available for managers to invest unwisely (Billett et al. 2007).

Furthermore, the pecking order theory was developed by Myers & Majluf (1984) to explain firms' financing preferences under conditions of asymmetric information. They argued that managers, who possess more information about the firm's value than external investors, would rather finance investments firstly with internal funds, then with debt, and finally with equity. Therefore, this financing hierarchy arises because issuing new equity may signal to the market that managers believe the firm is overvalued, leading to adverse selection and potential undervaluation. As a result, firms avoid issuing equity unless necessary, and fluctuations in debt levels occur not caused by a target capital structure but due to the need for external financing when internal funds are insufficient. Furthermore, Berger & Udell (1998) and Fazzari & Athey (1987) demonstrate private firm's priority usage of internal funds, then debt and finally equity due to their size, informational opacity, limited performance history or management characteristics. The majority of private firms are still far from reaching the stage where going public or issuing public debt is the right decision to obtain additional funds, and many do not manage to reach this point at all (Lefebvre, 2023; Venturelli & Gualandri, 2009). However, firms still have plenty of options to finance themselves, it can go from owner's funds, retained earnings, and angel investors to crowdfunding, bank loans, trade credit, venture capital or even government support (Berger and Udell, 1998; Carbó-Valverde et al., 2016; Abdulsaleh & Worthington, 2013; Abbasi et al., 2018). Even given all these options, debt financing is the externally most common method used to fund activities and investments in private firms, (Vera & Onji, 2008; Vos et al., 2007) especially when internal funds are scarce (Carpenter & Petersen, 2002; Rahaman, 2011). In Portugal, 61% of firms would prefer bank loans to finance investments, yet the greater part of them face mounting challenges to access them. From the answering firms, 56% identified high costs and collateral requirements as the main barriers

(*Data and Surveys - SAFE*, 2023). The report also highlights that of the firms requesting loans in Portugal, only 55% received the total requested, with 28% receiving partial or no funding.

Under such conditions, financial institutions play a big role in how these firms have access to finance and grow (Beck & Demirguc-Kunt, 2006; Petersen & Rajan, 2002; Wagenvoort, 2003), fundamentally in economies like Portugal's, where smaller, bank-dependent firms face tighter financing constraints, limited equity markets, and potentially less available internal funds. Furthermore, Portuguese firms report that they fell more confident talking about financing with banks rather than with equity investors/venture capital enterprises (*Data and Surveys - SAFE*, 2023).

The theoretical perspectives suggest that leverage can both facilitate and hold up investment, depending on factors such as growth opportunities, agency conflicts, and information asymmetries. As researchers tested these theories empirically, they found that leverage's effect may not be strictly linear but instead dependent on specific financing conditions and thresholds. Empirical studies in the United States (Lang et al., 1996; Hurme, 2010) have shown that firms with higher leverage, particularly beyond certain industry benchmarks, experience diminished investment growth. Additionally, Gebauer et al. (2017) jointly study firms from Italy, Spain, Portugal, Greece and Slovenia, where they find that the relationship between debt and investment depends on the leverage ratio of firms. Similarly, Martínez-Carrascal & Ferrando (2008) analysed Spanish firms and discovered a non-linear relationship between leverage and investment, indicating that for firms with leverage ratios below the 75th percentile, indebtedness does not significantly influence investment decisions. However, for firms exceeding this leverage threshold, there is a significant negative relationship between leverage and investment.

In the Portuguese context, Mendes et al. (2014) and Farinha & Prego (2013) investigated the effect of indebtedness on investment and found a significant negative relationship. The authors suggest that higher leverage limits firms' future investment opportunities, potentially due to increased financial constraints or risk aversion from potential financiers. Serrasqueiro (2016) provides a different perspective by distinguishing high-investment and low-investment firms. Consequently, the study reveals that for high-investment firms, leverage has a significant and positive relationship with investment, implying that for firms actively pursuing growth opportunities, debt serves as a crucial financing tool that enables expansion and capital expenditures. On the other hand, low-investment firms experience a significant negative relationship between leverage and investment. The research also indicates that smaller firms

tend to invest more than larger ones, possibly driven whether by the need to achieve a minimum efficient scale, or due to the space that exists in the economy for them to grow.

The literature indicates that while debt financing is a crucial resource for private firms, its impact on investment can vary and be context dependent. This study aims to examine the relationship between corporate debt and firm investment in Portugal, applying the threshold fixed-effects method from Hansen (1999). The research will investigate potential non-linearities in the leverage–investment relationship by identifying specific thresholds beyond which debt has a significantly different relation with firm's investment. This approach hopes to enrich the findings of previous Portuguese research by incorporating a non-linear analysis along with more recent data, providing a more detailed analysis of the Portuguese context, which was not extensively covered by Gebauer et al. (2017).

3. Data and Methodology

The dataset for this research was sourced from the Banco de Portugal Microdata Research Laboratory (BPLIM), which provided access to the Central Balance Sheet Database (CB) to obtain information on Portuguese companies between 2010 and 2022. The starting point of 2010 was chosen to keep the consistency of financial reporting under Accounting Standards System (SNC), as earlier data was reported under the Chart of Accounts (POC) system.

For data cleaning, firms with missing values, negative values for key variables (assets, debt, sales, depreciations), and with less than one employee were excluded. Furthermore, state-owned enterprises, financial firms, insurance companies, and pension funds were also removed. Finally, all variables were winsorized at the 1st and 99th percentile of the distribution to reduce the influence of outliers.

Both net investment and gross investment are analysed as dependent variables in the baseline model because, while related, they capture distinct aspects of a firm's investment activity. Net investment, defined as the annual percentage change in tangible fixed assets, is strongly related with an economy's productivity growth, highlighting firm's ability to increase its productivity capacity and real capital expansion (Gebauer et al., 2017; Lang et al., 1996; Serrasqueiro, 2016; Martinez-Carrascal & Ferrando, 2008; Nunes et al., 2012; Mendes et al., 2014). Gross investment provides a broader view of total investment activity since it accounts for all spending of fixed assets, including replacements of depreciated assets and new investments. Financial constraints are expected to influence both maintenance and expansion

capital (Gebauer et al., 2017). To accurately estimate the non-linear relationship between leverage and investment, it is essential to control for other firm characteristics that may influence investment. Therefore, and based on findings from previous literature, eight firm specific and time-varying variables are used to examine firms' investment relationship.

By these means, the study applies a panel threshold regression model based on Hansen's (1999) methodology and further developed by Wang (2015). The goal of this method is to determine if there exists a specific threshold level in leverage ratio beyond which the effect of debt on investment changes considerably, capturing the non-linear relation between leverage and investment. Initially, double threshold models (1) are estimated, in case of statistical insignificance, a single threshold model is estimated (2). In cases where it is not proven with statistical significance that there exists a non-linear relationship between leverage and investment, a linear model is estimated (3). All models control for the same fixed effects to ensure comparability between results.

$$I_{it} = \alpha + \beta_1 D_{it-1} I(D_{it-1} < \gamma_1) + \beta_2 D_{it-1} I(\gamma_1 \leq D_{it-1} < \gamma_2) + \beta_3 D_{it-1} I(D_{it-1} \geq \gamma_2) + \Phi Z_{it-1} + \theta_i + \epsilon_{it} \quad (1)$$

$$I_{it} = \alpha + \beta_1 D_{it-1} I(D_{it-1} < \gamma_1) + \beta_2 D_{it-1} I(\gamma_1 \leq D_{it-1}) + \Phi Z_{it-1} + \theta_i + \epsilon_{it} \quad (2)$$

$$I_{it} = \alpha + \beta_1 D_{it-1} + \Phi Z_{it-1} + \theta_i + \epsilon_{it} \quad (3)$$

In the equations, I_{it} represents the investment rate (either net or gross), D_{it-1} represents the firm's leverage ratio in the prior period; γ is the estimated threshold that differentiates leverage between regimes, and I is a binary variable, which indicates if a firm's leverage is below or above the estimated threshold in a given year. The non-linear equations allows to measure the relationship between leverage and investment in distinct regimes, given by β_1, β_2 or β_3, depending on the whether leverage is above or below γ. To further account for factors that might influence the investment-leverage relationship, a vector of covariates Z_{it-1} is included, and θ_i represents firm fixed effects[1]. This vector contains additional firm-level variables such as cash flow, liquidity, debt service capacity, collateral availability, sales growth, firm size and change in leverage which are all lagged by one period. The usage of lagged variables goes in line with the literature used and tries to reduce endogeneity. All variables will be better

[1] Year fixed effects were not included in threshold regressions due to computational incapacity.

explained in the next section. The errors ϵ_{it} are assumed to be independent and identically distributed.

Rather than testing every possible leverage ratio in the dataset, a grid search across a predetermined set of 393 quantiles of the leverage distribution was performed, following Hansen's (1999) and Gebauer et al., 2017, where each quantile represents a potential threshold candidate. By evaluating this finite set of candidates, it is possible to efficiently cover a broad range of leverage ratios, as well as minimize the computation complexity.

After estimating equations 1 or 2 for each threshold candidate γ, the threshold is chosen based on the minimum of the resulting sum of squared errors, represented as $S_n(\gamma)$, and it measures how well the model fits the data for each candidate threshold.

Once the threshold $\hat{\gamma}$ that minimizes $S_n(\gamma)$ if found, it is necessary to confirm its statistical significance to understand if there exists a significant non-linear relationship between leverage and investment. As a result, the test of the following null hypothesis requires constructing a confidence interval for $\hat{\gamma}$ using a likelihood ratio (LR) test, where γ_0 represents the true threshold value (Gebauer et al., 2017).

$$H_0: \gamma = \gamma_0$$

Since the distribution of $LR_n(\gamma)$ is non-standard, standard statistical tests cannot be directly applied. Following Hansen's method, it is necessary to compute $LR_n(\gamma)$ across different values to create "no-rejection regions," thereby establishing a confidence interval around the threshold estimate.

$$LR_i = \frac{S_n(\gamma_i) - S_n(\hat{\gamma})}{\hat{\sigma}^2(\gamma_i)}, i \in [1, 393] \quad (4)$$

After gathering the likelihood ratio (4), the results are compared with the critical values, which are computed using the inverse of the distribution function for a specific confidence level α (5). If $LR_i(\gamma)$ exceeds $c(\alpha)$, it confirms that the threshold effectively separates the data into distinct regimes, ensuring that $\hat{\gamma}$ is statistically significant at the chosen confidence level (Hansen, 1999).

$$c(\alpha) = -2\log\left(1 - \sqrt{1-\alpha}\right) \quad (5)$$

In the case of a double threshold model, the thresholds are found sequentially, and the process is similar. For the double threshold model, the null hypothesis is a single threshold model, and the alternative is a double threshold model (Wang, 2015). Following this method requires the usage of balanced panel data, where 82,284 observations corresponding to 6,857 firms are studied.

3.1 Variables and Hypothesis

Leverage

Leverage can serve as a critical source of external financing, enabling firms to pursue growth opportunities, especially when internal funds are insufficient (Myers & Majluf, 1984; Vera & Onji, 2008; Vos et al., 2007). The role of debt might be even more crucial for micro and small enterprises, which are likely to be more financially constrained.

Empirical research widely documents a negative relationship between leverage and investment, suggesting that debt can constrain investment due to financial obligations associated with debt servicing. For instance, Lang et al. (1996) find that debt has a generally negative relation with investment, aligning with debt overhang theory by Myers (1977). The results from Cai & Zhang (2011), Martinez-Carrascal & Ferrando (2008) and Gebauer et al. (2017) further support this view, indicating that when firms carry high debt levels, the increased financial burden restricts their ability to pursue positive net present value investments. Martinez-Carrascal & Ferrando (2008) and Gebauer et al. (2017) underline that, even though leverage is negatively related with investment, the relationship is non-linear, and high indebtedness hurts more investment than low indebtedness does.

In the Portuguese context, Farinha & Prego (2013) results do not differ when compared with international firms, illustrating with statistical significance that firm indebtedness hurts investment. However, Serrasqueiro (2016) and Mendes et al. (2014) highlight that the relationship between leverage and investment can vary depending on the level of investment of firms, where high investment tend to benefit from leverage. In this study, leverage is measured as the ratio of obtained funding (both long-term and short-term) to total assets, following the approach used by Gebauer et al. (2017), Serrasqueiro (2016) and Mendes et al. (2014). Moreover, a variable to account for the relative change in leverage between periods is added to the models.

H1: The relationship between a firm's leverage and investment is non-linear, with a significant negative relationship with investment above a certain leverage threshold.

Debt service capacity

Debt service represents a firm's ability to generate funds in comparison with the amount of outstanding debt. In this research, debt service is measured by dividing EBITDA by total debt, which provides a proxy for the firm's financial flexibility in managing its debt. Therefore, a higher ratio indicates greater capacity to service debt, leaving more cash flow available for investments. However, as indebtedness rises, the burden of debt service obligations increases, potentially constraining funds available for new investments and growth initiatives.

The study from Gebauer et al. (2017), identifies a positive relationship between a company's debt service capacity and its investment levels in Italy, Spain, Portugal, Greece, and Slovenia.

H2: There is a significant and positive relationship between firm's debt service capacity and investment.

Liquidity

Liquidity refers to a firm's ability to meet its short-term obligations and finance its operations using readily available assets. In the context of investment decisions, liquidity is crucial, as it provides firms with the internal resources necessary to fund new projects, particularly when access to external capital is limited or costly, due to information and incentive problems that firms face (Myers & Majluf, 1984; Myers, 1977; Jensen 1986).

Empirical studies have demonstrated a positive relationship between liquidity and investment. Hoshi et al. (1991), in their examination of Japanese firms, find that companies with higher liquidity levels tend to have greater investment expenditures. Their research suggests that liquid firms are less constrained by external financing limitations and can capitalise on investment opportunities more readily. Odit & Chittoo (2011) extend their analysis and also conclude that if firms have liquidity constraints, they will likely reduce their investment.

In this study, liquidity is measured as the ratio of current assets to current liabilities. Thus, in case of the liquidity ratio being greater than one, might indicate that firms may have surplus funds after settling their current liabilities, which can be positively related with

investment. On the other hand, firms with liquidity problems might enhance its likelihood of bankruptcy and enter in financial distress, reducing their investment.

H3: There is a significant and positive relationship between firm's liquidity and investment.

Sales Growth

The relationship between sales growth and investment was one key factor explored in the literature, where several researchers have found a positive relationship between sales growth and investment.

Lang et al. (1996) find that firms experiencing higher sales growth are more likely to increase their investment expenditures. Similarly, Aivazian et al. (2005) and Serrasqueiro et al. (2011) report that sales growth serves as a signal of profitable investment opportunities, prompting firms to allocate more resources toward capital expenditures. For smaller firms, which often rely heavily on internal financing as a result of limited access to external capital markets, sales growth can enhance internal cash flows, thereby easing financial constraints and enabling further investment (Fazzari et al., 1988).

Nevertheless, the relationship may not be straightforward for all firms. Nunes et al. (2012) argue that for smaller firms, especially those with limited investment levels, the additional funds from sales growth are often diverted to address immediate operational needs rather than long-term investments. Their empirical findings suggest that sales growth is negatively related with small investment firms and positively related with high investment firms. This indicates that the impact of sales growth on investment may be contingent upon the firm's investment capacity and strategic priorities. Additionally, Gebauer et al. (2017) also reinforces the positive and significant linkage between sales growth and investment.

Building on the methodologies of Gebauer et al. (2017) and Nunes et al. (2012), this study will utilise the annual growth rate of sales to measure sales relation with investment.

H4: There is a significant and positive relationship between firm's sales growth and investment.

Size

Firm size may also influence the investment of Portuguese firms, as the literature underlines that smaller firms tend to be more constrained when trying to obtain external financing caused by asymmetric information, lack of collateral, or limited performance history (Hennessy & Whited, 2007; Myers & Majluf, 1984; Beck & Demirguc-Kunt, 2006;

Serrasqueiro & Caetano, 2015). Larger firms are expected to be able to reduce information asymmetry and access external financing more easily and with better terms.

When relating size with investment, Gala & Julio (2012), Gebauer et al. (2017), find that smaller firms tend to invest more, and subsequently grow faster than larger ones. In the case of Portuguese firms, Farinha & Prego (2013), Serrasqueiro (2016) observe that the investment rates of micro and small firms are higher than larger ones. The reason behind this might be due to larger firms have reached already minimum efficient scale, while smaller firms aim to reach it, demonstrating the effort of small firms to grow, rather than being small forever. In this study, size is measured by the natural logarithm of total assets.

H5: There is significant and negative relationship between firm's size and investment.

Cash Flow

According to Fazzari et al. (1988), Myers & Majluf (1984) and Berger & Udell (1998), firms often face constraints in accessing the debt market caused by capital market imperfections, such as information asymmetries, high external financing costs, and agency problems, limiting their borrowing capacity. Furthermore, these frictions limit their borrowing capacity, making internal funds the primary source of financing for investment. Empirical studies consistently find a positive relationship between internal funds and investment across various economies (Lang et al., 1996; Fazzari et al., 1988; Kadapakkam et al., 1998; Carpenter & Guariglia, 2008; Martinez-Carrascal & Ferrando, 2008).

In Portugal, Serrasqueiro (2016), Nunes et al. (2012), Mendes et al. (2014), Oliveira & Fortunato (2006) find that cash flow has a positive and significant relationship with investment. Notably, Oliveira and Fortunato (2006) report that, unlike Kadapakkam et al. (1998), smaller Portuguese firms are more sensitive to cash flow than larger firms, possibly as a consequence of the relatively underdeveloped Portuguese financial markets and the use of equity being limited to a certain number of firms.

Given this context, cash flow is expected to have a positive relationship with investment among Portuguese firms. For the purposes of this study, cash flow will be measured as net income plus depreciation and amortisation, consistent with the proxies employed in prior literature.

H6: There is a significant positive relationship between a firm's cash flow and investment.

Collateral

Imperfect financial markets create frictions that urge lenders to require collateral from firms seeking loans, as information asymmetries and perceived risks increase the need for security in lending (Berger & Udell, 1998). While collateral reduces the lender's risk and may lower interest rates, the requirement for substantial collateral can limit firms' ability to obtain financing, particularly for those lacking sufficient tangible assets. This challenge is especially pronounced for small firms that often have fewer tangible assets to pledge, making it one of the most critical barriers to growth (Beck et al., 2005; Beck et al., 2006; Ryan et al., 2014).

Interestingly, Gebauer et al. (2017) finds a significant negative relationship between firm's tangible fixed assets and firms' investments, indicating that firms with better conditions to offer collateral may actually invest less.

Using data from a different geographical context, Ahmad et al. (2021) show opposite results, with a significant positive relationship between asset tangibility and investment. This discrepancy highlights the potential influence of regional financial systems, lending practices, and economic conditions on the collateral-investment relationship. Following Gebauer et al. (2017), collateral is computed based on the ratio of tangible fixed assets to total assets. All variables are summarised in Table 1.

H7: There is a significant and positive relationship between firm's collateral and investment.

Table 1

Variables Description

Variable	Definition
Gross Investment	Yearly variation in the net value of total fixed assets plus depreciations and amortisations (in %)
Net Investment	Yearly variation in the net value of total fixed assets (in %)
Cash Flow	Proportion of earnings after taxes and interest, including amortisations and depreciations, relative to total assets
Leverage	Proportion of obtained funding to total assets
Liquidity	Ratio of current assets to current liabilities
Debt Service Capacity	Proportion of earnings before interest, taxes, depreciations, and amortisations (EBITDA) to total obtained funding
Collateral	Proportion of tangible fixed assets to total assets
Sales Growth	Yearly rate of increase in sales
Size	Natural logarithm of total assets

4. Results

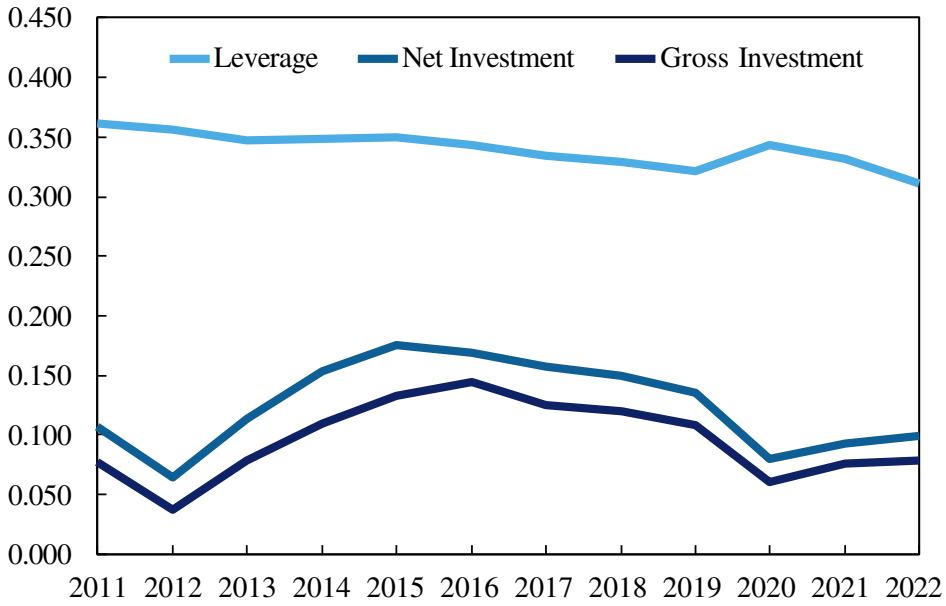
4.1 Evolution of the main variables

Between 2011 and 2022 corporate leverage has experienced a different trend when compared to the investment level of firms (Chart 1). Leverage, measured as the ratio of debt to total assets, followed a gradual downward trend over the period, starting at 36.08% in 2011, with a peak in 2012 of 35.61%. Following this peak, leverage steadily declined, reaching its lowest point of 31.06% in 2022. In 2020, leverage temporarily increased to 34.36% mainly due to the COVID-19 pandemic.

Chart 1

Evolution of Leverage, Net Investment and Gross Investment

The chart illustrates the evolution of corporate leverage, net and gross investment for 6,857 firms and 82,284 firm-year observations between 2011-2022. The definitions of all variables are presented in Table 1.



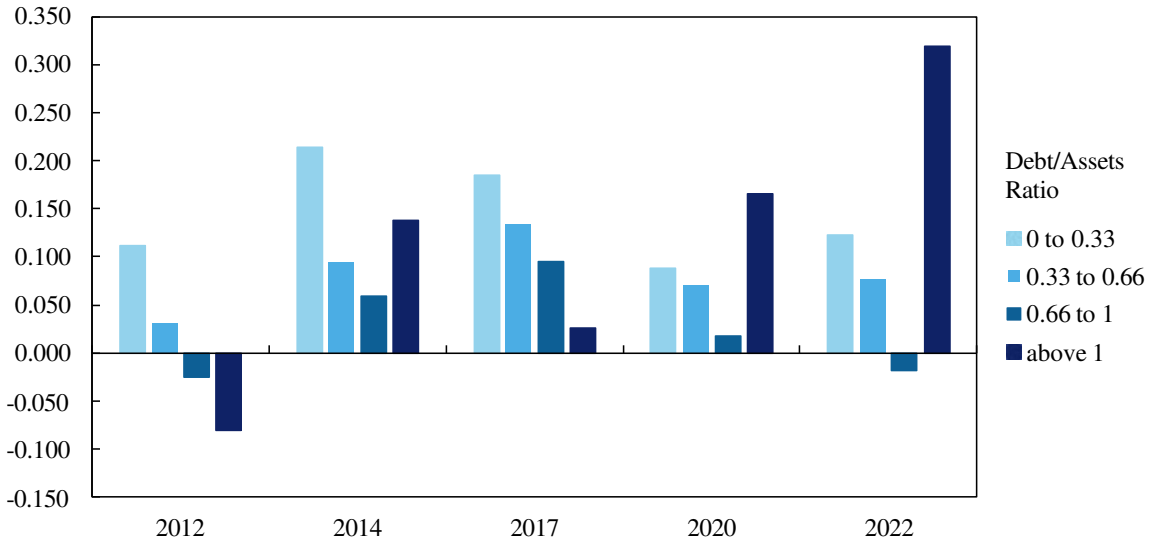
Net investment and gross investment experienced different trends when compared to leverage over the same period. Net investment started at 10.67% in 2011, while gross investment began at 7.65%. Additionally, both showed deterioration during the early crisis years, reaching their lowest levels in 2012, 6.48% and 3.77%, respectively. From 2012 onwards, both variables recovered, where net investment reached its maximum in 2015 with 17.49% and gross investment reached its highest level of 14.38% in 2016, signalling a period of recovery and capital expansion. However, after these peaks, both indicators showed gradual declines,

with a sharp drop in 2020 because of COVID-19 pandemic, followed by signs of recovery in subsequent years.

Chart 2

Investment Rate by Leverage Group

The chart illustrates the average net investment rate given firm's lagged one period leverage ratio. The four different Debt/Assets ratios were chosen based on Gebauer et al. (2017) and the years represented were chosen to visualize investment's historical evolution. The chart is performed using all 6,857 firms and 82,284 firm-year observations between 2011-2022. Firms in the "above 1" threshold represent only 0.45% of the sample. The definitions of all variables are presented in Table 1.



For a better visualisation of the evolution of corporate leverage and investment, Chart 2 reveals how net investment varies over time given a certain lagged leverage threshold. Moreover, the presence of outliers is visible on the chart, where only 0.45% of the firms have a leverage ratio above 1. Besides those firms, the ones with lower leverage ratios tend to present higher net investment rates in the subsequent period. The reason for this might be due to financial constraints that having more leverage brings to firms, in line with "debt overhang" theory (Myers, 1977). It is interesting to highlight that even in 2012, where investment levels reached their minimum, low leveraged firms are still capable of presenting strong (and positive) investment levels when compared with more leveraged firms.

Table 2 provides a detailed summary of the variables used in this study, covering the total sample of firms across the entire observation period. It includes descriptive statistics such as the mean, the median, the 25th and 75th percentiles, as well as the standard deviation. The figures are relatively similar with those reported by Gebauer et al. (2017) for firms in Italy, Spain, Portugal, Greece, and Slovenia, where net investment had a mean of 12% and a median of -6%. Corporate leverage for Portuguese firms in this sample displays an average of 34% and

a median of 32.5%, both lower than the Gebauer et al. (2017) sample, which reported averages of 48% and a median of 45%. In contrast, the leverage figures for U.S. industrial firms, as reported by Lang et al. (1996), are lower, with mean and median values of 24.3% and 23.4%, respectively.

Net investment demonstrates substantial variation, particularly between the 10th and 90th percentiles. Among all variables, size exhibits the highest standard deviation, highlighting heterogeneity in firm's dimensions.

Table 2

Summary Statistics

The table reports the summary statistics of the main variables for 6,857 firms and 82,284 firm-year observations between 2011-2022. The definitions of all variables are presented in Table 1. All variables (except size) are winsorized at the 1st and 99th.

Variable	Mean	SD	Median	p10	p90
Net Investment	0.125	0.730	-0.022	-0.182	0.408
Gross Investment	0.096	0.538	-0.020	-0.167	0.369
Leverage	0.340	0.191	0.325	0.109	0.568
Change in Leverage	0.055	0.556	-0.032	-0.303	0.379
Debt Service	0.535	1.364	0.224	0.045	1.026
Liquidity	1.821	1.355	1.488	0.772	3.127
Sales Growth	0.143	0.880	0.037	-0.238	0.399
Size	14.859	1.412	14.755	13.195	16.668
Cash Flow	0.060	0.074	0.053	0.005	0.144
Collateral	0.308	0.214	0.274	0.053	0.617

Table 3 provides an overview of the correlation coefficients between the dependent and independent variables in this research. The majority of the coefficients are statistically significant at the 1% level. The strongest correlation is observed between net investment and gross investment (0.957), reflecting their close conceptual relationship.

Among the explanatory variables, the highest correlation is between cash flow and debt service (0.394), which likely reflects firms' operating performance and their debt repayment capacity. The correlation coefficients between net investment and explanatory variables are in general small and statistically significant, with the largest being -0.149 for collateral. Notably, the correlation between sales growth and size is the only one which is not statistically significant. The modest magnitudes of the correlations, apart from net and gross investment, indicate a low risk of multicollinearity, supporting the validity of the regression analysis from this study.

Table 3

Correlation Matrix

The table reports the correlation coefficients between variables for 6,857 firms and 82,284 firm-year observations between 2011-2022. All explanatory variables are lagged one period. The definitions of all variables are presented in Table 1.

Variable	Net Inv.	Gross Inv.	Leverage	Change in Leverage	Debt Service	Liquidity	Sales Growth	Size	Cash Flow	Collateral
Net Investment	1									
Gross Investment	0.957***	1								
Leverage	-0.059***	-0.061***	1							
Change in Leverage	0.010***	0.016***	0.073***	1						
Debt Service	0.062***	0.062***	-0.378***	-0.110***	1					
Liquidity	0.045***	0.040***	-0.172***	0.032***	0.157***	1				
Sales Growth	0.022***	0.026***	-0.009***	-0.018***	0.033***	-0.015***	1			
Size	-0.063***	-0.050***	-0.043***	-0.019***	0.034***	-0.034***	0.004	1		
Cash Flow	0.049***	0.060***	-0.261***	-0.100***	0.394***	0.082***	0.077***	0.040***	1	
Collateral	-0.149***	-0.133***	0.217***	-0.015***	-0.085***	-0.246***	0.012***	0.065***	0.079***	1

***p-value < 0.01, **p-value < 0.05, *p-value < 0.1

For a more detailed analysis of the main variables, firms were grouped based on their economic activity (Table 4). Wholesale and retail trade, manufacturing, and construction are the dominant industries in the dataset, comprising nearly 87% of the total observations, which underlines their significance in the Portuguese economy. Additionally, it demonstrates how many firms in these industries thar are able to survive throughout the entire time window. On the contrary, mining and quarrying, transportation and storage and real estate account for a smaller share of the sample.

Table 4

Average Leverage and Investment by Industry

The table presents the average levels of leverage, net investment, and gross investment for each industry, based on 6,857 firms and 82,284 firm-year observations between 2011-2022. The industries are categorised based on their CAE Rev. 3 codes at the 2-digit level. CAE Rev.3 is the Portuguese classification of economic activities, aligned with the European NACE standard, which uses a 5 -digit code for the statistical classification of economic activities. Variables' definitions are presented in Table 1.

Industry	Observations	Weight	Leverage	Net Investment	Gross Investment
Wholesale and retail trade	35,340	42.95%	0.330	0.131	0.094
Manufacturing	32,124	39.04%	0.342	0.118	0.097
Construction	3,924	4.77%	0.304	0.141	0.106
Agriculture, animal production, forestry and fishing	3,660	4.45%	0.395	0.104	0.089
Others: Repair of goods, personal services, etc	2,760	3.35%	0.340	0.134	0.104
Accommodation and food services	1,392	1.69%	0.414	0.094	0.071
Administrative and support services	780	0.95%	0.397	0.110	0.080
Consultant, scientific and similar activities	732	0.89%	0.391	0.203	0.133
Mining and quarrying	684	0.83%	0.342	0.051	0.041
Transportation and storage	660	0.80%	0.353	0.105	0.081
Real Estate	228	0.28%	0.455	0.194	0.151
Total Sample	82,284	100%	0.340	0.125	0.096

Accommodation and food services exhibit the highest leverage ratio, at 41.4%, whereas consultant, scientific and similar services stand out as the industry with the highest net investment and gross investment rates, at 20.3% and 13.3%, respectively.

Table 5

Average Leverage and Investment by Size

The table presents the average levels of leverage, net investment, and gross investment for each firm size, based on 82,284 firm-year between 2011-2022. The sizes are categorized according to the European Union's definitions. Microenterprises are those with fewer than 10 employees and an annual turnover or balance sheet total of no more than EUR 2 million. Small enterprises have fewer than 50 employees, with an annual turnover or balance sheet total capped at EUR 10 million. Medium enterprises include companies with fewer than 250 employees and an annual turnover of up to EUR 50 million, or a balance sheet total not exceeding EUR 43 million (European Commission, 2003).

Industry	Observations	Weight	Leverage	Net Investment	Gross Investment
Small Enterprises	44,640	54.25%	0.333	0.126	0.099
Medium-Sized Enterprises	18,132	22.04%	0.334	0.091	0.078
Microenterprises	16,644	20.23%	0.366	0.165	0.111
Large Enterprises	2,868	3.49%	0.324	0.073	0.066
Total Sample	82,284	100%	0.340	0.125	0.096

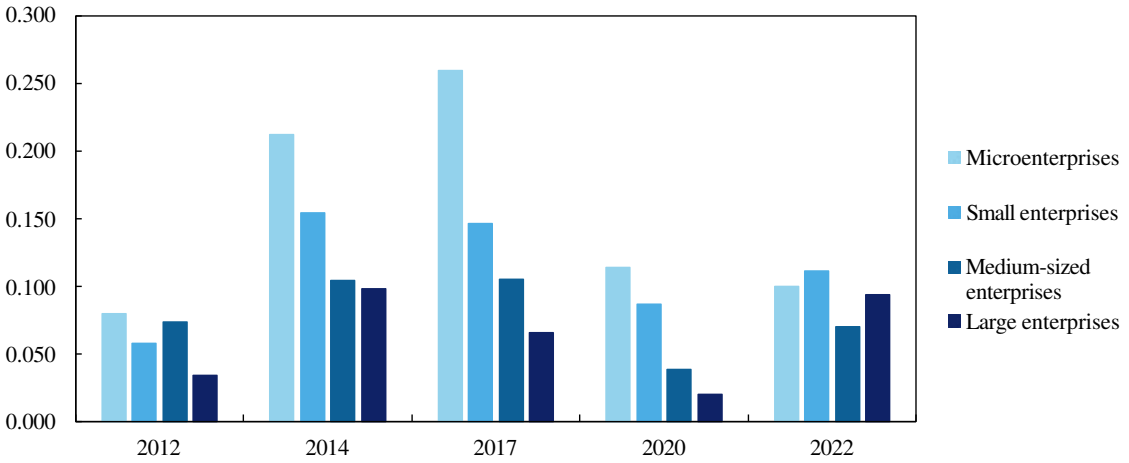
For a better understanding of the sample composition, firms were divided given their size, which can be either micro, small, medium, or large, according to the European Union definitions, that depend on firm's turnover, balance sheet size, and number of employees (European Commission, 2003). As presented in Table 5, 76% of the sample consists of small and medium enterprises. In the Portuguese economy, micro and small enterprises represent the majority of firms, although since this sample only uses firms with 12 years of consecutive data, the amount of micro enterprises is reduced due to their likelihood of not surviving throughout longer periods. In this sample, micro enterprises have the highest leverage and net investment rate, with 36.6% and 16.5%, respectively, while larger firms present the lowest leverage and net investment rate, 32.4% and 7.3%, respectively. Farinha & Prego (2013) and Serrasqueiro (2016) have already demonstrated these characteristics in their studies. It is worth emphasising that, although larger firms are generally expected to secure better financing terms and easier credit access, they nonetheless tend to use less leverage.

The evolution of firm's net investment rate and corporate leverage ratio by their size is presented in Chart 3 and Chart 4 respectively. Throughout the sample time window, small and micro firms generally present higher investment rates when compared to medium and larger firms. These high investments from micro and smaller firms might represent their goal in reaching a minimum efficient scale (Serrasqueiro, 2016) and their effort to grow within the Portuguese economy.

Chart 3

Investment Evolution by Firm Size

The chart presents the average levels of net investment for each firm size, based on 6,857 firms and 82,284 firm-year observations between 2010-2022. The sizes are categorized according to Table 5 description. The definitions of all variables are presented in Table 1.

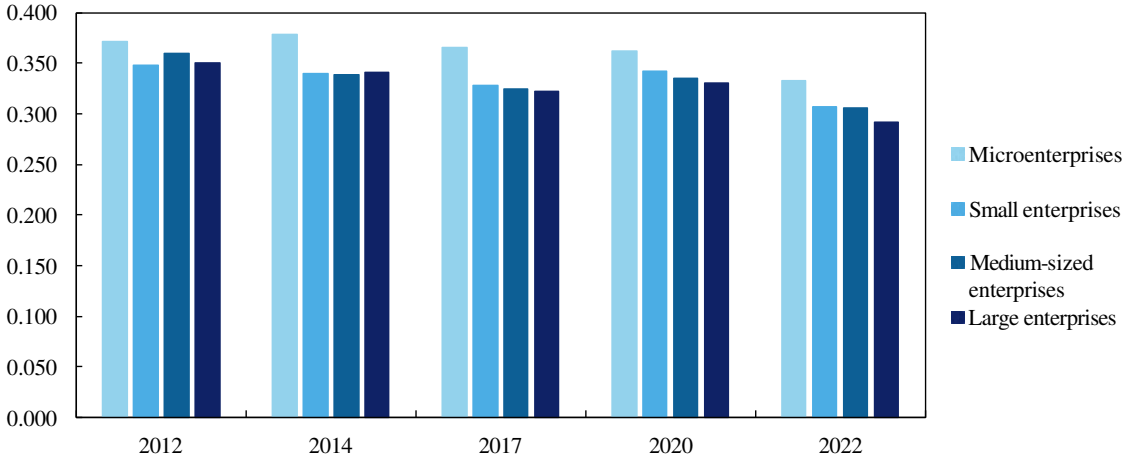


The lower investment rates from larger firms might be caused by these firms being less sensitive to investments, meaning that larger firms have greater flexibility in timing investments and may defer them (Kadapakkam et al. 1998). Larger firms can also have reached minimum efficient scale, with no need to further expansion. Micro firms on the other hand seem more sensitive to investments, as the average investment rate varies considerably between the years.

Chart 4

Leverage Evolution by Firm Size

The chart presents the average levels of leverage for each firm size, based on 6,857 firms and 82,284 firm-year observations between 2011-2022. The sizes are categorized according to Table 5 description. The definitions of all variables are presented in Table 1.



Throughout the years, micro and small enterprises present the highest leverage ratios (Chart 4), representing the importance of debt for these firms, especially to fund and deal with daily operations. All sizes in general present a tendency to decrease leverage over time. The same trend visible in Chart 1 can also be seen for different firm sizes.

4.2 Baseline Model

Table 6 introduces the baseline model for corporate leverage threshold estimations, using both net and gross investment as dependent variables. The primary objective was to identify double thresholds for firm's leverage ratio in each regression and test their statistical significance. In regressions where double thresholds proved not to be significant, a single threshold model is applied. Then, in cases where there is not any single threshold, a linear model is employed to ensure comparability between leverage coefficients. In all threshold models, leverage is the regime-indicating variable and the regime-dependent regressor whose coefficients represent the effect of corporate leverage within distinct leverage regimes: below the first threshold, between the thresholds, and above second threshold. For example, in the second regression (Table 6), firms with a leverage ratio below 5.4% exhibit a positive and significant coefficient of leverage on investment of 2.069. In contrast, firms with a leverage ratio between 5.4% and 51.4% have a negative coefficient of -0.216, and those exceeding a leverage ratio of 51.4% display a coefficient of -0.123. This pattern highlights the non-linear relationship between leverage and investment, where low leverage is positively related with investment and higher leverage is negatively related.

In four regressions reported in Table 6, the first threshold occurs at a leverage ratio of 5.4%. Furthermore, firms operating below this threshold, accounting for approximately 4% of the sample[2], present a positive relationship between leverage and investment, as indicated by the positive and statistically significant coefficients. However, once the leverage ratio exceeds 5.4%, the coefficients turn negative, meaning that even moderate levels of leverage are negatively related with investment, aligning with the debt overhang problem (Myers, 1977). The majority of firms (80% to 93% of the sample), operate within intermediate leverage regimes. The second threshold is less uniform across regressions, with a value of 51.4% for net investment and 69.6% for gross investment regressions. Beyond these thresholds, leverage continues to exert a negative and significant relationship with investment, even though the magnitude of the negative coefficient is smaller compared to the intermediate leverage regime.

[2] Different grid points were tested in order to try to increase the percentage of firms within thresholds as suggested by Hansen (1999) to emphasise results, although it has no impact on this sample.

Table 5

Threshold Regression Analysis – Baseline Model

A double threshold is performed, and in case of statistical insignificance a single threshold is estimated. Different specifications were assessed, although removing variables from the model does not change the results neither the R^2. All explanatory variables are lagged by one period. Firm fixed effects are considered. Variables definitions are presented in Table 1. Heteroskedasticity-robust standard errors of all variables are reported in brackets. Only firms with 12 years of available data are used.

Threshold Estimate (2011-2022)	**Net Investment**			**Gross Investment**		
First Threshold	0.514	0.054	0.054	0.087	0.054	0.054
Second Threshold		0.514	0.514	0.696	0.696	0.696
Impact of Debt/Assets						
Low-Leverage Regime	-0.178***	2.069***	2.161***	0.458**	1.666***	1.741***
	(0.041)	(0.690)	(0.691)	(0.215)	(0.496)	(0.497)
Moderate-Leverage Regime		-0.216***	-0.220***	-0.141***	-0.176***	-0.178***
		(0.040)	(0.040)	(0.026)	(0.026)	(0.026)
High-Leverage Regime	-0.103***	-0.123***	-0.124***	-0.070***	-0.085***	-0.084***
	(0.033)	(0.033)	(0.033)	(0.026)	(0.026)	(0.026)
Covariates						
Debt Service	0.024***			0.017***		
	(0.005)			(0.004)		
Liquidity	0.012***	0.013***		0.009***	0.009***	
	(0.004)	(0.004)		(0.003)	(0.003)	
Sales Growth	0.003	0.003	0.003	0.004	0.004	0.004
	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)
Size	-0.213***	-0.212***	-0.209***	-0.157***	-0.156***	-0.154***
	(0.012)	(0.012)	(0.012)	(0.009)	(0.009)	(0.009)
Cash Flow	0.234***	0.354***	0.365***	0.168***	0.250***	0.258***
	(0.067)	(0.065)	(0.065)	(0.052)	(0.051)	(0.051)
Collateral	-1.984***	-1.993***	-2.018***	-1.426***	-1.432***	-1.451***
	(0.048)	(0.048)	(0.048)	(0.034)	(0.035)	(0.034)
Change in Leverage	0.017***	0.013**	0.014**	0.021***	0.018***	0.019***
	(0.006)	(0.006)	(0.006)	(0.004)	(0.004)	(0.004)
Firm Fixed Effects	YES	YES	YES	YES	YES	YES
R2 (Between)	0.064	0.064	0.065	0.035	0.035	0.036
Observations	75,427	75,427	75,427	75,427	75,427	75,427
Number of Firms	6,857	6,857	6,857	6,857	6,857	6,857
% of Obs. In Low-Debt Regime	84%	4%	4%	7%	4%	4%
% of Obs. In Moderate-Debt Regime		80%	80%	90%	93%	93%
% of Obs. In High-Debt Regime	16%	16%	16%	3%	3%	4%

***p-value < 0.01, **p-value < 0.05, *p-value < 0.1

For net investment, the coefficients for the moderate debt regime range between -0.220 and -0.216, while for the high debt regime they vary between -0.124 and -0.123. For gross investment, the coefficients for the moderate debt regime range between -0.178 and -0.141, while -0.085 and -0.070 for the high debt regime.

The reason the coefficient for leverage becomes less negative as firms are at a higher threshold is intriguing, since it goes against the findings of Gebauer et al. (2017), where the coefficients are more negative in higher debt regimes. Firms that are above the second threshold are, on average, smaller, have more than two times the leverage ratio, and half of the average net investment of firms in the moderate debt regime. This can be possibly explained by the reduced sensitivity of investment to leverage in the high-debt regime, since at high levels of leverage, firms are often highly constrained and already operating at minimal investment levels, leaving little room for further reductions in investment (Mendes et al., 2014). Consequently, additional increases in leverage have a smaller marginal impact on investment, leading to a less negative coefficient. Additionally, since the model only considers surviving firms, the ones in the high-debt regime may have adapted to financial constraints by prioritising survival strategies, such as paying financial obligations or seeking operational efficiency, thereby mitigating the impact of additional leverage on their already low investment levels. This reflects a reduction in the sensitivity between leverage and investment, as firms approach financial distress or operate at leverage saturation. The results are in line with hypothesis 1, where the relationship between a firm's leverage and investment is non-linear, with leverage having a significant and negative coefficient above a certain threshold, as suggested by Gebauer et al. (2017) and Hernando & Martínez-Carrascal (2008). Moreover, the findings align with Mendes et al. (2014), Serrasqueiro (2016) and Farinha & Prego (2013), who reported a negative relationship between leverage and investment for Portuguese firms. What is possible to add to prior research in Portugal is that leverage is negatively related with investment, but in a non-linear way, and with specific thresholds. Besides, in Table 6 the positive and significant coefficient for the change in leverage variable, presents that there is a positive relationship between firm's increasing their leverage ratio and investment, also found by Gebauer et al. (2017).

Even though the majority of the leverage coefficients appear significant, it is important to highlight that, as presented in Table 4, the percentage of observations in the upper and lower limit, in some regressions, range between 3% and 7%, representing a very small portion of firms in the analysis. Therefore, conclusions based on these results should be carefully considered, as it is challenging to generalise findings from a small percentage of observations.

The analysis of the remaining variables provides information in order to understand the variation of in investment. Firms with a higher capacity to repay debt using operational funds exhibit a positive and significant relationship with investment, emphasising the importance of financial health in facilitating growth. This goes in line with hypothesis 2, where debt service has a significant and positive relationship with investment, which matches with the findings from Gebauer et al. (2017). Liquidity has a positive and significant relationship with investment, highlighting how important it is to maintain adequate current assets to cover short-term liabilities. This finding is in line with hypothesis 3 and it is consistent with prior studies done by Hoshi et al. (1991) and Odit & Chittoo (2011), underlining the importance of financial stability as a prerequisite for investment, as maintaining a healthy liquidity position is not only vital for operational continuity but also serves as a foundation for pursuing investment opportunities. In contrast to Gebauer et al. (2017), sales growth is not statistically significant in the baseline model, although the results are aligned with previous literature in Portugal (Nunes et al., 2012) suggesting that it is not possible to take any statistically significant conclusion about the relationship between both variables, leading hypothesis 4 inconclusive. Furthermore, larger firms are observed to invest less, a result consistent with prior literature (Gala & Julio, 2012; Gebauer et al., 2017; Farinha & Prego 2013; Serrasqueiro, 2016) and in line with hypothesis 5, which will be explored further in subsequent sections. Cash flow, a measure of profitability, has a positive relationship with investment, highlighting the reliance of Portuguese firms on internal funds, aligning with pecking order theory (Myers & Majluf, 1984). These results confirm hypothesis 6, also matching with Serrasqueiro (2016), Nunes et al. (2012), Mendes et al. (2014), Oliveira & Fortunato (2006). It is interesting to observe that firm's sales do not have a statistically significant relation with investment, even though what is left from those sales, represented by cash flow, has a statistically significant and positive relationship. This suggests that sales fluctuations alone are not decisive for investment as it is the firm's ability to manage costs and maintain positive cash flow that determines whether funds are available for investment even when sales increase.

Additionally, the capacity to offer fixed tangible assets as collateral has a significant and negative relationship with investment, as also found by Gebauer et al. (2017), which leads to the rejection of hypothesis 8. Although firms with more tangible assets are expected to have better credit access and could consequently invest at a lower cost, this relation might be explained by some firms having already a high proportion of tangible assets in their balance sheets that may not be looking to invest more.

The thresholds differ when net investment and gross investment are considered, although the significance and qualitative interpretation of coefficients is consistent between the two variables. To better align the research goals with result interpretation, only net investment will be considered in subsequent analyses, as it focuses on genuinely new capital formation rather than capital replacement.

4.3 Size and Sectoral Analysis

In this section, additional tests were performed to verify how corporate leverage thresholds differ across industries and how variables change regarding the baseline model. Firstly, the sample was then divided into the industries for which the sample has the largest number of observations: Wholesale and retail trade; manufacturing; construction; and agriculture, animal production, forestry and fishing. The analysis of these subsamples reveals heterogeneity across sectors, as significant leverage thresholds were only found in the manufacturing industry. For the remaining industries, a linear model is presented. In the manufacturing industry, firms below 15.5% leverage experience a positive and statistically significant relationship with investment: a result also observable for leverage within 15.5% and 27.9%. For higher leverage ratios, it is not possible to take any conclusions from the debt-investment relationship. These findings cannot be directly compared with Gebauer et al. (2017), who did not find any significant relationship in this sector. The variable change in the leverage ratio is also positive and statistically significant for manufacturing firms, which might indicate that there are firms increasing their leverage ratio to invest in the subsequent period.

The positive leverage coefficients observed in the manufacturing industry may be attributed to its high capital requirements to enhance and innovate production capabilities, where leverage helps obtaining additional funds. Unlike other industries analysed, sales play a significant role in this sector, evidenced by a positive and statistically significant coefficient. This distinction could be explained by this industry being Portugal's largest exporter, benefiting from stable demand across diverse geographical markets. Additionally, the frequent sale of assets within this sector contributes to increased sales, further reinforcing financial stability. These factors likely enhance the credit-worthiness of manufacturing firms from the perspective of banks, which enables them to secure more favourable financing terms and leverage debt effectively for investment. This observation is in line with the SAFE 2023 report, which

highlights manufacturing as the leading sector in the use of bank loans, where firms emphasise their critical importance for funding investment (*Data and Surveys - SAFE*, 2023).

Table 6

Threshold Regression Analysis - Industry

A double threshold is performed, and in case of statistical insignificance a single threshold is estimated. If both threshold models are statistically insignificant, a linear model is presented to ensure comparability. Industries are chosen based on the number of observations in the sample. All explanatory variables are lagged by one period. Firm fixed effects are considered. Variables definitions are presented in Table 1. Heteroskedasticity-robust standard errors of all variables are reported in brackets. Only firms with 12 years of available data are used. The R2 presented is the "between" for threshold models and the "adjusted R2" for the linear ones.

	Net Investment			
Threshold Estimate (2011-2022)	**Wholesale and Retail Trade**	**Manufacturing**	**Construction**	**Agriculture, Animal P.,F., Fishing**
First Threshold		0.155		
Second Threshold		0.279		
Impact of Debt/Assets				
Linear Model	-0.102*		-0.202	-0.066
	(0.055)		(0.140)	(0.072)
Low-Debt Regime		0.960***		
		(0.227)		
Moderate-Debt Regime		0.226**		
		(0.097)		
High-Debt Regime		-0.004		
		(0.054)		
Covariates				
Debt Service	0.026***	0.028***	0.006	0.021
	(0.009)	(0.007)	(0.018)	(0.016)
Liquidity	0.013**	0.012*	0.032	-0.001
	(0.006)	(0.006)	(0.020)	(0.009)
Sales Growth	-0.011	0.015*	-0.009	0.012
	(0.009)	(0.008)	(0.006)	(0.011)
Size	-0.226***	-0.198***	-0.164***	-0.225***
	(0.021)	(0.016)	(0.062)	(0.045)
Cash Flow	0.237*	0.191*	0.485	0.017
	(0.126)	(0.094)	(0.302)	(0.185)
Collateral	-2.336***	-1.825***	-2.341***	-1.256***
	(0.096)	(0.071)	(0.295)	(0.169)
Change in Leverage	0.013	0.024***	-0.019	0.028
	(0.010)	(0.009)	(0.030)	(0.028)
Firm Fixed Effects	YES	YES	YES	YES
R2	0.063	0.070	0.065	0.088
Observations	32,395	29,447	3,597	3,355
# of Firms	2,945	2,677	327	311
% of Obs. In Low-Debt Regime		15%		
% of Obs. In Moderate-Debt Regime		23%		
% of Obs. In High-Debt Regime		62%		

***p-value < 0.01, **p-value < 0.05, *p-value < 0.1

For wholesale and retail trade firms, the model is not able to find non-linearities in the debt-investment relationship, thereby, a linear model is employed, revealing the negative and statistically significant relationship between leverage and investment. Nothing can be concluded for the construction and agriculture sectors.

Regarding the remaining explanatory variables, for both wholesale and retail trade and manufacturing firms, they generally behave consistently with previous results. Gebauer et al. (2017) found much less heterogeneity on leverage thresholds across sectors when compared with this research, potentially due to the number of observations which decreases considerably, especially for the construction and agriculture sectors.

In Table 7, the analysis considers firm size by dividing the sample according to the European Union's definitions (European Commission, 2003). The results confirm that leverage threshold estimations are not uniform across different firm sizes. Small enterprises have a moderate threshold at 43.5%, medium enterprises at 70.1%, and large enterprises at a notably low threshold of 3.7%. For micro firms, the model was not able to find a statistically significant threshold. For small firms, the coefficients for leverage are negative and statistically significant in both regimes, while for medium enterprises the relationship between leverage and investment is negative and statistically significant only for firms below 70.1% leverage ratio.

The main differences from the Gebauer et al. (2017) research is that in these results leverage has not proven statistically significant for Portuguese micro enterprises. No conclusions could be taken from the relationship between leverage and investment in larger enterprises, as also found by Gebauer et al. (2017).

Regarding the remaining explanatory variables, it is also important to highlight the decrease in the marginal effect of firm's debt service ratio as size increases, which reveals the importance of financial health in facilitating investment, essentially in firms with smaller sizes. For micro enterprises, sales growth has a positive and significant coefficient, which is something that it is not observable in the remaining sizes, which can be explained by firms reacting to increased market demand. This idea is also presented by Nunes et al. (2012), who argued that if firms present sales growth, there exists an opportunity to invest and expand production capacity. Regarding the cash flow variable, it is interesting to see that the marginal effect of cash flow is higher in micro firms than it is for smaller firms, revealing how micro firms are more sensible to internal funds, as discussed by Oliveira and Fortunato (2006). This positive relationship suggests that profitability and the ability to generate internal cash flows are crucial for investment decisions in smaller firms. The variable change in leverage is positive and statistically significant for both small and medium firms, possibly because these firms

already use leverage to invest, instead of just using it to finance daily activities and operational costs, as reported in the SAFE report (*Data and Surveys - SAFE*, 2023).

Table 7
Threshold Regression Analysis – Size

The sample is divided according to the European Union's definitions. Microenterprises have fewer than 10 employees and turnover or assets ≤ EUR 2 million. Small enterprises have fewer than 50 employees and turnover or assets ≤ EUR 10 million. Medium enterprises have fewer than 250 employees, with turnover ≤ EUR 50 million or assets ≤ EUR 43 million (European Commission, 2003). All explanatory variables are lagged by one period. Firm fixed effects are considered. Variables definitions are presented in Table 1. Heteroskedasticity-robust standard errors of all variables are reported in brackets. Only firms with 12 years of available data are used. For threshold regressions the R2 presented is the "between". For linear regressions, the adjusted R2 is presented.

	Net Investment			
Threshold Estimate (2011-2022)	**Micro Enterprises**	**Small Enterprises**	**Medium Enterprises**	**Large Enterprises**
First Threshold		0.435	0.701	0.037
Second Threshold				
Impact of Debt/Assets				
Linear Model	-0.027			
	(0.081)			
Low-Debt Regime		-0.265***	-0.212***	8.484
		(0.065)	(0.051)	(5.960)
Moderate-Debt Regime				
High-Debt Regime		-0.166***	-0.051	0.027
		(0.046)	(0.053)	(0.108)
Covariates				
Debt Service	0.048***	0.025***	0.014**	0.010
	(0.017)	(0.008)	(0.007)	(0.010)
Liquidity	0.006	0.016***	0.007	-0.010
	(0.008)	(0.005)	(0.006)	(0.018)
Sales Growth	0.031**	-0.006	0.006	0.007
	(0.014)	(0.004)	(0.007)	(0.011)
Size	-0.213***	-0.206***	-0.197***	-0.261***
	(0.032)	(0.016)	(0.020)	(0.052)
Cash Flow	0.399**	0.181**	0.035	0.100
	(0.160)	(0.089)	(0.106)	(0.156)
Collateral	-2.452***	-1.965***	-1.546***	-1.183***
	(0.135)	(0.062)	(0.085)	(0.190)
Change in Leverage	0.004	0.017**	0.034***	0.019
	(0.015)	(0.008)	(0.010)	(0.021)
Firm Fixed Effects	YES	YES	YES	YES
R2	0.060	0.050	0.035	0.045
Observations	15,257	40,920	16,621	2,629
# of Firms	1,387	3,720	1,511	239
% of Obs. In Low-Debt Regime		73%	98%	5%
% of Obs. In Moderate-Debt Regime				
% of Obs. In High-Debt Regime		27%	2%	95%

***p-value < 0.01, **p-value < 0.05, *p-value < 0.1

5. Robustness Analysis

To strengthen the robustness of the previously obtained results, this section introduces additional tests that address potential survivorship bias and capture the influence of distinct economic conditions on corporate investment decisions.

A critical concern with the sample used in the study is that it only includes firms with 12 consecutive years of data due to the balance panel data requirement (Wang, 2015), thereby excluding those that entered or exited the market during the study period. Such an exclusion can skew results by focusing solely on mature and surviving firms, which may systematically differ from those that failed or ceased operations.

Consequently, the full observation period was divided into three shorter intervals: 2011–2014, 2015–2019, and 2020–2022. This segmentation not only allows for the inclusion of firms that do not persist throughout the entire horizon, but also aligns the analysis with different macroeconomic periods in Portugal, which impact lending and investment level (Berger & Udell, 1998; Carbó-Valverde et al., 2016). The 2011–2014 period coincides with the euro area sovereign debt crisis, 2015–2019 reflects a phase of recovery and relative stability, and 2020–2022 coincides with the COVID-19 pandemic and the associated economic challenges.

In addition, a binary variable was introduced to identify whether a firm received governmental subsidies[3] (BPLIM) in the year preceding the investment. By incorporating this factor, the model not only captures whether government support plays a meaningful role in alleviating financial constraints and encouraging firms to invest, especially in different economic contexts, but also captures if firms keep investing the year after receiving support.

The results, presented in Table 8, reconfirm the non-linear relationship between leverage and investment, similar to what was observed in the main models. Across the three intervals, significant thresholds are found, and the leverage coefficient generally remains negative and statistically significant, although as also found before, the leverage-investment sensitivity decreases as leverage increases.

Firms with greater capacity to generate funds relative to their outstanding debt continue to present a positive relationship with investment. The size and collateral variables remain its negative and significant coefficients, with larger coefficients in absolute terms when compared with previous full-period analysis, mainly due to the inclusion of exiting firms, which are likely to investment less, intensifying the negative relationship.

[3] Cash flows from investing activities – Cash receipts from investment subsidies

Table 8

Threshold Regression Analysis – Year Intervals

The whole sample is divided into three time windows: 2011-2014, 2015-2019 and 2020-2022. All explanatory variables are lagged 1 period. A dummy variable is added to the model and equals 1 if a firm has received a subsidy in the year before the investment. Firm fixed effects are considered. Variables definitions are presented in Table 1. Heteroskedasticity-robust standard errors of all variables are reported in brackets. Only firms with 12 years of available data are used.

	Net Investment		
Threshold Estimate	**(2011-2014)**	**(2015-2019)**	**(2020-2022)**
First Threshold	0.584	0.443	0.684
Second Threshold		0.816	
Impact of Debt/Assets			
β_1 (Low-Debt Regime)	-0.326***	-0.499***	-0.243***
	(0.044)	(0.091)	(0.094)
β_2 (Moderate-Debt Regime)		-0.335***	
		(0.071)	
β_3 (High-Debt Regime)	-0.179***	-0.133**	0.047
	(0.029)	(0.063)	(0.064)
Covariates			
Debt Service	0.030***	0.024***	0.017*
	(0.009)	(0.008)	(0.010)
Liquidity	-0.004	0.012*	-0.002
	(0.006)	(0.006)	(0.009)
Sales Growth	0.003	0.003	0.003
	(0.004)	(0.004)	(0.005)
Size	-0.684***	-0.657***	-1.146***
	(0.038)	(0.032)	(0.070)
Cash Flow	-0.082	0.003	-0.086
	(0.061)	(0.097)	(0.136)
Collateral	-4.654***	-4.747***	-6.793***
	(0.117)	(0.116)	(0.197)
Change in Leverage	0.009	0.031***	-0.030***
	(0.007)	(0.009)	(0.011)
Dummy Subsidy	-0.005	-0.001	-0.014
	(0.018)	(0.016)	(0.029)
Firm Fixed Effects	YES	YES	YES
R2 (Between)	0.005	0.037	0.016
Observations	69,036	50,432	34,118
# of Firms	23,012	12,608	17,059
% of Obs. In Low-Debt Regime	85%	73%	93%
% of Obs. In Moderate-Debt Regime		24%	
% of Obs. In High-Debt Regime	15%	2%	7%

***p-value < 0.01, **p-value < 0.05, *p-value < 0.1

Variables like liquidity and cash flow lose their statistical significance, and this can be caused by firms leaving the market which probably have exhausted their liquid reserves to cover

operational losses, service debt, or are simply unprofitable firms, whose volatile or negative cash flows may have prevented them from sustaining investments and grow. Additionally, between 2015 and 2019 liquidity has a significant and positive coefficient, which indicates that liquidity is positively related with investment in stable economic periods. Interestingly, during 2020-2022 the coefficient for change in leverage is statistically significant, and for the first time negative which means that some firms were probably leveraging themselves to cover for operational losses or fixed costs during COVID-19 pandemic. Between 2015 and 2019, which represents a more stable economic period, firms change in leverage has a positive relationship with investment. These results are in line with Farinha & Félix (2015) and Pinto et al. (2023) who found that during financial crises, firms in Portugal tend to borrow money in order to finance their operational activities, instead of borrowing for investment purposes.

Regarding the dummy subsidy variable, there are no statistically significant coefficients, so no conclusions can be taken from the relationship between firms receiving subsidies and their investment in the subsequent period.

Other specifications are presented in Table 9, specially to test different dynamics and firm characteristics. First, the firm size variable is redefined as the natural logarithm of total employees, providing an alternative measure of size (Carpenter & Guariglia, 2008; Lang et al., 1996). Then, firms are divided into three samples, the first focuses on firms with at least four consecutive years of investment, in order to capture which firm characteristics better explain long-term investment capacity. The second and third subsamples split firms into "high profit" and "low profit" groups based on the median cash flow value of the sample (5.3%). Firms to be selected into "high profit" group should have, throughout the entire 12 years of data, all cash flow observations above the median, and vice versa for the "low profit" group. This split aims to assess whether less profitable firms, which are more likely to be constrained by limited internal funds, are still able to invest by leveraging external financing as an alternative.

When considering firms with at least 4 consecutive years, the model finds an incredibly low leverage threshold, as it does for "high profit" firms. In both models, the coefficients are positive and statistically significant and become negative as firms move to higher leverage ratios. Additionally, cash flow remains its positive relationship with investment as internal funds seem to play a critical role for firms that invest consecutively. For these 2 specifications, the results are in line with the baseline model (Table 5), even when a different measure of size is used. For the "low profit" specification, the leverage coefficients are always positive and statistically significant, independently from the leverage threshold, which could indicate that these firms use debt as an alternative to internal funds.

Table 9

Threshold Regression Analysis – Other Specifications

Variables description are in Table 1. All explanatory variables are lagged 1 period. Employee size is an alternative of firm's size, measured by natural logarithm of total employees. "4 Consecutive Years" refers to firms with at least 4 consecutive years of positive investment. Whether a firm is used in "High Profit" or "Low Profit" models, depends on whether cash flow is above or below cash flow sample median (5.3%). Firm fixed effects are considered. Heteroskedasticity-robust standard errors of all variables are reported in brackets. Only firms with 12 years of available data are used.

	Net Investment		
Threshold Estimate (2011-2022)	**4 Consecutive Years**	**High Profit**	**Low Profit**
First Threshold	0.064	0.083	0.212
Second Threshold			
Impact of Debt/Assets			
β_1 (Low-Debt Regime)	2.302**	1.434**	0.984***
	(1.087)	(0.587)	(0.315)
β_2 (Moderate-Debt Regime)			
β_3 (High-Debt Regime)	-0.396***	-0.229***	0.230**
	(0.063)	(0.076)	(0.095)
Covariates			
Debt Service	0.017**	0.013*	0.004
	(0.008)	(0.007)	(0.023)
Liquidity	0.021***	0.001	0.001
	(0.009)	(0.008)	(0.011)
Sales Growth	-0.002	-0.006	-0.001
	(0.007)	(0.005)	(0.012)
Employee Size	-0.049**	-0.136***	-0.036
	(0.022)	(0.028)	(0.053)
Cash Flow	0.511***	0.604***	-0.081
	(0.132)	(0.161)	(0.361)
Collateral	-1.905***	-1.560***	-2.318***
	(0.074)	(0.096)	(0.247)
Change in Leverage	0.040***	0.012	0.014
	(0.012)	(0.010)	(0.028)
Dummy Subsidy	-0.018	-0.003	-0.041
	(0.014)	(0.013)	(0.030)
Firm Fixed Effects	YES	YES	YES
R2 Between	0.070	0.063	0.018
Observations	18,678	12,243	6,050
# of Firms	1,698	1,113	550
% of Obs. In Low-Debt Regime	5%	10%	19%
% of Obs. In Moderate-Debt Regime			
% of Obs. In High-Debt Regime	95%	90%	81%

***p-value < 0.01, **p-value < 0.05, *p-value < 0.1

This result is emphasised as the cash flow variable loses its significance. This conclusion is in line with pecking order theory (Myers & Majluf, 1984), although it is important to highlight that the average investment rate is 7.85% for "low profit" firms and 12.91% for "high profit" firms, while average leverage is 37.23% and 29.09% for each one respectively. Meaning that even though the coefficients are positive and statistically significant, leverage itself does not lead to the same investment levels as internal funds do.

6. Is Debt Always Negative?

Along the research, the coefficient of leverage on investment has consistently proven to be negative and statistically significant across the majority of the different specifications tested.

To further investigate the relationship between leverage and investment, this section explores how indebtedness varies across the investment distribution. For that purpose, quantile regressions are employed, using 274,623 firms. This approach allows to study leverage at different investment intensities, particularly capturing heterogeneity among high and low investment firms.

In this analysis, leverage is divided into long-term and short-term debt. The goal is to break down debt and see how both variables behave across the distribution, as long-term financing is often used to finance huge capital expenditures or to strategically spread financial obligations throughout time, while short-term debt is often used to finance daily operations or fill cash flow gaps. Alongside these, all the other variables used in the study are presented in Table 10.

The results suggest once more the non-linearity between leverage and investment. The coefficient for long-term debt is negative and statistically significant until net investment reaches its 90th percentile, where it becomes positive and statistically significant. In other words, for firms with annual investment rates of at least 47%, the relationship between long-term debt and investment is positive. This result is aligned with Serrasqueiro (2016) who finds leverage to be positively related with high investment firms and with Mendes et al. (2014) who finds the same for young SME's. Furthermore, it seems that firms tend to use long-term debt when the necessary funds to perform the investment are higher than the internal available resources, as the cash flow coefficient decreases as firms move from the 90^{th} to the 95^{th} percentile. As previously thought, there is no evidence in the usage of short-term debt to finance investments.

Table 10

Quantile Regression Analysis

Only firms with 3 consecutive years are considered. Both industry and year fixed effects are considered. All explanatory variables are lagged 1 period. Long-term debt is defined as the ratio between non-current obtained funding and total assets. Short-term debt is defined as the ratio between current obtained funding and total assets. The remaining variables description are reported in Table 1. Regressions use data between 2011-2022 and 274,623 firms. Heteroskedasticity-robust standard errors of all variables are reported in brackets.

	OLS	5th	10th	25th	50th	75th	90th	95th
Long-Term Debt	-0.012	-0.105***	-0.080***	-0.053***	-0.029***	-0.021***	0.025***	0.070***
	(0.010)	(0.008)	(0.004)	(0.002)	(0.001)	(0.002)	(0.008)	(0.028)
Short-Term Debt	-0.048***	-0.146***	-0.093***	-0.056***	-0.031***	-0.036***	-0.024*	-0.021
	(0.013)	(0.012)	(0.007)	(0.003)	(0.001)	(0.003)	(0.009)	(0.041)
Debt Service	0.015***	-0.004***	-0.003***	-0.001***	0.002***	0.020***	0.056***	0.105***
	(0.002)	(0.001)	(0.001)	(0.0003)	(0.0003)	(0.001)	(0.004)	(0.014)
Liquidity	-0.004***	0.004***	0.004***	0.004***	0.001***	-0.003***	-0.009***	-0.015***
	(0.001)	(0.001)	(0.001)	(0.0002)	(0.0001)	(0.0004)	(0.002)	(0.006)
Sales Growth	0.014***	-0.0004	-0.0003	0.001*	0.002***	0.011***	0.029***	0.050***
	(0.001)	(0.001)	(0.001)	(0.0004)	(0.0002)	(0.001)	(0.002)	(0.008)
Size	-0.013***	0.042***	0.038***	0.029***	0.016***	0.001***	-0.037***	-0.074***
	(0.001)	(0.001)	(0.001)	(0.0002)	(0.0001)	(0.0003)	(0.001)	(0.004)
Cash Flow	0.458***	0.286***	0.155***	0.070***	0.117***	0.249***	0.462***	0.402***
	(0.012)	(0.016)	(0.010)	(0.004)	(0.001)	(0.004)	(0.022)	(0.080)
Collateral	-0.514***	0.503***	0.406***	0.260***	0.099***	-0.125***	-0.830***	-1.862***
	(0.009)	(0.006)	(0.003)	(0.002)	(0.001)	(0.003)	(0.010)	(0.029)
Change in Leverage	0.016***	0.008***	0.004***	-0.0004	0.003***	0.019***	0.040***	0.046***
	(0.003)	(0.002)	(0.001)	(0.006)	(0.0004)	(0.001)	(0.005)	(0.010)
Industry Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Number of Obs	274,623	274,623	274,623	274,623	274,623	274,623	274,623	274,623
Number of Firms	56,541	56,541	56,541	56,541	56,541	56,541	56,541	56,541
R2/Pseudo R2	0.026	0.132	0.119	0.071	0.018	0.020	0.054	0.093

7. Conclusion

This research investigates the non-linear relationship between corporate leverage and firm investment in Portuguese firms over the period of 2011-2022, focusing on trying to find specific thresholds where leverage might have a different relationship with investment. Using a balanced panel dataset of 6,857 firms and 82,284 firm-year observations, the study controls for additional variables that might explain the variation in investment, such as debt service capacity, liquidity, sales growth, size, cash flow, collateral, and changes in leverage. Additional specifications, including industry and firm size heterogeneity provide a more complete study on the non-linear relation between leverage and investment.

The findings reveal that the sensitivity of investment to leverage decreases as firms take on more debt, suggesting a saturation effect where higher leverage constrains additional

investment. While leverage has a negative relationship with investment, firms with higher net investment rates (above 46%) are positively related with long-term debt, which might indicate that debt is often used when substantial investments are performed and internal funds are insufficient.

Among industries, only the manufacturing sector demonstrates a positive relationship between leverage and investment, likely due to its high capital requirements and critical role in the economy, facilitating borrowing from banks. Micro and small enterprises, which dominate the Portuguese economy, are more dependent on internal financing and are expected to face higher financing costs, probably due to poorer credit-worthiness. In periods of economic crisis, the significance of liquidity and cash flow diminishes, as firms may prioritise survival over growth, reducing overall investment. The results also demonstrate that firms able to sustain consistent investment rely heavily on internal profits and cash flows, rather than on debt. For "low profit" firms, there is the possibility of leverage to be an alternative when internal funds are scarce, although the average investment rate for "high profit" is higher, as the latest are expected to rely more on internal funds.

However, the results suggest that Portuguese firms may need to deleverage, as moderate and high leverage ratios are negatively related with investment across the majority of firms, aligning with the findings of Gebauer et al. (2017).

Future research could explore alternative threshold estimation methods that retain more firms in the sample, potentially identifying more robust and consistent thresholds. In addition, this study analyses lagged variables, additional insights could be found if leverage and investment were measured in the same year, or how do these explanatory variables explain leverage in the subsequent period. Finally, examining the role of bank-firm relationships could be particularly valuable, given the localized nature of Portuguese firms.

Overall, the study contributes to a better understanding of the relationship between leverage and investment, especially in the case of Portugal, where financial markets are underdeveloped and banks play a critical role in lending to firms and helping them to invest when internal funds are scarce.

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