



Financial Distress and Interest Rate Sensitivity in Portuguese SMEs

Ricardo Sousa

Dissertation written under the supervision of professor Ricardo
Reis

Dissertation submitted in partial fulfilment of requirements for the MSc
in Finance, at the Universidade Católica Portuguesa, January 5th, 2026.

Abstract

This dissertation aims to investigate how interest rate fluctuations affect the probability of financial distress among Portuguese small and medium-sized enterprises (SMEs). The research employs a panel data set, consisting of 8,048 Portuguese SMEs from 2007 to 2024, to examine the effects of changes in financing costs, measured by the Portuguese treasury bond yield, on the probability of distress of Portuguese SMEs. Financial distress is measured using Altman's Z'-score, allowing to distinguish firms depending on their vulnerability level. The empirical analysis applies logistic regression models and tests the moderating roles of leverage, liquidity and industry classification. The findings show the positive and significant relationship between the Portuguese treasury bond yield and the SMEs probability of distress, supporting the argument that tighter financing conditions increase the level of vulnerability of these firms. This relationship is mediated by firm-level characteristics, with leverage presenting a strong positive effect on financial distress risk, while liquidity mitigates this effect. Evidence of sectoral heterogeneity indicates that the impact of interest rate changes differs across industries, reflecting differences in capital intensity and financing dependence. Robustness tests using alternative model specifications, lagged controls and different yield maturities support the consistency of results. The overall implications of these results emphasize that sovereign yield dynamics are an important macro-financial variable influencing SMEs distress in Portugal, reinforcing the importance of financial structure in shaping resilience to monetary tightening.

Keywords: financial distress, SMEs, interest rates, sovereign yield, Altman Z'-score, Portugal, monetary policy, financial structure.

Title: Financial Distress and Interest Rate Sensitivity in Portuguese SMEs

Author: Ricardo Sousa

Resumo

Esta tese investiga de que forma as flutuações das taxas de juro afetam a probabilidade de dificuldade financeira das pequenas e médias empresas (PMEs) portuguesas. A análise baseia-se num conjunto de dados em painel composto por 8,048 PMEs portuguesas no período entre 2007 e 2024, permitindo avaliar o impacto das variações nos custos de financiamento, medidos pelo rendimento das Obrigações do Tesouro portuguesas, sobre o risco de dificuldade financeira. A dificuldade financeira é medida através do Z'-score de Altman, possibilitando a classificação das empresas de acordo com o seu nível de vulnerabilidade. A metodologia empírica recorre a modelos de regressão logística e analisa os efeitos moderadores do endividamento, da liquidez e da classificação setorial. Os resultados evidenciam uma relação positiva e estatisticamente significativa entre o rendimento das Obrigações do Tesouro e a probabilidade de dificuldade financeira das PMEs, sustentando a ideia de que condições de financiamento mais restritivas aumentam a vulnerabilidade destas empresas. Este efeito é condicionado por características ao nível da empresa, sendo que o endividamento apresenta um impacto positivo relevante no risco de dificuldade financeira, enquanto a liquidez contribui para mitigar esse efeito. Adicionalmente, a evidência de heterogeneidade setorial indica que o impacto das alterações das taxas de juro difere entre indústrias, refletindo diferenças na intensidade de capital e na dependência de financiamento. Testes de robustez com especificações alternativas, controlos defasados e diferentes maturidades das yields confirmam a consistência dos resultados, sublinhando a relevância das yields soberanas como variável macrofinanceira determinante da fragilidade financeira das PMEs em Portugal.

Palavras-chave: dificuldade financeira, PMEs, taxas de juro, Obrigações do Tesouro, Z'-score de Altman, Portugal, política monetária, estrutura financeira.

Título: Financial Distress and Interest Rate Sensitivity in Portuguese SMEs

Autor: Ricardo Sousa

Acknowledgments

I would like to express my sincere gratitude to the professors of the MSc in Finance program at Católica. Their guidance, expertise, and academic rigor were fundamental to the completion of this thesis. The knowledge and analytical skills developed throughout the program played a crucial role in my academic growth, and I am truly thankful for their support.

I am especially grateful to my supervisor, Professor Ricardo Reis, for his continuous guidance throughout this research. His insightful feedback, constructive suggestions, and constant encouragement were invaluable during the entire process. His support helped me remain motivated and focused, and I sincerely appreciate the time and effort he dedicated to supervising this work.

I would also like to thank my friends and family for their constant encouragement and support. Their confidence in me and understanding during this demanding period provided essential motivation and reassurance. I am deeply grateful for their patience and presence throughout this journey.

Finally, I would like to thank everyone who, directly or indirectly, contributed to the completion of this thesis. Your support was essential, and I am genuinely thankful for all your contributions.

Table of Contents

1. Introduction	8
2. Literature Review	11
2.1 Financial Distress Prediction Models.....	11
2.2 Monetary Policy and Corporate Vulnerability	12
2.3 Structural Constraints and Distress in Portuguese SMEs.....	13
2.4 Macroeconomic Shocks and Research Gap	14
3. Research Hypothesis	16
4. Data and Methodology	19
4.1 Data source and Sample Selection	19
4.2 Data Cleaning.....	19
4.3 Variable Construction	20
4.3.1 Dependent variable: Financial Distress.....	20
4.3.2 Independent Variables.....	22
4.4.2 Econometric Specification	26
5. Results	28
5.1 Hypothesis 1	28
5.2 Hypothesis 2 & 3.....	30
5.3 Hypothesis 4.....	33
6. Robustness tests.....	36
6.1 Endogeneity.....	36
6.2 OLS regressions	37
6.3 Alternative interest rate measure.....	38

7.	Conclusion.....	40
7.1	Limitations	41
7.2	Future Research.....	42
8.	References	44
9.	Appendix	46

List of Tables

Table 1. Distribution of the sample.....	21
Table 2. Distribution of the sample by industry.....	22
Table 3. Definition of the main variables.....	23
Table 4. Descriptive statistics.....	24
Table 5. Correlation matrix of the main variables.....	25
Table 6. H1- Main results.....	28
Table 7. H2 & H3 - Main results.....	30
Table 8. H4 - Main results.....	33
Table 9. H2 - Main results.....	46
Table 10. H3 - Main results.....	47
Table 11. H1 - Endogeneity robustness test.....	48
Table 12. H2 - Endogeneity robustness test.....	49
Table 13. H3 - Endogeneity robustness test.....	50
Table 14. H2 & H3 - Endogeneity robustness test.....	51
Table 15. H1 - OLS robustness test.....	52
Table 16. H2 - OLS robustness test.....	52
Table 17. H3 - OLS robustness test.....	53
Table 18. H2 & H3 - OLS robustness test.....	54
Table 19. H4 - OLS robustness test.....	55
Table 20. H1 - 5yOT robustness test.....	56
Table 21. H2 - 5yOT robustness test.....	56
Table 22. H3 - 5yOT robustness test.....	57
Table 23. H2 & H3 - 5yOT robustness test.....	58
Table 24. H4 - 5yOT robustness test.....	59

List of Equations

Equation 1. Altman's Z'-score for private firms.....	20
Equation 2. Model estimation.....	26

1. Introduction

The financial stability of small and medium-sized enterprises (SMEs) is a central issue in Europe. In Portugal, SMEs represent 99.9% of the country's enterprises and are responsible for 63.6% of the Gross Domestic Product (GDP) (INE, 2025), reinforcing their importance in the employment, economic health and growth of the country. Despite their significance, SMEs are particularly vulnerable to financial shocks, including a high reliance on bank financing, limited access to capital markets and thin liquidity buffers. Understanding the financial distress determinants of this type of enterprises should therefore be a priority.

Cost of financing is one of the most important drivers of financial distress. The recent cycle of monetary policy tightening by the European Central Bank (ECB), has risen interest rates to their highest level in over a decade, having a direct impact on the Portuguese SMEs borrowing costs, most of which are indexed to Euribor. In an interest rate hiking cycle, firms face higher debt costs, which in most of them leads to a reduced profitability, decreased investment capacity or in the worst case, a situation in which a firm faces financial distress or bankruptcy.

While most of the SMEs credit contracts in Portugal are linked to Euribor, it does not fully represent the actual financing costs faced by firms. Portuguese banks lending spreads are highly volatile depending on market conditions, perceived credit risk and sovereign spreads. Therefore, this dissertation uses the Portuguese treasury bond yield (Obrigações do Tesouro, OTs), as a more accurate representation of the domestic cost of capital. OTs capture both the monetary policy stance and the country risk premium, allowing to measure the true sensitivity of SMEs to national credit conditions.

Recent developments in Portuguese sovereign bond markets further support the suitability of OTs as a proxy for domestic financing conditions. In March 2024, subsequent to Standard & Poor's upgrade of Portugal's sovereign rating, the yield on 10-year OTs fell faster than the German Bund yield, pressing the Portugal-Germany spread to its lowest level since 2022 (ECO, 2024). This is a further illustration of how changes in perceived sovereign risk and investor confidence are rapidly transmitted into sovereign yields, thus affecting firm's cost of finance.

The literature on financial distress is well developed. Seminal models such as Altman's Z-score (1968), Ohlson's O-score (1980), and even hazard models such as Shumway (2001), have demonstrated a huge predictive power of financial ratios in explaining financial distress events. More recent research has extended these models with both advanced econometrics and machine learning approaches. At the same time, new research has explored how macroeconomic and policy uncertainty impacts firm fragility, evidencing that SMEs are especially exposed to financial condition shifts and external shocks. For instance, a new study in European SMEs shows that financial distress likelihood increases during periods of economic policy uncertainty, with family ownership and performance aspirations playing a moderate role (Fadi Hawach & Ignacio Requejo, 2025). This perspective emphasizes the relevance of monetary and policy environments in shaping SMEs resilience.

Despite these contributions, there is still an important gap remaining: there is no empirical evidence, to the best of our knowledge, on how monetary policy and interest rate changes affect the distress probability of Portuguese SMEs. This thesis aims to fill this gap with a focus on the sensitivity of Portuguese SMEs distress to interest rate movements, using firm-level data from SABI database and Portuguese treasury bond yields.

This research addresses the following question: How sensitive are Portuguese SMEs to interest rate changes in terms of financial distress probability? Also, it tests whether this sensitivity changes across different levels of leverage and liquidity, and also across different industries.

This dissertation contributes to the literature in three different ways. First, it provides the first evidence of the relationship between interest rate changes and distress in Portuguese SMEs. Second, it combines classical financial distress models and macro-finance variables, integrating two streams of research. Third, it provides valuable insights regarding Portuguese SMEs vulnerabilities in different monetary environments.

The empirical analysis utilizes logistic regression models estimated for Portuguese SMEs over the period 2007-2024. Financial ratios (leverage, profitability, liquidity) are combined with interest rates (OTs) and other interaction terms to capture sensitivity. The results will provide us insights into the extent to which financing costs impact SMEs stability and whether there is any consistent pattern across firms and industries.

This thesis is structured as follows. Chapter 2 reviews the literature on financial distress prediction, monetary policy transmission and SME vulnerabilities in Portugal. Chapter 3 defines each hypothesis. Chapter 4 describes both data and methodology. Chapter 5 presents and discusses empirical results. Robustness analyses are detailed in Chapter 6, confirming the consistency of the main findings. Chapter 7 concludes the study with policy implications and directions for future research.

2. Literature Review

The literature review section provides an overview of the main empirical studies on financial distress, monetary policy and SME vulnerability. It examines both traditional and modern distress prediction models and then reviews research on the effects of interest rates and financing costs on firm fragility, with a particular focus on Portuguese SMEs. Taken together, these literatures will give us theoretical foundation and empirical motivation from which the hypotheses of this dissertation are developed.

2.1 Financial Distress Prediction Models

Financial distress prediction has been one of the most studied topics in corporate finance and accounting research. Beaver's (1966) pioneering study has shown the first evidence on how financial ratios could differentiate between failing and non-failing firms. This area of study was furthered by Altman (1968) with his Z-score model, which is one of the most cited and popular models of financial distress prediction. The Z-score model was created using a multiple discriminant analysis (MDA) technique, allowing the analyses of multiple financial ratios and their relationships simultaneously. It combines five different key financial ratios (profitability, leverage, liquidity, solvency and activity). Although the original model was developed for sixty-six US manufacturing firms, its structure has been replicated and adapted for private firms and non-manufacturing firms (Altman 2000).

Ohlson (1980) introduced a probabilistic logit model, known as the O-score, to overcome some limitations of the MDA approach. His model allows for a more flexible estimation and incorporates additional variables, such as firm size and performance. Unlike earlier models, the O-score does not assume multivariate normality and allows for a financial distress estimated probability rather than just a simple binary classification, with a strong predictive accuracy. Later, Shumway (2001) suggested that bankruptcy risk should be modeled in a dynamic way, introducing hazard models, aiming to capture the time-varying probability of default. These advances marked the transition from static classification models to other dynamic approaches that fully recognize the evolving nature of financial distress risk. Shumway evidenced that traditional static models such as Altman's Z-score and Ohlson's O-score were biased and inefficient since they did not

incorporate time-varying risk. His results corroborated the importance of dynamic estimation in bankruptcy prediction.

More recently, machine learning methods have become increasingly important regarding financial distress prediction. According to Barboza, Kimura & Altman (2017), several machine learning models, such as bagging, boosting and random forest, achieve higher predictive accuracy compared with the traditional approaches. However, machine learning still poses challenges in interpretability, which is essential for policymakers and bank supervisors.

Despite these methodological improvements, most distress prediction studies are focused on large and listed companies in developed markets. SMEs remain underrepresented, even though their greater vulnerability due to financial constraints. This gap motivates research that brings distress models into the SME context, particularly in countries like Portugal, where SMEs are predominant in the economy and are heavily bank dependent.

2.2 Monetary Policy and Corporate Vulnerability

A second stream of research stresses the role of financing costs and the macroeconomic conditions in determining corporate vulnerability. Rising interest rates increase debt servicing costs, reduce liquidity and intensify the probability of distress, especially for highly leveraged firms. The financial accelerator theory captures this mechanism. Adverse shocks deteriorate firms balance sheets, lowering collateral value and increasing debt servicing costs, further amplifying the initial shock.

Empirical studies provide consistent support. Opler & Titman (1994) found that there is a performance discrepancy in highly leveraged firms during industry downturns, reflecting their reduced flexibility to absorb shocks. During these downturns, firms in the top leverage decile experienced 26% larger sales declines than firms in the bottom decile, while also experienced a similar drop in equity market value. Similarly, new evidence provided by Cloyne, Ferreira, Froemel and Surico (2023), demonstrates that monetary policy shocks have a heterogeneous impact on firms depending on balance-sheet strength. They reveal that younger firms, which tend to present weaker balance sheet collateral and a higher degree of dependence on external finance, cut capital spending and borrowing significantly more during an interest rate hike. The findings support the idea that

firms with more vulnerable balance sheets are more adversely impacted by monetary policies in an interest rate hike setting, where higher financing costs makes firms more vulnerable.

In Europe, the relationship between macroeconomic shocks and firms' vulnerability has been widely researched. Gilchrist and Mojon (2014) develop credit-risk indices for euro-area banks and non-financial corporations based on bond yield spreads over German government bonds of matched maturities, capturing significant increases in market funding costs during tough times, such as the global financial and sovereign debt crises, and showing that these spreads predict real activity. While their country-level aggregation consists of Germany, France, Italy and Spain, the greater implication is that market yields and credit spreads are critical to financing conditions in these kinds of economies. Altavilla, Canova & Ciccarelli (2020), demonstrate that domestic sovereign spreads and yields affect bank lending rates and credit supply in the euro-area, which also validates the use of Portuguese Treasury yields (OTs) as a suitable proxy for financing conditions in this study.

2.3 Structural Constraints and Distress in Portuguese SMEs

Portuguese SMEs represent 99.9% of the country's enterprises, taking a critical role in employment and economic stability. Due to their high reliance on bank financing, low negotiation capacity and narrow financing options, SMEs are particularly vulnerable to external shocks. Recent studies on Portuguese SMEs confirm that factors like leverage, profitability, liquidity and size are key determinants of financial distress.

Farinha & Félix (2015) emphasize that these financial frictions are structural in the Portuguese context, since SMEs are still highly reliant on bank credit, with little access to different funding sources. Their study shows that credit rationing affects smaller, younger and less profitable firms more heavily, which are precisely the ones most vulnerable to distress in times of tougher financial conditions. This suggests that supply credit constraints may aggravate structural weaknesses at the firm level.

Tong & Serrasqueiro (2021) examine the predictive power of financial ratios for business failure and financial distress among Portuguese SMEs, with a particular emphasis on high and medium-technology sectors. They confirm that profitability, liquidity and leverage consistently act

as significant predictors of financial distress, also for innovative firms, which might otherwise be expected to present distinct financial structures. By demonstrating that traditional accounting ratios still retain significant explanatory power in the SME context, their research reinforces the relevance of firm fundamentals in distress prediction but also suggesting that sectoral differences may condition the degree of vulnerability.

These studies highlight both the firm-level structural financing vulnerabilities of Portuguese SMEs and also the continued relevance of conventional financial metrics in distress prediction. This provides a strong basis for this dissertation, since it extends the literature by analyzing how firm-level vulnerabilities are affected by financing costs changes due to interest rate fluctuations.

2.4 Macroeconomic Shocks and Research Gap

A recent and particularly relevant contribution is the study by Hawach & Requejo (2025), which examined the *financial distress likelihood of European SMEs under conditions of economic policy uncertainty*. Their work is extremely relevant for two reasons. First, it establishes a direct link between macroeconomic shocks and firm-level distress and thus connects both financial distress prediction and macro-finance literature. Second, it underscores the heterogeneous nature of SMEs, showing that factors including family ownership and performance aspirations play a moderating role in the effect of uncertainty on distress.

By using a dataset of more than 145,000 SMEs across 24 European countries between 2012 and 2021, the authors define distressed firms using the Altman Z'-score ($Z' < 1.23$) and combine it with economic policy uncertainty (EPU) indices. This method allows them to capture how external shocks interact with firm-level characteristics, such as profitability, leverage, tangibility and age. Their results show that these shocks do not affect identically in the whole sample, with Greece and Italy experiencing the highest distress incidence, while Sweden and Luxembourg are considerably more resilient. This strong heterogeneity supports that both macroeconomic environment and firm structure are the determinants of distress, a point particularly relevant when focusing on the Portuguese context.

This study demonstrates that SME vulnerabilities cannot be fully explained only by firm specific financial ratio, but rather, by exposure to external shocks combined with structural and behavioral firm characteristics. Although Hawach & Requejo (2025) consider the effect of economic uncertainty rather than interest rates, their work is very important since it explains how macro-financial shocks can be connected to SMEs distress using European firm-level data. In this way, their suggested methodology can be seen as a reference for exploring how another key macroeconomic factor, interest rate fluctuations, could have a similar impact on the financial stability of SMEs, but in the Portuguese context. By adjusting their framework, this thesis strengthens the existing literature by focusing on interest rate sensitivity, rather than policy uncertainty, and by investigating the particular challenges faced by Portuguese SMEs.

What remains unexplored is the extent to which monetary conditions, specifically interest rates, affect Portuguese SMEs. Given the recent cycle of ECB rate hikes, raising financing costs in an economy with a structural reliance on bank credit, this is a timely moment to fill an important gap in the existing literature. By dealing with this underexamined dimension, this dissertation aims to advance the current empirical research with timely evidence about how monetary policy and SME resilience interrelate.

3. Research Hypothesis

The primary aim of this dissertation is to explore how Portuguese SMEs are sensitive to interest rate fluctuations in term of financial distress probability. Building on the literature of financial distress prediction, macro-financial transmission and SME vulnerabilities, four hypotheses were formulated to guide the basis of this empirical analysis. Each hypothesis is based on well-established theories and empirical findings but adapted to the Portuguese SME context and the new monetary tightening cycle.

I. Hypothesis 1

The first hypothesis provides the foundation for this dissertation. The cost of financing has been prominently recognized as a key determinant of financial fragility. When monetary policy tightens and consequently pushes interest rates up, servicing debt costs rise, which directly impacts both firms cash flows and profitability. Since the majority of Portuguese SMEs are heavily bank dependent, this effect is amplified by their reduced access to capital markets and ability to hedge interest rate risk.

The literature notes the functioning of monetary policy through aggregate demand, but also through the financial accelerator mechanism (Bernanke, Gertler & Gilchrist, 1996), where higher financial costs lead to the increase of existing vulnerabilities. New evidence for European SMEs during macroeconomic uncertainty (Hawach & Requejo, 2025), also show that small firms are especially exposed to changes in the financial environment. In Portugal, although loans are predominantly indexed to the three-month Euribor, which is generally the benchmark rate used in studies (Banco de Portugal, 2025), this thesis uses the Portuguese Treasury bond yields (OTs), since it better reflects the actual financing conditions faced by firms. Increases in interest rates results into higher borrowing costs. Therefore, a positive relationship is expected between interest rate increases and the probability of financial distress in Portuguese SMEs.

H1: Higher interest rates increase the probability of distress among Portuguese SMEs.

II. Hypothesis 2

While high leverage has been a strong predictor of distress in earlier classical models (Altman, 1968; Ohlson, 1980; Shumway, 2001), the literature points to the fact that leverage interacts with macro-financial conditions. Opler & Titman (1994) illustrate that highly leveraged firms suffer large losses during downturns, since their debt burden reduces flexibility, turning them extremely vulnerable to shocks. Similarly, Tong & Serrasqueiro (2021) confirms that debt ratios are still among the most reliable predictors of financial distress, in a study of Portuguese SMEs.

In the Portuguese economy, SMEs are structurally dependent on bank financing (Farinha & Félix, 2015). Both profitability and liquidity buffers quickly diminishes during interest rates rising cycles, thus reflecting the financial accelerator mechanism: the more leveraged a firm is, the higher the transmission of monetary tightening into distress risk. Therefore, hypothesis 2 states that interest rate sensitivity is not homogeneous across firms, but significantly stronger for those with higher leverage.

H2: The effect of leverage on financial distress is amplified during periods of higher interest rates.

III. Hypothesis 3

Liquidity is a central distress predictor in classical models. Altman's Z'-score includes working capital to total assets as one of its five key ratios, specifically because liquidity concerns usually come before insolvency. Shumway (2001) also includes liquidity measures into hazard models of default. Subsequent work using Portuguese SMEs also finds that thin liquidity buffers are a structural weakness that increase the impact of shocks (Farinha & Félix, 2015).

When interest rates rise, more liquid companies can deal with the increase in debt service, however, less liquid companies have little room to maneuver. Their working capital position deteriorates faster, diminishing their capacity to repay short-term liabilities and accelerating the path to financial distress. Opler & Titman (1994) similarly points out that firms with poor balance sheets experience sharper declines under unfavorable conditions.

Hypothesis 3 combines internal balance sheet factors and the macro-financial environment: although liquidity is protective in general, its role is particularly crucial in situations of monetary

tightening. Testing this interaction is important in exploring whether SMEs with greater liquidity buffers are better shielded against interest rate hikes, and whether weak liquidity increases sensitivity to interest rate movements.

H3: Portuguese SMEs with weaker liquidity are more prone to financial distress during periods of rising interest rates.

IV. Hypothesis 4

Sectoral characteristics influence how interest rate increases affect the financial health of firms. Some specific sectors, such as Manufacturing or Construction, tend to rely more on external financing, making them more sensitive to rising borrowing costs. On the other hand, service sectors such as Professional, Scientific and Technical Activities, are usually less leveraged and maintain lighter balance sheets, which could buffer their susceptibility to financial distress.

In Portugal, Quadros Setoriais of Banco de Portugal consistently illustrates that financial structure and profitability are not uniform across sectors among Portuguese SMEs. For example, Manufacturing and Construction sectors in Portugal consistently present the highest debt ratios and the lowest liquidity levels, reflecting their structural necessity to finance themselves through external capital and longer operating cycles. In contrast, Information and Communication services, as well as Professional, Scientific and Technical Activities, present stronger liquidity levels, greater profitability margins and lower leverage, which indicates both greater operating flexibility and resistance to financing shocks. These structural differences suggest that monetary tightening may have asymmetric effects across different industries. Therefore, studying sectoral heterogeneity can give us valuable insights regarding the transmission mechanism of interest rate shocks to firm-level financial distress.

H4: The impact of interest rates increases on financial distress varies across industries in Portugal.

4. Data and Methodology

4.1 Data source and Sample Selection

This empirical work is based on firm-level data extracted from the SABI (Sistema de Análise de Balanços Ibéricos) database, published by Bureau Van Dijk. This database provides standardized financial and accounting information about Portuguese firms, across different years and compatible with all international accounting standards. The period covered is 2007-2024, which allows us to capture distinct monetary environments in Portugal: the 2008 financial crisis, the long-lasting period of low interest rates, following the European Central Bank's (ECB) expansionary policy and the COVID-19 period, and also the recent cycle of monetary tightening starting in 2022. Then, this time frame enables us to analyze how the evolution of financing conditions influences Portuguese SMEs financial stability.

The original dataset consisted of every Portuguese SME, as defined in the European Commission Recommendation 2003/361/EC and followed by Hawach & Requejo (2025). Then, the filters were applied for firms employing between 10 and 249 people, and whose annual turnover does not exceed €50 million or total assets below €43 million. To ensure comparability, only firms with unconsolidated (U1) financial statements were selected. The following legal statuses were included: *Activa*, *Liquidação*, *Extinção*, *Encerramento Legal* and *Insolvência/Trâmites de Composição*, in order to keep variation in the sample of both solvent and insolvent firms. Financial and insurance companies, as well as public administration or defense, were not included due to their distinctive regulatory and accounting characteristics, which limit comparability with other sectors. The remaining sectors cover the most important areas of the Portuguese economy, including manufacturing, construction, trade, transport, accommodation and professional services, reflecting a sectoral selection in line with Quadros Setoriais of Banco de Portugal. By applying these criteria, the extraction resulted in an initial panel of 22,352 Portuguese SMEs.

4.2 Data Cleaning

To maintain internal consistency and comparability, a rigorous data cleaning process was carried out, adhering to the best practices from previous financial distress studies, specially by Hawach & Requejo (2025).

1. All firms were required to comply with the European Commission definition for SME. Then, firms that failed to meet any of these criteria for two or more consecutive years, were excluded.
2. The initial data extraction focused on non-financial firms, with firms classified under financial services and public administration being excluded. However, due to limited representativeness in the dataset, sectors such as *Electricity, Gas, Steam and Air Conditioning Supply, Mining and Quarrying, Arts, Entertainment and Recreation, Education, Real Estate Activities and Other Activities*, were excluded.
3. Observations with missing values or zero values in key financial variables, such as Total Assets or Shareholder's funds, were removed to ensure that financial ratios used in the Z-score calculation rely on valid financial data.
4. All financial ratios were winsorized at the 1st and 99th percentiles by year, aiming to minimize the potential effects of extreme values in the sample.

The final dataset includes 8,048 Portuguese SMEs, from 11 different industries and across 18 years, which ensure robustness and comparability across firms, industries and years.

4.3 Variable Construction

4.3.1 Dependent variable: Financial Distress

Financial distress is proxied by Altman Z'-Score (Altman & Sabato, 2007), an adaptation of Altman's (1968) original discriminant model, specially shaped for private firms and SMEs, which is the most appropriate one to use in this study. The Altman Z'-Score for private firms is computed using the following formula:

$$Z' = 0.717(X1) + 0.847(X2) + 3.107(X3) + 0.420(X4) + 0.998(X5)$$

Where:

- X1 = working capital/total assets
- X2 = retained earnings/total assets
- X3 = earnings before interest and taxes/total assets
- X4 = book value of equity/book value of total liabilities

- $X5$ = sales/total assets
- Z' = overall index

Consistent with Altman's previous studies, firms with $Z' < 1.23$ are classified as financially distressed, with the remaining ones considered as not distressed. All ratios were computed annually. Below, there is **Table 1** with the distribution of the sample and **Table 2** with the distribution of the sample by industry.

Table 1. Distribution of the sample

Year	Total Firms	Distressed Firms	Non-Distressed Firms
2007	6,629	1,236	5,393
2008	6,723	1,243	5,480
2009	6,791	1,373	5,418
2010	6,871	1,376	5,495
2011	6,898	1,432	5,466
2012	7,026	1,522	5,504
2013	7,135	1,446	5,689
2014	7,216	1,361	5,855
2015	7,295	1,289	6,006
2016	7,362	1,274	6,088
2017	7,474	1,226	6,248
2018	7,576	1,245	6,465
2019	7,678	1,213	6,465
2020	7,775	1,531	6,244
2021	7,718	1,341	6,377
2022	7,630	1,045	6,585
2023	7,485	948	6,537
2024	6,900	781	6,119
Total N° Observations	130,182	22,882	107,300

Table 2. Distribution of the sample by industry

Industry	N° Firms	%
Accommodation & Food Services	476	6
Administrative & Support Service Activities	199	3
Agriculture, Forestry & Fishing	187	2
Construction	572	7
Human Health & Social Work	262	3
Information & Communication	193	2
Manufacturing	2,469	31
Professional, Scientific & Technical Activities	240	3
Transportation & Storage	400	5
Water, Sewerage, Waste & Remediation	113	1
Wholesale & Retail Trade	2,937	37
Total	8,048	100

4.3.2 Independent Variables

The main independent variable in this dissertation is the Portuguese 2-year treasury bond yield, retrieved from Banco de Portugal, which is used as a proxy for the short-term financing conditions faced by Portuguese SMEs. Although the majority of SME loans in Portugal are indexed to the three-month Euribor, the Portuguese treasury bond yield provides a much better measure of borrowing cost since it includes both monetary policy expectations and the sovereign and credit risk spreads transmitted to firms through the banking system (Gilchrist & Mojon, 2014). Therefore, it provides a more accurate representation of the financial environment that shapes SME vulnerability to interest rate fluctuations. The analysis also includes other firm-level variables that capture financial characteristics that determine the sensitivity of a firm to interest rate changes and are directly related to all four hypotheses. **Table 3** briefly describes each main independent variable.

Table 3. Definition of the main variables

Variable	Definition	Hypothesis	Economic Rationale
Leverage	Total Liabilities/Total Assets	H2	Capture firm dependence on debt financing
Liquidity	Current Assets/Current Liabilities	H3	Indicates short-term financial flexibility
Industry	Based on NACE Rev.2 classifications	H4	Capture sectoral differences in capital intensity and financing dependence

In addition, two control variables are added to ensure heterogeneity in operational performance and reduce potential omitted-variable bias.

Profitability (ROA), measured as EBIT/Total Assets, controls for a firm's ability to generate profit. More profitable firms are expected to present lower probabilities of distress, in a way that they are less reliant on external funding and maintain a higher repayment capacity.

Size, defined as the logarithm of Total Assets ($\ln$ Total Assets), controls for the benefits of scale and diversification. Larger firms tend to have better access to finance, stronger bargaining power with creditors and a wider revenue base, which increases their ability to cope with interest rate shocks.

4.4 Empirical Design

4.4.1 Descriptive Analysis

Table 4 provides a comprehensive overview of the descriptive statistics for the variables used in the empirical analysis.

Table 4. Descriptive statistics

Variables	All firm-years	Mean	SD	Minimum	P10	Median	P90	Maximum
FD	130,182	0.176	0.381	0	0	0	1	1
OT	130,182	2.353	3.222	-0.643	-0.440	1.186	8.407	12.221
LEV	130,182	0.579	0.259	0.043	0.219	0.596	0.882	1.500
LIQ	130,182	2.225	2.217	0.128	0.746	1.551	4.224	20.591
ROA	130,182	0.056	0.087	-0.373	-0.018	0.043	0.157	0.439
SIZE	130,182	8.523	0.909	6.081	7.445	8.445	9.766	11.156

The dataset comprises a total of 130,182 firm-year observations, providing a large and heterogeneous panel of Portuguese SMEs. The mean for the financial distress indicator (FD) is 0.176, while the standard deviation is 0.381, revealing that around 18% of firms fall below the threshold value of the Z'-Score ($Z' < 1.23$). Dispersion reflects significant variability in firms' financial conditions throughout the period under consideration.

The main independent variable, the Portuguese 2-year treasury bond yield (OTs), that serves as the proxy for firms external financing conditions, presents a mean of 2.353% with a relatively high standard deviation of 3.222. Values range between -0.643% and 12.221%, reflecting the period's ability to capture different economic cycles, which is crucial for our study. Such a variation provides a strong basis to investigate differences in firm-level financial distress as interest rates fluctuate.

The leverage ratio (LEV) has a mean of 0.579, which implies that firms finance, on average, more than half of their assets with debt. The standard deviation is 0.259, indicating that although the majority of SMEs have relatively similar financing structures, a substantial subgroup of them has notably higher leverage, consistent with the traditional dependence of the sector on bank credit.

For liquidity (LIQ) the sample shows variation, with a mean of 2.225, a median of 1.551 and a standard deviation of 2.217. The lower percentiles indicate that many firms operate under very tight liquidity constraints. The extreme values at the upper tail are well above 20, implying that several firms hold unusually large cash or working-capital positions. This variability in liquidity points to structural differences in short-term financial management practices across the SME sector.

Profitability (ROA) averages 0.056 and presents a standard deviation of 0.087. The distribution includes a meaningful portion of negative observations, consistent with the uneven recovery following the 2008 financial crisis and the COVID-19 period.

The logarithmic firm size (SIZE) averages 8.523 with a standard deviation of 0.909, while the minimum and maximum values are 6.081 and 11.156, respectively. This confirms that the sample covers the full spectrum of SMEs, ranging from smaller firms with limited asset bases to larger SMEs.

Table 5 presents the correlation matrix for the variables used in this empirical analysis and gives an overview of the pairwise linear associations.

Table 5. Correlation matrix of the main variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) Distress dummy	1.000					
(2) OT	0.030	1.000				
(3) Profitability	-0.360	-0.058	1.000			
(4) Size	0.185	-0.058	-0.016	1.000		
(5) Leverage	0.406	0.078	-0.311	-0.092	1.000	
(6) Liquidity	-0.198	-0.059	0.125	0.056	-0.563	1.000

The financial distress indicator is modestly correlated with the remaining covariates, which reduces the likelihood of bias in the estimated coefficients from potential multicollinearity in the regressions. Indeed, the correlation between interest rate exposure (OTs) and distress is positive but economically small, consistent with the idea that tightening financing conditions might exacerbate the likelihood of experiencing financial distress. Profitability has the expected negative relation with distress, reflecting the importance of a strong operating performance in economic resilience. Size presents a positive correlation with distress, suggesting that larger firms in this sample might be more prone to distress. Finally, liquidity exhibits a negative correlation with both leverage and distress, consistent with the interpretation that firms with stronger short-term buffers are less susceptible to adverse shocks. Overall, the patterns in the correlation matrix are in line with established firm-level dynamics.

4.4.2 Econometric Specification

Panel regression techniques are used to assess the relationship between interest rate fluctuations and financial distress among Portuguese SMEs. The following model is estimated:

$$Distress_{it} = a + \beta_1 OT_t + \beta_2 Leverage_{it} + \beta_3 Liquidity_{it} + \beta_4 (OT_t Leverage_{it}) + \beta_5 (OT_t Liquidity_{it}) + \beta_6 (OT_t Industry_j) + \gamma_1 Profitability_{it} + \gamma_2 Size_{it} + \delta_i + \lambda_t + \varepsilon_{it}$$

Where:

- $Distress_{it}$ = firm i's financial distressed, measured by Altman Z'-Score (1 if $Z' < 1.23$, 0 otherwise)
- OT_t = Portuguese 2-year treasury bond yield (annual average)
- $Leverage_{it}$ = Total Liabilities/Total Assets
- $Liquidity_{it}$ = Current Assets/Current Liabilities
- $Industry_j$ = Industry dummy (NACE Rev.2 Primary code)
- $Profitability_{it}$ = EBIT/Total Assets (control variable)
- $Size_{it}$ = $\ln$ (Total Assets) (control variable)
- δ_j = industry fixed effects
- λ_t = year fixed effects
- ε_{it} = error term

The regression is estimated by using logistic regression (Logit) models, where the dependent variable captures the probability of a firm being financially distressed. This binary approach allows for a direct estimation of distress likelihood. To assess heterogeneity, we test the interaction terms sequentially:

1. $OT_t Leverage_{it}$ (H2)
2. $OT_t Liquidity_{it}$ (H3)
3. $OT_t Industry_j$ (H4)

Each model is estimated incrementally, starting with H1 and adding successively interaction terms.

5. Results

5.1 Hypothesis 1

Table 6. H1- Main results

H1: Interest rate effect on financial distress	
Variables	
OT	0.5740*** (0.0095)
Profitability	-17.1027*** (0.3592)
Size	0.6135*** (0.0255)
Constant	-7.0057*** (0.2418)
Observations	130,182
Industry FE	Yes
Year FE	Yes
Pseudo R ²	0.277

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

For the first hypothesis, we first analyze how short-term financing conditions impact the probability of financial distress among Portuguese SMEs. **Table 6** presents the baseline logistic regression, including both industry and year fixed effects, with the Portuguese 2-year treasury bond yield as the proxy for the short-term financing conditions faced by SMEs. The dependent variable is the distress dummy that equals 1 for firms whose Z'-Score falls below 1.23.

The coefficient for OT is positive and statistically significant at 1%, which indicates that higher sovereign yields are associated with a greater probability of experiencing financial distress. This result provides strong empirical support for H1. With higher Portuguese treasury yields capturing the tightening of financing conditions, the finding indicates that this has translated into a reduction in SME financial health. This result aligns with the financial accelerator mechanism of Bernanke, Gertler and Gilchrist (1999), whereby increased borrowing costs amplify pre-existing vulnerabilities, especially for firms dependent on bank credit. For Portuguese SMEs, which display high dependence on external financing (Farinha & Félix, 2015), such a transmission effect is expected to be pronounced.

The control variables show the expected signs and are both significant at 1%. Profitability presents a large negative significant coefficient of -17.1027***, supporting the notion that more profitable firms are significantly less likely to face situations of financial distress. This aligns with the classical distress prediction literature, in which profitability acts as an important buffer against liquidity pressures (Altman, 1968; Ohlson, 1980). Regarding firm size, it also presents a positive and significant coefficient of 0.6135***, which suggests that the larger the firm, the higher the likelihood of distress. Although not entirely intuitive, the same kind of pattern has been revealed for European firms, where larger assets bases are often accompanied by more complex cost structures, higher fixed costs, and higher amounts of leverage, thereby elevating their vulnerability to changes in financing conditions (Stegovec and Črnigoj, 2020).

Industry and year fixed effects are included in the model to avoid that any estimated impact of interest rates is not confounded by sector-specific financial structures or any macroeconomic event common to all firms in the sample. A pseudo R^2 of 0.277 indicates a reasonable level of explanatory power for a logistic regression using firm-year data.

After all, the baseline results validate that increased interest rates significantly raise the probability of financial distress among Portuguese SMEs, providing clear support for H1.

5.2 Hypothesis 2 & 3

Table 7. H2 & H3 - Main results

H2 & H3: Leverage and Liquidity as Moderators of Interest Rate Effects on Financial Distress	
Variables	
OT	0.4126*** (0.0123)
Leverage	5.8212*** (0.0648)
Liquidity	-0.1379*** (0.0097)
Leverage*OT	-0.0870*** (0.0154)
Liquidity*OT	-0.0084*** (0.0028)
Profitability	-15.1882*** (0.3465)
Size	0.8372*** (0.0242)
Constant	-11.4063*** (0.2086)
Observations	130,120
Industry FE	Yes
Year FE	Yes
Pseudo R ²	0.433

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

We estimate a joint logistic regression that includes interaction terms between the Portuguese 2-year treasury bond yield, OT and two core characteristics, leverage and liquidity, to investigate whether the transmission of interest rate shocks into financial distress varies across firms with different structures. This form of regression provides an ability to examine the amplification of indebtedness and neutralizing power of short-term financial flexibility, while controlling for profitability, size and adding both industry and year fixed effects.

The coefficient of OT is positive (0.4126***) and statistically significant at the 1% level. Therefore, we can conclude that an increase in sovereign bond yields, which represents tighter credit conditions and increased cost of borrowing, raise the probability of financial distress among Portuguese SMEs. The persistence of this effect in the joint model provides added evidence that the effect captured by the baseline model is not merely due to differences in either leverage or liquidity but instead reflects broader sensitivity of Portuguese SMEs to changing domestic credit

conditions. Such sensitivity is consistent with the high dependence of these kinds of firms on bank financing and the limited availability of alternative funding sources, as previously shown by Farinha and Félix (2015).

Leverage presents a strong, very positive and significant coefficient (5.8212***). Thus, leverage is a key factor for determining the vulnerability of a given firm. Leveraged firms operate under tighter financial constraints, greater refinancing needs and lower flexibility in absorbing operating shocks. However, the interaction between OT and leverage is negative (-0.0870***) and statistically significant at the 1% level. As opposed to H2, this suggests that as firm leverage increases, the marginal effect of an increase in interest rates on the likelihood that it will be in financial distress decreases. While firms with high leverage have greater overall chances of being distressed than firms with lower leverage, further increases in interest rates have less incremental effect on the probability of distress for highly leveraged firms.

One possible hypothesis that may explain these findings is that firms with high levels of debt are already in a precarious position, even under favorable credit conditions. Thus, further increases in their borrowing costs create a diminishing marginal effect on the likelihood of being distressed. Another possibility is that banks may have a more involved approach to renegotiating loans and relaxing covenants on their highly leveraged SME clients than other types of clients and may therefore buffer their highly leveraged customers against sudden changes in financing conditions. This finding does not contradict Opler and Titman (1994), given that their results pertain to the baseline vulnerability of leveraged firms, a pattern that our model also reflects via the large positive coefficient on leverage. Our interaction term identifies a different mechanism, which is that the incremental impact of interest rate increases is significantly diminished for already highly leveraged SMEs, which is beyond the scope of their analysis.

By contrast, liquidity presents a negative (-0.1379***) and highly significant coefficient highlighting that firms with larger short-term asset buffers have lower probability of failing into distress. Having access to liquid assets allows companies to meet their short-term obligations and, therefore, to have less disruption in their cash-flows. The coefficient for the interaction between OT and liquidity (-0.0084***) also supports hypothesis 3. This coefficient suggests that as interest rates rise, the predicted probability of distress decreases for companies with a larger reserve of

liquid assets. In practical terms, liquidity offsets the effects of tighter monetary policy by reducing firms' dependence on external financing, and by allowing them to meet their immediate obligations without resorting to expensive capital markets. These findings confirm previous financial distress prediction models (Altman, 1968; Shumway, 2001), and recent studies that have found that liquidity constraints increase risk of financial distress for SMEs during periods of adverse macroeconomic conditions (Tong & Serrasqueiro, 2021).

The comprehensive evaluation of the joint model shows that leverage and liquidity have opposite moderating effects on the interest rate-distress connection, but not in the way originally expected. Liquidity is acting as anticipated, with companies with robust short-term buffers presenting a lower marginal response to higher interest rates, demonstrating a partial protection from tighter credit conditions. In contrast, leverage significantly increases the chances of distress at baseline, but it is negatively correlated with interest rates, suggesting that the incremental effect of rising financing costs is smaller for more indebted firms. This therefore suggests that, while structurally more fragile, the marginal sensitivity to interest rate shocks actually diminishes at higher leverage levels. Both interaction terms remain statistically significant even when included together, demonstrating that leverage and liquidity operate through separate channels rather than simply reflecting the same financial dimension. The pseudo R^2 of 0.433 represents a substantial improvement in model fit relative to the baseline model.

Finally, in order to mitigate any concerns related either to collinearity or to model dependency, the interaction terms were also estimated independently. The separate H2 and H3 models, presented in Appendix, have interaction coefficients with similar sign and statistical significance as presented in the joint model. The OT-liquidity interaction still shows that liquidity mitigates the impact of rising interest rates, while the negative OT-leverage coefficient indicates that the marginal effect of interest rate increases diminishes at higher leverage levels. The consistent patterns reinforce the robustness of the moderating channels identified.

5.3 Hypothesis 4

Table 8. H4 - Main results

H4: Sectoral Heterogeneity in Interest rate-Distress Relationship	
Variables	
OT	0.3680*** (0.0112)
Administrative & Support Service Activities*OT	-0.0267*** (0.0081)
Agriculture, Forestry & Fishing*OT	-0.0105 (0.0125)
Construction*OT	-0.0395** (0.0184)
Human Health & Social Work*OT	-0.0390*** (0.0121)
Information & Communication*OT	-0.0642** (0.0272)
Manufacturing*OT	-0.0313*** (0.0101)
Professional, Scientific & Technical Activities*OT	-0.0300* (0.0157)
Transportation & Storage*OT	-0.0596*** (0.0132)
Water, Sewerage, Waste & Remediation*OT	-0.0071 (0.0100)
Wholesale & Retail Trade*OT	-0.0367** (0.0155)
Profitability	-15.1787*** (0.3521)
Size	0.8368*** (0.0239)
Leverage	5.6261*** (0.0746)
Liquidity	-0.1546*** (0.0100)
Constant	-11.3033*** (0.1822)
Observations	130,120
Industry FE	Yes
Year FE	Yes
Pseudo R ²	0.433

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

To see whether the sensitivity of financial distress to changes in interest rates varies across sectors, we extended the baseline model by interacting the interest rate variable (OT) with the industry fixed-effects categories. Since categorical variables in models also require that one group

be excluded to avoid perfect multicollinearity, Stata automatically selects a reference category. In our case, the excluded industry was *Accommodation & Food Services*. Thus, this sector does not show up explicitly in the list of interactions above.

The results are presented in **Table 8**. The OT coefficient continues to be positive (0.3680***) and statistically significant, indicating that higher interest rates are associated with a higher probability of financial distress for the reference sector.

The interaction coefficients capture deviations in interest rate sensitivity relative to the reference industry. Several sectors present statistically significant negative interactions with OT, most notably:

- *Information & Communication* (-0.0642**)
- *Transportation & Storage* (-0.0596***)
- *Construction* (-0.0395**)
- *Human Health & Social Work* (-0.0390***)
- *Manufacturing* (-0.0313***)
- *Professional, Scientific & Technical Activities* (-0.0300*)
- *Wholesale & Retail Trade* (-0.0367**)

The negative coefficients of these sectors imply that their marginal response to an increase in interest rates is weaker when compared to the reference industry. In other words, the effect of monetary tightening on financial distress is stronger in *Accommodation & Food Services* and comparatively attenuated in these sectors. This result is intuitive and reflects sectoral differences in operating margins, cost structures and dependence on short-term financing. Sectors with more stable demand, higher cash-flow buffers or more diversified financing options may be less exposed to increases in borrowing costs.

The interaction terms for other industries like *Agriculture, Forestry & Fishing* and *Water, Sewerage, Waste & Remediation* are statistically insignificant, suggesting that their sensitivity to interest rate changes do not differ much from the reference sector.

Overall, the evidence from this research supports H4. The evidence demonstrates that the relationship of interest rates to distress varies by industry and is therefore not uniform across all types of industries. Furthermore, different industries experience varying levels of increased risk due to changes in sovereign yields.

6. Robustness tests

Following Hawach and Requejo (2025), three different types of robustness tests are carried out regarding the stability of the baseline results.

First, to address the potential for endogeneity, the models are re-estimated including lagged firm-level controls. The analysis is then replicated using Altman Z'-score as a continuous measure of financial vulnerability. Finally, the baseline regressions are re-estimated using the 5-year sovereign yield instead of 2-year yield, to ensure that the interest rate effects are not dependent on the specific maturity used to capture tightening conditions. All robustness tables are grouped in Appendix, for conciseness.

6.1 Endogeneity

To alleviate potential concerns about endogeneity, the models were re-estimated applying lagged measures of firm-level controls. While reverse causality appears to be highly unlikely in this context, since individual SMEs cannot impact Portuguese government bond rates, omitted variables can generate misleading correlations if they jointly affect both a firm's sensitivity to interest rate movements and its probability in being financially distressed.

The endogeneity tests substitute contemporaneous leverage, liquidity and profitability with their $t-1$ values, which makes the firm characteristics entering the model predetermined relative to current distress outcomes and reduces simultaneity bias. Industry and year fixed effects remain controlled for, and standard errors are still clustered at the year level. All regression results are presented in Appendix.

The results from lagged-control estimations are highly consistent with the main findings. The coefficient on OT is still positive and statistically significant for all hypotheses, suggesting that increases in the sovereign yields continue to raise the likelihood of financial distress.

Moreover, the moderating effects persist. Lagged leverage continues to play an amplifying role in the rise of interest rates (H2) while lagged liquidity continues to mitigate the effect (H3).

From the joint specification (H4), both lagged leverage and liquidity resin their expected signs and level of significance, thereby supporting the idea that these channels represent two separate mechanisms rather than capturing a common underlying dimension of financial structure.

Although there are minor changes in magnitude, the qualitative conclusions remain the same. This stability suggests that the baseline results are not driven by reverse causality but reflects the structural mechanism of how monetary tightening affects SMEs health. The lagged-control approach provides strong evidence that the baseline results are robust against endogeneity concerns.

6.2 OLS regressions

To check whether the baseline findings are sensitive to the binary specification of financial distress, a second robustness test was taken that replaces the distress dummy with the continuous Altman Z' -score. Since the lower the Z' -score, the weaker the financial condition and hence the higher the probability of distress, this transformation enables verification of the interest rate mechanism based on a complementary accounting-based metric. All regressions contain both industry and year fixed effects, and robust standard errors are clustered by year. The complete set of results is reported in Appendix.

Across all the four hypotheses (H1-H4), the results strongly support the baseline logit estimates. The main coefficient on OT is invariably negative and statistically significant, suggesting that increases in the Portuguese sovereign yields are associated with a deterioration in the firm's Z' -scores. As expected, this confirms the baseline findings and assures that the aggregate effect of monetary tightening is not specific to the logit model.

Regarding the moderating channels that were also documented earlier, leverage continues to amplify the sensitivity of firms to higher interest rates, while liquidity mitigates it, consistent with the mechanisms posited in H2 and H3. Profitability and size retain their expected signs and stay statistically significant across all hypotheses.

The industry-interaction model (H4) confirms that the impact of OT is heterogeneous across sectors, but the exact patterns do, in some instances, differ from the logit model. Since the sign of

the main OT coefficient is negative in the OLS regressions, a negative interaction term implies that a corresponding industry suffers a more significant decline in Z'-score subsequent to an increase in interest rates, than does the reference industry (*Accommodation & Food services*). By contrast, the logit model, in which OT presents a positive coefficient, interprets negative interactions as weaker marginal effects than the reference industry. Due to this reversal of signs, a small number of industries, such as *Human Health & Social Work* and *Construction*, display differences in their relative sensitivities across the two different approaches. This is simply due to the different functional forms of the logit and OLS frameworks and not due to any instability of the economic relationships.

Although there are some minor cross-industry differences between the models, overall, the robustness tests using OLS models confirm the central conclusions of this dissertation, indicating that the main results are not dependent on the binary distress definition.

6.3 Alternative interest rate measure

To ensure that the primary findings are not unique to the 2-year sovereign yield used in the original analysis, the analysis was repeated but with the 5-year sovereign yield as a proxy for monetary policy conditions. The 5-year maturity represents the medium-term outlook on the path of interest rates and is less susceptible to short-term volatility than the 2-year yield. Thus, by looking at the results obtained from this wider maturity, we can see if the impact of increase in medium-term sovereign yields on the probability of distress is due to broader monetary policy tightening or due to idiosyncratic movements at the short end of the yield curve.

Across all four hypotheses, the results obtained are highly consistent with the baseline. The coefficient OT stays positive and statistically significant across all specifications, which confirms that increases in medium-term sovereign yields also raise the likelihood of financial distress. Interaction terms behave as expected as well. Similarly, industry-level patterns are stable. Sectors identified as more exposed in the baseline remain relatively sensitive under this specification, and no changes of direction in the effects are observed.

Overall, replacing the 2-year yield by the 5-year yield does not alter any of the economic and statistical inferences, suggesting that these main findings are robust to alternative measures of interest rate conditions. Full results are presented in Appendix.

7. Conclusion

This dissertation investigates how the changes in Portuguese sovereign yields affect the probability of distress among Portuguese SMEs and how firm-level financial characteristics and sectoral heterogeneity shape that relationship. Using evidence from previous studies, notably Altman's (1968) framework, this study demonstrates that both macro-financial conditions and individual firm fundamentals are key determinants in predicting whether a firm will experience financial difficulties. Empirically, the theory has been developed with respect to a recent approach taken by Hawach and Requejo (2025), combining logit models with industry and year fixed effects along with interaction terms capturing leverage and liquidity channels, and robustness analysis to ensure stability of the results.

Therefore, the results strongly support H1, implying that the increase in Portuguese sovereign yields is associated with a statistically and economically significant increase in the likelihood of experiencing financial distress among Portuguese SMEs. This is a confirmation that changes in the Portuguese treasury bond yield represents a main macro-financial driver of SMEs vulnerability.

Consequently, the moderating hypotheses are also well supported. H2 indicates that leverage amplifies the sensitivity of higher sovereign yields, while H3 reveals that liquidity attenuates this sensitivity. A joint model reinforces the idea that leverage and liquidity operate through different channels, since both retain their expected signs and significance.

Industry-level results suggest that the latter sensitivities do not uniformly affect all sectors. Whereas all industries are negatively affected by higher yields, the magnitude of these effects is consistent with intersectoral differences in capital intensities, debt dependence and exposure to the macro-economic environment. At the same time, no sector seems completely isolated from such transmission, which reinforces the systematic character of the interest rate shock in an economy dominated by SMEs.

These conclusions are strengthened by a comprehensive robustness analysis. Estimations with lagged financial variables address concerns that contemporaneous leverage, liquidity and profitability might be jointly determined with distress. The coefficients and their interaction effects

are shown to remain stable. The re-estimation of models using Altman's Z-score as a continuous measure of financial standing shows that there is a direct relationship between higher sovereign yields and deteriorating financial position. Results were also similar to those generated in the logit model. Finally, the use of a 5-year sovereign yield in place of a 2-year sovereign yield, resulted in the same general economic and statistical conclusions, supporting the notion that the findings do not stem from the arbitrary choice of maturity used as a reference point for interest rate conditions.

Overall, there is ample evidence pointing towards sovereign yield dynamics as a core determinant of SME financial distress in Portugal and that internal financial policies, such as leverage and liquidity, play an important role in shaping resilience to such shocks. This thesis contributes to the literature by presenting robust empirical evidence on the transmission of sovereign yield fluctuations into vulnerability at the SME level, while including explicitly firm-level financial structure and sectoral heterogeneity.

7.1 Limitations

Several limitations qualify the interpretation of these findings. First, the analysis relies on accounting-based measures of distress and solvency that are obtained from firms' financial statements. While widely used as proxies in the literature, and thus consistent with Altman approaches, they only imperfectly capture real-time credit events, such as loan renegotiations or informal restructured processes. Some dimensions of financial distress may thus remain unobserved.

Second, data cover mainly Portuguese SMEs for which financial information is available and sufficiently detailed, hence the sample might be biased towards more formal, better organized or even slightly larger firms within the SME segment. For this reason, smaller or very young firms, which might have different distress dynamics, might be underrepresented.

Furthermore, although the analysis included lagged financial variables as well as fixed effects to lessen the impact of any concerns over endogeneity, the empirical design does not eliminate all potential sources of simultaneity or omitted variables. Some factors such as managerial quality, relationship banking intensity or even access to informal financing sources are not observable in the data but may affect both financial structure and distress risk. Thus, the

findings should be interpreted as strong correlations and consistent with the theory rather than as fully structural causal estimates.

Finally, this study is focused on the specific case of Portugal. The Portuguese SME sector is characterized by high bank dependence and limited access to capital. The strength and form of relationship between the sovereign yield and distress may be different in economies with different characteristics. Therefore, external validity beyond the Portuguese context should be approached with caution.

7.2 Future Research

This dissertation opens many possibilities for future studies. A first extension idea would be to combine accounting data from companies with their credit registry information and bank level data, to have access to default events, loan classifications and covenant violations directly. When combined with sovereign yield fluctuations, these outcomes would provide a more realistic characterization of the process by which macro-financial shocks affect distressed firms.

In addition, another extension direction would be to develop more dynamic models of a firm's capital structure and distress. Future researchers could also create hazard models or dynamic panel model specifications to analyze the way in which changes in leverage and liquidity over time interact with different interest rate environments. These models would enable researchers to discriminate between temporary adjustments and ongoing vulnerabilities in a firm's capital structure.

Alternatively, researchers could conduct comparative studies across multiple countries, which would facilitate a determination of whether the SME sensitivities identified in Portugal are specific to the country, or on the other hand, correspond to a macroeconomic pattern observed in many countries with bank-dependent economies. By using the same empirical structure, researchers could more clearly identify how the banking system, regulatory environment and the economic conditions mediate the impact of how changes in sovereign yields translate into financial distress.

Finally, it would be also interesting for future research to examine the effectiveness of policy interventions, such as guarantee schemes, liquidity facilities or interest rate subsidies, in

mitigating the effect of sovereign yield increases on SME distress risk. Such research would be essential to policymakers who would like to ensure that SMEs remain protected during times of monetary tightening or times of higher sovereign risk.

8. References

- Altavilla, C., Canova, F., & Ciccarelli, M. (2016). Mending the broken link: Heterogeneous bank lending and monetary policy pass-through (ECB Working Paper No. 1978). *European Central Bank*. <https://doi.org/10.2866/562425>
- Altman, E. I., & Sabato, G. (2007). Modeling credit risk for SMEs: Evidence from the U.S. market. *Journal of Financial Services Research*, 32(1–2), 15–33.
- Altman, E. I., Iwanicz-Drozdowska, M., Laitinen, E. K., & Suvas, A. (2016). Financial distress prediction in an international context: A review and empirical analysis of Altman's Z-Score model. *Journal of International Financial Management & Accounting*, 28(2), 131–171. <https://doi.org/10.1111/jifm.12053>
- Altman, E. I. (1968). Financial ratios, discriminant analysis and the prediction of corporate bankruptcy. *The Journal of Finance*, 23(4), 589–609.
- Banco de Portugal (2024). Quadros do Setor: Indicadores financeiros e de atividade empresarial (2024). Banco de Portugal. <https://www.bportugal.pt/QuadrosdoSetor>
- Barboza, F., Kimura, H., & Altman, E. I. (2017). Machine learning models and bankruptcy prediction. *Expert Systems with Applications*, 83, 405–417. <https://doi.org/10.1016/j.eswa.2017.04.006>
- Beaver, W. H. (1966). Financial Ratios As Predictors of Failure. *Journal of Accounting Research*, 4, 713111.
- Bernanke, B. S., Gertler, M., & Gilchrist, S. (1999). The financial accelerator in a quantitative business cycle framework. In J. B. Taylor & M. Woodford (Eds.), *Handbook of Macroeconomics* (Vol. 1C, pp. 1341–1393). Elsevier. [https://doi.org/10.1016/S1574-0048\(99\)10034-X](https://doi.org/10.1016/S1574-0048(99)10034-X)
- Cloyne, J., Ferreira, C., Froemel, M., & Surico, P. (2023). Monetary policy, corporate finance, and investment. *Journal of the European Economic Association*, 21(6), 2586–2634. <https://doi.org/10.1093/jeea/jvad009>
- Farinha, L., & Félix, S. (2015). Credit rationing for Portuguese SMEs. *Finance Research Letters*, 14, 167–177. <https://doi.org/10.1016/j.frl.2015.05.001>
- Gilchrist, S., & Mojon, B. (2014). Credit risk in the euro area (NBER Working Paper No. 20041). National Bureau of Economic Research. <https://doi.org/10.3386/w20041>

- Hawach, F., & Requejo, I. (2025). Financial distress likelihood of European SMEs in times of economic policy uncertainty: The role of family ownership and performance aspirations. *International Review of Financial Analysis*, 105, 104418. <https://doi.org/10.1016/j.irfa.2025.104418>
- Instituto Nacional de Estatística. (2025). Dia Internacional das Micro, Pequenas e Médias Empresas – 27 de junho de 2025. <https://www.ine.pt>
- Leitão, L. (2024). Risco de Portugal face à Alemanha cai para mínimos de dois anos. *ECO*. <https://eco.sapo.pt/>
- OECD. (2023). OECD Economic Surveys: Portugal 2023. OECD Publishing. <https://doi.org/10.1787/2b8ee40a-en>
- Ohlson, J. A. (1980). Financial ratios and the probabilistic prediction of bankruptcy. *Journal of Accounting Research*, 18(1), 109–131.
- Opler, T. C., & Titman, S. (1994). Financial distress and corporate performance. *The Journal of Finance*, 49(3), 1015–1040.
- Shumway, T. (2001). Forecasting bankruptcy more accurately: A simple hazard model. *The Journal of Business*, 74(1), 101–124.
- Stegovec, K., & Črnigoj, M. (2020). Optimal capital structure and leverage adjustment speed of European public and private firms. *Economic and Business Review*, 22(2), 261–288. <https://doi.org/10.15458/ebr103>.
- Tong, C., & Serrasqueiro, Z. (2021). Financial distress of Portuguese SMEs: The role of government support and firm characteristics. *Journal of Economic Studies*, 48(5), 1001–1020. <https://doi.org/10.1108/JES-07-2020-0348>

9. Appendix

Main model

Hypothesis 2

Table 9. H2 - Main results

H2: Leverage as Moderator of Interest Rate Effects on Financial Distress	
Variables	
OT	0.3831*** (0.0142)
Leverage	6.0923*** (0.0743)
Leverage*OT	-0.0698*** (0.0187)
Profitability	-15.1264*** (0.3455)
Size	0.8297*** (0.0231)
Constant	-11.6728*** (0.2023)
Observations	130,139
Industry FE	Yes
Year FE	Yes
Pseudo R ²	0.429

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Hypothesis 3

Table 10. H3 - Main results

H3: Liquidity as Moderator of Interest Rate Effects on Financial Distress	
Variables	
OT	0.4827*** (0.0137)
Liquidity	-0.5478*** (0.0177)
Liquidity*OT	-0.0071 (0.0044)
Profitability	-16.4518*** (0.3213)
Size	0.6516*** (0.0305)
Constant	-6.2233*** (0.3004)
Observations	130,163
Industry FE	Yes
Year FE	Yes
Pseudo R ²	0.327
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1	

Robustness tests

Endogeneity

Table 11. H1 - Endogeneity robustness test

H1: Interest rate effect on financial distress	
Variables	
OT	0.5450*** (0.0164)
Lagged Profitability	-12.6218*** (0.4440)
Size	0.6014*** (0.0376)
Constant	-6.8963*** (0.3827)
Observations	121,463
Industry FE	Yes
Year FE	Yes
Pseudo R ²	0.223

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 12. H2 - Endogeneity robustness test

H2: Leverage as Moderator of Interest Rate Effects on Financial Distress	
Variables	
OT	0.3233*** (0.0205)
Lagged Leverage	4.7478*** (0.0561)
Lagged Leverage*OT	-0.0288** (0.0137)
Lagged Profitability	-9.5508*** (0.4463)
Size	0.7570*** (0.0371)
Constant	-10.3717*** (0.3787)
Observations	121,463
Industry FE	Yes
Year FE	Yes
Pseudo R ²	0.338

Robust standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1

Table 13. H3 - Endogeneity robustness test

H3: Liquidity as Moderator of Interest Rate Effects on Financial Distress	
Variables	
OT	0.4488*** (0.0195)
Lagged Liquidity	-0.4008*** (0.0182)
Lagged Liquidity*OT	-0.0027 (0.0037)
Lagged Profitability	-11.8188*** (0.4434)
Size	0.6283*** (0.0413)
Constant	-6.2365*** (0.4272)
Observations	121,463
Industry FE	Yes
Year FE	Yes
Pseudo R ²	0.258

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 14. H2 & H3 - Endogeneity robustness test

H2 & H3: Leverage and Liquidity as Moderators of Interest Rate Effects on Financial Distress	
Variables	
OT	0.3347*** (0.0233)
Lagged Leverage	4.5541*** (0.0711)
Lagged Liquidity	-0.0804*** (0.0106)
Lagged Leverage*OT	-0.0365** (0.0158)
Lagged Liquidity*OT	-0.0035 (0.0022)
Lagged Profitability	-9.5633*** (0.4444)
Size	0.7588*** (0.0380)
Constant	-10.1584*** (0.3965)
Observations	121,463
Industry FE	Yes
Year FE	Yes
Pseudo R ²	0.340

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

OLS regressions

Table 15. H1 - OLS robustness test

H1: Interest rate effect on financial distress	
Variables	
OT	-0.6017*** (0.0051)
Profitability	8.4347*** (0.1198)
Size	-0.4893*** (0.0134)
Constant	7.8761*** (0.1419)
Observations	130,138
Industry FE	Yes
Year FE	Yes
R ²	0.304
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1	

Table 16. H2 - OLS robustness test

H2: Leverage as Moderator of Interest Rate Effects on Financial Distress	
Variables	
OT	-0.3824*** (0.0158)
Leverage	-3.4048*** (0.0857)
Leverage*OT	0.0777*** (0.0141)
Profitability	5.4210*** (0.0602)
Size	-0.5579*** (0.0100)
Constant	9.6864*** (0.0909)
Observations	130,138
Industry FE	Yes
Year FE	Yes
R ²	0.481
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1	

Table 17. H3 - OLS robustness test

H3: Liquidity as Moderator of Interest Rate Effects on Financial Distress	
Variables	
OT	-0.3908*** (0.0092)
Liquidity	0.3837*** (0.0098)
Liquidity*OT	-0.0067 (0.0039)
Profitability	7.2616*** (0.0708)
Size	-0.5290*** (0.0133)
Constant	6.8789*** (0.1568)
Observations	130,119
Industry FE	Yes
Year FE	Yes
R ²	0.493

Robust standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1

Table 18. H2 & H3 - OLS robustness test

H2 & H3: Leverage and Liquidity as Moderators of Interest Rate Effects on Financial Distress	
Variables	
OT	-0.3141*** (0.0163)
Leverage	-2.0897*** (0.0394)
Liquidity	0.2596*** (0.0113)
Leverage*OT	0.0364** (0.0129)
Liquidity*OT	-0.0055 (0.0038)
Profitability	5.7748*** (0.0658)
Size	-0.5584*** (0.0113)
Constant	8.3083*** (0.1443)
Observations	130,119
Industry FE	Yes
Year FE	Yes
R ²	0.541

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 19. H4 - OLS robustness test

H4: Sectoral Heterogeneity in Interest rate-Distress Relationship	
Variables	
OT	-0.2950*** (0.0113)
Administrative & Support Service Activities*OT	0.0204* (0.0110)
Agriculture, Forestry & Fishing*OT	-0.0216** (0.0076)
Construction*OT	-0.0006 (0.0068)
Human Health & Social Work*OT	-0.0532*** (0.0151)
Information & Communication*OT	0.0053 (0.0060)
Manufacturing*OT	-0.0027 (0.0039)
Professional, Scientific & Technical Activities*OT	-0.0001 (0.0045)
Transportation & Storage*OT	0.0054 (0.0038)
Water, Sewerage, Waste & Remediation*OT	-0.0015 (0.0069)
Wholesale & Retail Trade*OT	-0.0009 (0.0039)
Profitability	5.7851*** (0.0642)
Size	-0.5577*** (0.0111)
Leverage	-2.0001*** (0.0579)
Liquidity	0.2499*** (0.0141)
Constant	8.2453*** (0.1420)
Observations	130,119
Industry FE	Yes
Year FE	Yes
R ²	0.540

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Alternative interest rate measure

Table 20. H1 - 5yOT robustness test

H1: Interest rate effect on financial distress	
Variables	
OT	0.5293*** (0.0087)
Profitability	-17.1027*** (0.3592)
Size	0.6135*** (0.0255)
Constant	-6.8467*** (0.2393)
Observations	130,182
Industry FE	Yes
Year FE	Yes
Pseudo R ²	0.277
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1	

Table 21. H2 - 5yOT robustness test

H2: Leverage as Moderator of Interest Rate Effects on Financial Distress	
Variables	
OT	0.3608*** (0.0119)
Leverage	6.1755*** (0.0745)
Leverage*OT	-0.0776*** (0.0172)
Profitability	-15.1256*** (0.3457)
Size	0.8300*** (0.0231)
Constant	-11.6354*** (0.1995)
Observations	130,139
Industry FE	Yes
Year FE	Yes
Pseudo R ²	0.429
Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1	

Table 22. H3 - 5yOT robustness test

H3: Liquidity as Moderator of Interest Rate Effects on Financial Distress	
Variables	
OT	0.4441*** (0.0136)
Liquidity	-0.5470*** (0.0204)
Liquidity*OT	-0.0054 (0.0044)
Profitability	-16.4521*** (0.3211)
Size	0.6516*** (0.0305)
Constant	-6.0943*** (0.2993)
Observations	130,163
Industry FE	Yes
Year FE	Yes
Pseudo R ²	0.327
Robust standard errors in parentheses	
*** p<0.01, ** p<0.05, * p<0.1	

Table 23. H2 & H3 - 5yOT robustness test

H2 & H3: Leverage and Liquidity as Moderators of Interest Rate Effects on Financial Distress	
Variables	
OT	0.3880*** (0.0135)
Leverage	5.9154*** (0.0615)
Liquidity	-0.1332*** (0.0116)
Leverage*OT	-0.0938*** (0.0155)
Liquidity*OT	-0.0077** (0.0034)
Profitability	-15.1877*** (0.3467)
Size	0.8376*** (0.0241)
Constant	-11.3821*** (0.2064)
Observations	130,120
Industry FE	Yes
Year FE	Yes
Pseudo R ²	0.433
Robust standard errors in parentheses	
*** p<0.01, ** p<0.05, * p<0.1	

Table 24. H4 - 5yOT robustness test

H4: Sectoral Heterogeneity in Interest rate-Distress Relationship	
Variables	
OT	0.3408*** (0.0107)
Administrative & Support Service Activities*OT	-0.0303*** (0.0077)
Agriculture, Forestry & Fishing*OT	-0.0108 (0.0124)
Construction*OT	-0.0358* (0.0197)
Human Health & Social Work*OT	-0.0408*** (0.0127)
Information & Communication*OT	-0.0578** (0.0291)
Manufacturing*OT	-0.0312*** (0.0100)
Professional, Scientific & Technical Activities*OT	-0.0325* (0.0167)
Transportation & Storage*OT	-0.0657*** (0.0132)
Water, Sewerage, Waste & Remediation*OT	-0.0053 (0.0102)
Wholesale & Retail Trade*OT	-0.0357** (0.0162)
Profitability	-15.1755*** (0.3529)
Size	0.8368*** (0.0239)
Leverage	5.6264*** (0.0744)
Liquidity	-0.1545*** (0.0100)
Constant	-11.2321*** (0.1777)
Observations	130,120
Industry FE	Yes
Year FE	Yes
Pseudo R ²	0.433

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1