

Louvain School of Management

What is the impact of interest rate volatility on fixed investment by SMEs?

Author : Kassi Blanpain
Supervisor : Bertrand Candelon
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INTRODUCTION

Between 2018 and 2021, the European Central Bank kept its policy rate at zero (European Central Bank, 2024). This created an exceptionally stable monetary environment. This period came to an abrupt end in 2022. The energy price shock and post-pandemic supply disruptions triggered a sharp surge in inflation (Gigante et al., 2025). In less than two years, the ECB raised its key interest rates from zero to over four percent (European Central Bank, 2024). This rapid and unpredictable shift raises a fundamental question: beyond the level of interest rates, does their volatility itself constrain firm investment decisions?

This question is particularly relevant for Belgian SMEs. They represent over 99% of all businesses and around two thirds of private sector employment (European Commission, 2024). Unlike large firms, they rely almost exclusively on bank credit for external financing (Piette & Zachary, 2020). Their investment capacity is therefore directly exposed to fluctuations in interbank market rates. Understanding the effect of this volatility on their investment decisions is crucial for firms, financial institutions, and policymakers alike.

The research question of this thesis is the following: What is the impact of interest rate volatility on fixed investment by SMEs?

To answer this question, this thesis combines a theoretical and an empirical approach. The theoretical part examines the mechanisms through which interest rate volatility affects SME investment, drawing on real options theory and the financial accelerator mechanism. The empirical part analyses a panel of 31,171 Belgian firms over the period 2018–2024, using a fixed effects regression model complemented by several robustness checks.

The main difficulty encountered in this work relates to the macro nature of the key variable. Euribor volatility is identical for all firms in a given year. This means the effect is identified solely from time-series variation over seven years. This limits statistical power and makes it difficult to isolate the effect of volatility from other aggregate shocks occurring simultaneously, such as the energy price shock in 2022 (Gigante et al., 2025).

The remainder of this thesis is structured as follows. Chapters 1 to 3 develop the theoretical framework. Chapter 4 presents the data and methodology. Chapters 5 to 7 report the empirical results and robustness checks. Chapter 8 discusses the results and their implications. A conclusion summarises the main findings.

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Chapter 1: Fixed Investment by SMEs: Concepts and Key Issues

This chapter lays the conceptual foundations of the analysis. It defines fixed investment, presents the specific characteristics of SMEs that make them particularly sensitive to financing conditions, and reviews the traditional determinants of investment at the firm level.

1. Definition of fixed investment

1.1 Productive investment and capital accumulation

Investment is broadly defined as the allocation of resources to assets that generate future returns. In macroeconomic terms, fixed investment refers specifically to expenditure on physical capital. This includes machinery, buildings, equipment, and other tangible assets used in the production process. It is distinct from financial investment, which involves the acquisition of financial claims such as stocks or bonds.

At the firm level, fixed investment drives capital accumulation. When a firm invests in new machinery or expands its production facilities, it increases its stock of productive capital. This enhances its capacity to generate revenue in future periods (Fazzari, Hubbard & Petersen, 1988).

Fixed investment is inherently forward-looking. Firms commit resources today in anticipation of future returns that are uncertain by nature. Once made, investment expenditure cannot easily be reversed (Dixit & Pindyck, 1994). This irreversibility is a fundamental characteristic that distinguishes fixed investment from financial investment. It makes fixed investment particularly sensitive to uncertainty about future conditions (Dixit & Pindyck, 1994). Investment decisions are also characterised by persistence over time.

Adjustment costs, contractual commitments, and installation lags mean that this year's investment is positively correlated with last year's investment (Carruth, Dickerson & Henley, 2000).

1.2 Distinction between fixed investment and financial investment

Fixed investment and financial investment differ fundamentally in their nature and implications for the real economy. Fixed investment involves the acquisition of tangible productive assets. These assets directly contribute to the production process. Financial investment, by contrast, involves the purchase of financial instruments such as shares, bonds, or derivatives. These instruments represent claims on future cash flows but do not directly create productive capacity.

This distinction matters for this thesis. The analysis focuses exclusively on fixed investment, measured as the change in fixed assets on the firm's balance sheet. This captures net capital accumulation, defined as the difference between new investment and the depreciation or disposal of existing assets. It reflects the firm's decision to expand, maintain, or reduce its productive capital stock.

2. Specific characteristics of SMEs

2.1 Definition of SMEs

The European Commission defines SMEs as enterprises with fewer than 250 employees, an annual turnover not exceeding €50 million, and a balance sheet total not exceeding €43 million (European Commission, 2003). This is the official definition used across the European Union for regulatory, statistical, and policy purposes. It is adopted throughout this thesis.

SMEs are not a homogeneous category. The European Commission further distinguishes between micro enterprises (fewer than 10 employees), small enterprises (10 to 49 employees), and medium-sized enterprises (50 to 249 employees). Each sub-category faces different financing conditions and investment constraints. However, all share the common characteristic of limited access to capital markets relative to large corporations (Fazzari, Hubbard & Petersen, 1988).

In Belgium, SMEs represent over 99% of all non-financial businesses and account for approximately two thirds of private sector employment (European Commission, 2024). Their economic weight makes their investment behaviour a key driver of economic growth in Belgium.

2.2 Financial constraints and access to credit

A defining characteristic of SMEs is their exposure to financial constraints. Financial constraints arise when a firm cannot obtain external financing on terms that reflect the true productivity of its investment projects. This forces it to rely on internal funds or to forgo potentially profitable investments (Fazzari, Hubbard & Petersen, 1988).

SMEs face these constraints more strongly than large firms for several reasons. First, they typically have shorter operating histories and less established reputations. This makes it harder for lenders to assess their creditworthiness (Ghulam, Hakro & Naumani, 2025). Second, information asymmetries between SME owners and external financiers are more severe. SMEs are generally not subject to the same disclosure requirements as listed companies (Ganau & Rodríguez-Pose, 2022). Third, SMEs often lack the collateral required to secure bank loans on favourable terms, particularly during periods of financial stress (Ganau & Rodríguez-Pose, 2022).

These constraints have real consequences for investment. When internal funds are insufficient and external financing is costly or unavailable, SMEs may be forced to scale back or postpone investment projects. This happens even when these projects would generate positive returns under normal financing conditions (Fazzari, Hubbard & Petersen, 1988). This sensitivity to external financing conditions is particularly pronounced in Europe, where credit constraints represent a major barrier to SME investment (Ganau & Rodríguez-Pose, 2022 ; Ghulam, Hakro & Naumani, 2025).

2.3 Dependence on bank financing

Unlike large corporations, SMEs rely almost exclusively on bank credit as their primary source of external financing. Large firms can access bond markets, equity markets, and international capital markets. SMEs typically cannot (Lian & Ma, 2021). This bank

dependence is a structural feature of SME financing across Europe (Piette & Zachary, 2020).

This dependence has important implications for the transmission of monetary policy to SME investment. When monetary conditions tighten, SMEs have limited ability to substitute bank credit with alternative financing sources. They are therefore more directly exposed to changes in bank lending conditions than large firms (Ghulam, Hakro & Naumani, 2025).

Belgium constitutes the empirical setting of this study due to the availability of comprehensive firm-level accounting data through the Belfirst database. It nonetheless represents a relevant case. Its economy is largely dominated by SMEs and its firms rely heavily on bank credit, characteristics that are well documented in the Belgian context (Piette & Zachary, 2020).

3. Traditional determinants of investment

3.1 Expected demand

According to the accelerator theory of investment, investment is primarily driven by expected demand for output (Carruth, Dickerson & Henley, 2000). When firms anticipate an increase in demand, they invest in additional productive capacity. When demand is expected to fall, investment declines. This relationship between expected output and investment is one of the oldest and most robust findings in the investment literature (Carruth, Dickerson & Henley, 2000).

For SMEs, expected demand is particularly important as their investment decisions are often linked to specific customer relationships or local market conditions. In uncertain economic environments, the difficulty of forecasting future demand becomes a significant barrier to investment (Carruth, Dickerson & Henley, 2000).

3.2 Profitability and internal financing

Profitability is a key determinant of investment for two reasons. First, profitable firms generate internal cash flows that can be reinvested directly without recourse to external financing. This reduces the firm's dependence on costly external funds. Second, profitability signals the quality of a firm's investment opportunities to external financiers. This improves

its access to credit on favourable terms.

Fazzari, Hubbard & Petersen (1988) show that investment is significantly more sensitive to internal cash flows for financially constrained firms than for unconstrained ones. For SMEs, which are typically more financially constrained than large firms, profitability therefore plays a dual role. It directly funds investment and determines the firm's ability to attract external financing.

In this thesis, profitability is measured by return on assets (ROA), defined as net income divided by total assets. ROA captures how efficiently a firm uses its asset base to generate profits. It serves as a standard proxy for internal financing capacity in firm-level investment models (Fazzari, Hubbard & Petersen, 1988). It should be noted, however, that the relationship between profitability and investment is not always monotonic. Highly profitable firms may already hold a well-optimised asset base and therefore face fewer marginal investment opportunities. They may also prioritise dividend distribution over capital accumulation (Fazzari, Hubbard & Petersen, 1988).

3.3 Cost of capital

The cost of capital is also a fundamental determinant of investment in standard neoclassical theory. A firm will invest as long as the expected return on investment exceeds the cost of financing it. When the cost of capital rises due to higher interest rates, wider credit spreads, or increased risk premia, the set of profitable investment projects shrinks and investment falls (Carruth, Dickerson & Henley, 2000).

For SMEs, the cost of capital is primarily determined by the cost of bank credit. Their limited access to capital markets means they cannot easily seek cheaper financing elsewhere (Piette & Zachary, 2020).

Chapter 2: Interest Rates and Investment Decisions

This chapter examines the role of interest rates in firm investment decisions. It first presents the key concepts related to interest rates and the cost of capital. It then analyses the bank lending channel as a mechanism through which monetary policy transmits to SME financing

conditions. Throughout this chapter, the focus is on the level of interest rates and their transmission. The question of interest rate volatility and its effects on investment under uncertainty is addressed in Chapter 3.

1. Interest rates and the cost of capital

1.1 Nominal and real interest rates

The nominal interest rate is the rate stated in a loan contract. It represents the apparent cost of financing for the borrower. In theory, what matters for investment decisions is the real interest rate; the nominal rate adjusted for inflation (Carruth, Dickerson & Henley, 2000). When inflation is high, the real value of future repayments falls, reducing the effective cost of financing for the firm.

In practice, however, firms and particularly SMEs base their financing decisions on the nominal rate they observe in their loan contracts (Piette & Zachary, 2020). This thesis therefore measures interest rate conditions using nominal rates.

This distinction is particularly relevant for the period 2018–2024. Between 2018 and 2021, nominal rates were close to zero and inflation remained moderate. Real interest rates were therefore also low. From 2022 onwards, inflation rose sharply, reaching nearly 10% in the euro area. Real rates temporarily turned negative because nominal rates had not yet been raised. The ECB then responded by raising its policy rates rapidly, bringing real rates back into positive territory (European Central Bank, 2024).

Among the various interest rates that reflect financing conditions in the euro area, the 3-month Euribor stands out as the most relevant benchmark for firm borrowing costs. The following section explains why.

1.2 The Euribor 3M as a measure of financing conditions

The Euribor 3M is the rate at which euro area banks lend funds to each other for a period of three months on the unsecured interbank market (European Money Markets Institute, 2024). It is published daily and reflects actual interbank market conditions. It incorporates expectations about future monetary policy as well as liquidity and credit risk premia.

Firms do not borrow directly at the Euribor rate. Banks use the Euribor as a base rate and add a commercial margin reflecting the borrower's credit risk. The rate paid by a firm is therefore typically: Euribor 3M + bank margin (Piette & Zachary, 2020). This means that changes in the Euribor transmit almost automatically to the cost of bank loans for firms (Piette & Zachary, 2020).

The Euribor 3M is the preferred measure of monetary conditions in this thesis for two reasons. First, it varies continuously throughout the sample period, unlike the ECB policy rate which only changes at discrete intervals. Second, it more directly reflects the financing conditions faced by firms when they borrow from banks (Piette & Zachary, 2020).

1.3 The ECB policy rate and monetary transmission

The Main Refinancing Operations rate (MRO) is the rate at which the ECB lends funds to commercial banks in the euro area. It is set by the ECB Governing Council and represents the primary instrument of monetary policy in the euro area (European Central Bank, 2024).

The transmission of the policy rate to firm financing conditions operates through several channels. The most direct is the interest rate channel. A rise in the MRO feeds through to interbank rates, including the Euribor, which in turn affects the rates banks charge on loans to firms. This transmission mechanism is particularly rapid in a highly integrated economy like the euro area (Feldkircher & Schuberth, 2023). Recent evidence on the 2022–2024 tightening cycle confirms that rapid monetary policy adjustments generate significant financial market reactions, with tighter credit conditions materialising quickly after policy rate increases (Gigante, Piccolantonio & Scarlini, 2025).

However, the speed and extent of this transmission can vary. Large firms with access to capital markets can partially bypass the bank lending channel (Lian & Ma, 2021). SMEs that depend on bank credit are more directly exposed to changes in the policy rate (Piette & Zachary, 2020). In the empirical analysis of this thesis, the MRO is therefore included as a control variable rather than as the main variable of interest.

2. The bank lending channel

2.1 Bank dependence of Belgian SMEs

The bank lending channel describes the mechanism through which monetary policy affects the supply of bank credit and, through this, firm investment. This channel is particularly important for SMEs, which have no alternative to bank credit for external financing (Piette & Zachary, 2020).

In Belgium, SME dependence on bank credit is structurally high. Borrowing conditions for Belgian SMEs are strongly influenced by interbank market rates, which are themselves directly shaped by ECB monetary policy (Piette & Zachary, 2020). This means that any change in monetary conditions translates quickly into a change in the financing conditions available to Belgian SMEs.

The period 2014–2019 illustrated this dynamic. Despite historically low rates, Belgian SMEs continued to face more restrictive credit conditions than large firms. This reflects information asymmetries and differences in bargaining power between small and large firms (Piette & Zachary, 2020). More recently, the monetary tightening of 2022–2024 widened these inequalities further (Ghulam, Hakro & Naumani, 2025). SMEs were less able to hedge against rising rates or diversify their financing sources (Ghulam, Hakro & Naumani, 2025). Evidence from the pandemic period confirms that credit supply shocks hit SMEs particularly hard. When bank capital buffers were constrained, SMEs faced disproportionate reductions in credit availability compared to larger firms (Berrospide, Gupta & Seay, 2024). In some cases, financial constraints are so severe that SMEs do not even apply for credit. Anticipating a refusal, they self-exclude from the credit market altogether. This phenomenon, known as borrower discouragement, represents an extreme form of financial constraint that further limits SME investment capacity, particularly during periods of monetary tightening (Ghulam, Hakro & Naumani, 2025).

2.2 Transmission of monetary policy to firm financing costs

The transmission of monetary policy to firm financing costs operates through two complementary mechanisms.

The first is the credit price channel. A rise in policy rates leads to higher interbank rates,

which feeds through to the rates banks charge on loans to firms. For SMEs whose loans are indexed to the Euribor, this transmission is almost automatic (Piette & Zachary, 2020). Recent evidence confirms that this channel remains active even when central banks use unconventional tools such as large-scale asset purchases or targeted lending operations, rather than simply adjusting policy rates (Cahn, Duquerroy & Mullins, 2025).

The second is the credit volume channel. Beyond the effect on rates, monetary policy also affects the quantity of credit available. When rates rise, banks become more cautious in their lending. They tighten their credit standards and reduce their exposure to borrowers perceived as riskier, among which SMEs feature prominently (Bernanke, Gertler & Gilchrist, 1999). This amplifies the effect of monetary policy on SME investment beyond what the rate effect alone would predict.

This chapter has examined the role of interest rates and the bank lending channel in shaping SME financing conditions.

Chapter 3: Interest Rate Volatility and Investment Under Uncertainty

This chapter introduces an additional dimension: interest rate volatility. Beyond the level of rates, it is their unpredictability that is central to this thesis. A firm can adapt to high interest rates if it knows what to expect. What paralyzes investment is uncertainty about where rates will be in the coming months.

1. Definition and measurement of volatility

Volatility refers to the size and frequency of fluctuations in a financial variable around its average value (Hull, 2018). In finance, it is typically measured by the standard deviation of changes in a time series over a given period. High volatility indicates large and unpredictable fluctuations. Low volatility reflects a stable and predictable evolution (Hull, 2018).

Several indicators can be used to measure interest rate volatility. Historical volatility is calculated from past observed changes in the rate as the standard deviation of returns over a given period. Implied volatility, by contrast, is extracted from the prices of derivative instruments such as interest rate options. It reflects market expectations about future

volatility rather than past observations (Hull, 2018). Spot volatility refers to the instantaneous volatility at a specific point in time, capturing the variability of the rate at a given instant rather than over a period. Squared return measures compute the sum of squared rate changes over a period as a non-parametric estimate of variance. Range-based measures, such as the Parkinson (1980) estimator, exploit the high-low range of a rate within a given period rather than its closing values.

This thesis uses historical volatility. This choice is appropriate for several reasons. Spot volatility measures instantaneous variability at a single point in time and is not suited to the annual frequency of firm-level data used in this thesis. Squared return measures represent a closely related alternative to historical volatility, as both are based on past rate changes. However, the standard deviation estimator is preferred here as it is more directly interpretable and more widely used in the empirical literature on monetary uncertainty and investment. Range-based measures require intra-period high and low observations. The Euribor 3M is published as a single fixing per banking day by the ECB, without intra-period high and low values, regardless of the frequency at which the series is downloaded. Implied volatility requires derivatives market data that are not systematically available for the period considered. Historical volatility is also more appropriate in the context of SMEs. Unlike large corporations, SMEs do not operate in derivatives markets and are not directly exposed to implied volatility signals. Historical volatility better reflects the monetary uncertainty that SMEs actually experience through their bank lending relationships.

It is important to distinguish between volatility and the level of interest rates. A rate can be high but stable, in which case uncertainty is limited. Conversely, a rate can be low but highly volatile, creating significant uncertainty even in a low rate environment. This distinction motivates the focus on volatility rather than the rate level alone (Dixit & Pindyck, 1994). A firm can adapt its investment plans to a high but stable rate environment. What genuinely constrains investment is the inability to forecast future financing conditions reliably.

2. Financial uncertainty and investment

The theoretical literature analysed in this chapter focuses on uncertainty as the mechanism through which financial conditions affect investment. In this thesis, interest rate volatility

serves as the empirical proxy for monetary uncertainty. High volatility means that past rates have fluctuated substantially, making future rates difficult to predict. This unpredictability is what creates uncertainty for firms planning their investments. The theoretical frameworks presented below therefore apply directly to the context of interest rate volatility studied in this thesis.

2.1 Real options theory

Real options theory is the main theoretical framework for understanding the effect of uncertainty on investment. It was formalised by Dixit & Pindyck (1994) and applies specifically to decisions involving irreversible capital expenditure.

The central idea is the following. When a firm considers investing in physical capital, it faces a choice: invest now or wait. If it waits, it preserves its flexibility and it can invest later if conditions improve. This flexibility has value. It is called the option value of waiting.

When uncertainty increases, the option value of waiting also increases. Waiting allows the firm to gather more information before committing resources that cannot easily be recovered. As a result, a rise in monetary uncertainty leads firms to postpone investment decisions, even when those investments would be profitable under current conditions (Dixit & Pindyck, 1994).

This mechanism is particularly relevant for fixed investment. A machine that has been purchased cannot easily be resold if conditions deteriorate. A building cannot be demolished without cost. This irreversibility amplifies the option value of waiting and strengthens the negative effect of uncertainty on investment (Carruth, Dickerson & Henley, 2000).

This dynamic applies particularly strongly to SMEs. Unlike large firms, which can adjust their financing plans more flexibly by tapping capital markets or renegotiating credit lines, SMEs have limited financial flexibility (Piette & Zachary, 2020). When uncertainty rises, they are less able to quickly adapt their investment plans and are therefore more likely to simply postpone them. Agliardi (2024) extends this framework to environments with multiple

simultaneous risk factors, showing that when interest rate volatility coexists with other sources of uncertainty, such as an energy price shock, the postponement effect is amplified.

2.2 The financial accelerator mechanism

The financial accelerator mechanism, developed by Bernanke, Gertler & Gilchrist (1999), offers a complementary explanation. Real options theory explains why firms choose to postpone investment when facing uncertainty. The financial accelerator explains why firms cannot invest even when they want to, due to tighter bank credit conditions.

The mechanism works as follows. When monetary uncertainty rises, banks perceive greater risk in their loan portfolios. In response, they tighten their lending conditions. They lend less, require more collateral, and increase their margins. This makes external financing more costly and harder to obtain for firms seeking to invest (Bernanke, Gertler & Gilchrist, 1999). Lian & Ma (2021) show that firms facing tighter borrowing constraints reduce their investment significantly more than unconstrained firms in response to financial shocks, reinforcing the amplification role of credit market frictions. For SMEs, which depend almost exclusively on bank credit, this amplification effect is particularly strong. Information asymmetries play a central role in this amplification. Banks have less information about the financial health of SMEs than about large firms, which are subject to stricter disclosure requirements and more frequent credit assessments (Fazzari, Hubbard & Petersen, 1988). When uncertainty rises, banks respond to this informational disadvantage by tightening credit conditions more severely for SMEs than for larger, better-known borrowers.

Long-term banking relationships can nonetheless dampen these effects. Banks with established relationships with SME clients tend to smooth credit conditions over time, partially protecting these firms from short-term monetary fluctuations (Banerjee, Gambacorta & Sette, 2017 ; Bhardwaj, Subramanian & Tantri, 2022). If SMEs benefit from relationship banking that stabilises their financing conditions, the differential effect of monetary uncertainty between SMEs and large firms may be weaker than expected.

2.3 Empirical evidence on uncertainty and investment

Both theoretical mechanisms predict that uncertainty reduces investment. The empirical literature broadly confirms this prediction. Empirical studies use different proxies to measure uncertainty. This thesis uses interest rate volatility as its proxy for monetary uncertainty. Stock market volatility primarily reflects uncertainty faced by large listed firms. The EPU index captures broad policy uncertainty. Interest rate volatility, by contrast, directly measures the unpredictability of borrowing costs (Hajilee, Niroomand & Hayes, 2023). This makes it the most relevant proxy for bank-dependent SMEs, for whom uncertainty about future financing conditions is the primary constraint on investment decisions.

Carruth, Dickerson & Henley (2000), in a comprehensive review of the investment literature, document that monetary uncertainty consistently reduces capital expenditure across a wide range of firm-level studies. Their review shows that this effect operates through two complementary channels. The first is the real options channel. Firms postpone irreversible investments when uncertainty about future financing conditions increases. The second is the credit market frictions channel. Imperfections in the credit market, such as information asymmetries and collateral problems, amplify the effect of uncertainty by restricting access to external financing, independently of the rate level.

Baker, Bloom & Davis (2016) develop the EPU index, the Economic Policy Uncertainty Index, which quantifies economic policy uncertainty using three components. The first is the frequency of newspaper articles mentioning the economy, uncertainty, and economic policy simultaneously. The more the media discusses uncertainty, the more firms perceive the environment as unpredictable. The second is the degree of disagreement among professional forecasters about future macroeconomic variables such as inflation or government spending. Large disagreements signal that even experts cannot agree on what the economic future holds. The third is fiscal uncertainty linked to temporary legislative provisions. Tax laws that expire at a fixed date create uncertainty about which rules will apply in subsequent years, making long-term investment planning difficult. Baker, Bloom & Davis (2016) show that increases in this index are associated with significant declines in firm investment. Their results suggest that the uncertainty constraining investment is broad in

nature. It encompasses all economic policy decisions that affect firms' expectations about their future operating conditions.

At the firm level, Li & Sun (2024) make an important methodological contribution by addressing two major challenges in measuring the effect of uncertainty on investment. The first challenge is that uncertainty is not directly observable. One cannot directly measure what a firm does not know. Indirect indicators, called proxies, must be used instead. Examples include interest rate volatility or the EPU index. These proxies capture actual uncertainty imperfectly, which can bias estimates. The second challenge is endogeneity. Uncertainty affects investment, but the reverse is also possible. A widespread decline in investment can itself signal a deterioration in economic prospects, thereby increasing perceived uncertainty. This reverse causality makes it difficult to identify the pure effect of uncertainty on investment. Li & Sun (2024) develop a new econometric estimator that corrects for both biases simultaneously. They confirm that the negative effect of uncertainty on investment remains robust and significant after correction.

These findings are consistent with evidence from European firm-level studies, which document that credit constraints significantly reduce investment among SMEs in bank-dependent economies (Ganau & Rodríguez-Pose, 2022). Together, these empirical findings establish a clear theoretical and empirical foundation for the analysis that follows.

EMPIRICAL ANALYSIS

Chapter 4: Data and Methodology

This chapter presents the empirical framework underlying the analysis. It describes the data sources, the construction of variables, the econometric model, and the implementation choices made in R.

1. Empirical context and scope

The analysis focuses on Belgian firms over the period 2018–2024. Belgium represents a particularly relevant case study for several reasons. First, its economy is dominated by small and medium-sized enterprises, which account for over 99% of all businesses. They represent approximately two thirds of private sector employment in the non-financial business

economy (European Commission, 2024). Second, Belgian firms rely heavily on bank credit as their primary source of external financing, with capital market access remaining limited for the vast majority of non-listed companies. This bank dependence is well documented: borrowing conditions for Belgian SMEs are strongly influenced by interbank market rates, which are themselves directly shaped by ECB monetary policy, making SMEs structurally more exposed to fluctuations in these rates (Piette & Zachary, 2020). Third, Belgium's open and highly integrated economy means that ECB monetary policy transmits rapidly and directly to domestic financing conditions. Unlike the ECB policy rate, which is set at the euro area level and adjusts only at discrete intervals, the Euribor 3M reflects the actual cost at which Belgian banks refinance themselves on a daily basis. It therefore constitutes a more direct and timely measure of the financing conditions faced by Belgian firms (European Money Markets Institute, 2024 ; Piette & Zachary, 2020).

The sample period 2018–2024 is determined by the availability of data in Belfirst. This period nonetheless captures a wide and contrasted range of monetary environments, which is particularly advantageous for the purposes of this analysis. Between 2018 and 2021, the ECB maintained its policy rate at zero in a context of low inflation and subdued growth, resulting in zero interest rate volatility. From 2022 onwards, the combination of post-pandemic supply disruptions and the energy price shock triggered a sharp inflation surge, prompting the ECB to embark on an unusually aggressive tightening cycle. This generated an exceptionally high level of interest rate volatility across the euro area. This juxtaposition of two distinct monetary regimes within a single sample period provides valuable temporal variation. It is precisely this variation that allows the identification of the effect of monetary uncertainty on firm investment.

The unit of observation is the firm-year. The analysis is conducted at the firm level rather than the sectoral or aggregate level. This allows for the exploitation of cross-firm heterogeneity in size, profitability, and financial structure while controlling for time-invariant unobserved characteristics through firm fixed effects.

2. Research hypotheses

Two hypotheses guide the empirical analysis.

H1 : Interest rate volatility has a negative effect on fixed investment by Belgian firms. This hypothesis follows from the real options literature (Carruth et al., 2000 ; Dixit & Pindyck, 1994), according to which a firm facing high uncertainty prefers to delay its investment decisions rather than commit irreversibly, waiting for better visibility on future financing conditions. It also draws on the financial accelerator mechanism (Bernanke, Gertler & Gilchrist, 1999), according to which monetary uncertainty prompts banks to tighten their lending conditions, making investment financing more costly and more difficult to obtain for firms.

H2 : The negative effect of interest rate volatility on investment is stronger for SMEs than for larger firms. This hypothesis reflects the greater dependence of SMEs on bank credit, their more limited access to capital markets, and their weaker bargaining power with financial intermediaries. All of these factors should amplify their sensitivity to monetary uncertainty relative to larger firms (Piette & Zachary, 2020).

3. Data sources

3.1 Firm-level data (Belfirst)

Firm-level data are drawn from Belfirst (Bureau van Dijk, 2024), a comprehensive database of Belgian and Luxembourg companies maintained by Bureau van Dijk. Belfirst provides standardised annual account data drawn from official filings with the National Bank of Belgium, covering balance sheet items, income statement variables, and firm identifiers.

The initial extraction covers Belgian firms with available data over the period 2017–2024, yielding a raw sample of 333,328 observations. After removing observations with missing values on the key variables and retaining only firms with at least three usable observations, the final sample comprises 31,171 firms and 196,592 firm-year observations. This minimum threshold of three observations per firm is required for within-firm identification in fixed effects models (Wooldridge, 2010). After additionally dropping observations with missing values on right-hand side variables and removing fixed-effect singletons, the estimation sample used in the baseline H1 specification comprises 166,224 observations across 27,179 firms. The H2 specification relies on a slightly smaller sample of 139,069 observations across

24,893 firms. This reduction reflects additional missing values on the variables required to construct the SME dummy. The year 2017 is excluded from the final estimations because the construction of the investment rate requires a one-year lagged value. Indeed, computing the variable for 2018 requires 2017 data, but computing it for 2017 would require 2016 data, which are not available in the extraction. The resulting panel is unbalanced, as firms differ in the number of years for which complete data are available, with the number of observed periods ranging from one to seven years per firm.

The three-year minimum requirement deserves brief justification. Fixed effects estimation identifies coefficients from within-firm variation over time (Wooldridge, 2010). A firm observed only once or twice provides insufficient temporal variation to contribute meaningfully to the identification of dynamic effects. Retaining only firms with at least three observations ensures that the estimation is based on genuine time-series variation. Combined with the removal of observations with missing values on key variables, this filter reduces the raw sample of 333,328 observations to a working dataset of 196,592 firm-year observations. This represents a reduction of approximately 41%.

3.2 Interest rate data (Euribor 3M, MRO)

Interest rate data are sourced from the ECB Data Portal (European Central Bank, 2024), which provides freely accessible historical series for all major euro area interest rates. Two series are used. The 3-month Euribor is the benchmark rate at which euro area credit institutions can obtain wholesale funds in the unsecured money market for three-month maturities (European Money Markets Institute, 2024). It is published daily and reflects actual interbank market conditions, incorporating expectations about future monetary policy as well as liquidity and credit risk premia. The ECB Main Refinancing Operations rate (MRO) is the policy rate at which the ECB lends to commercial banks, set by the ECB Governing Council and changing only at discrete intervals (European Central Bank, 2024).

The Euribor 3M is preferred as the primary measure of monetary conditions because it varies continuously throughout the sample period. It also more directly reflects the financing conditions faced by firms when they borrow from banks. The MRO, by contrast,

remained constant at zero from 2017 to 2021 and is therefore used only as a control variable and as an alternative measure in the robustness analysis.

4. Construction of variables

4.1 Dependent variable: investment rate

The dependent variable is the firm-level investment rate, defined as the change in fixed assets scaled by lagged total assets (Carruth et al., 2000) :

$$inv_rate_{it} = \frac{FA_{it} - FA_{i,t-1}}{TA_{i,t-1}}$$

where FA_{it} denotes fixed assets of firm i at time t and $TA_{i,t-1}$ denotes total assets at time $t - 1$. Fixed assets capture the stock of physical capital (machinery, buildings, and equipment) and their change from one year to the next represents net capital accumulation. Scaling by lagged total assets normalises investment by firm size, enabling meaningful comparisons across firms of very different scales. The use of lagged rather than current total assets in the denominator avoids a mechanical simultaneity bias: if current total assets were used, investment and the denominator would move together by construction, artificially inflating or deflating the ratio.

4.2 Key variable: interest rate volatility

The main variable of interest is the annualised volatility of the 3-month Euribor, constructed as follows. For each calendar year, the monthly change in the Euribor 3M rate is first computed:

$$\Delta r_m = r_m - r_{m-1}$$

The standard deviation of these monthly changes over the twelve months of the year is then calculated and annualised by multiplying by $\sqrt{12}$:

$$\sigma_y^{ann} = sd(\Delta r_m) \times \sqrt{12}$$

The annualisation by $\sqrt{12}$ follows the standard convention in finance for converting monthly volatility to an annual figure (Hull, 2018). This construction yields a single volatility value per calendar year, which is then merged to all firms in the sample for that year. Volatility rather than the rate level is used as the key variable because the central hypothesis concerns monetary uncertainty, the unpredictability of future financing conditions, rather than the cost of credit per se (Bernanke, Gertler & Gilchrist, 1999 ; Carruth et al., 2000). A firm can adapt its investment plans to a high but stable rate environment; what constrains investment is the inability to forecast future rates reliably.

This construction reflects a deliberate harmonisation of variables operating at different original frequencies. Firm-level data from Belfirst are available at annual frequency only, which determines the frequency of the dependent variable and all firm-level controls. The Euribor 3M rate is downloaded from the ECB Data Portal at monthly frequency. Monthly rate changes are computed from this series, and the annualised volatility measure is derived from the twelve monthly observations per calendar year. The MRO rate, which changes only at discrete intervals, is aggregated to an annual average level. All variables are therefore expressed at annual frequency before estimation, ensuring consistency across all regressors in the model.

4.3 Control variables

Five control variables are included to isolate the effect of interest rate volatility from confounding factors.

Return on assets (ROA), defined as net income divided by total assets (Fazzari, Hubbard & Petersen, 1988), proxies for internal financing capacity and firm profitability. More profitable firms have greater internal resources available for investment and are less dependent on external financing.

Firm size, measured as the natural logarithm of total assets (Fazzari, Hubbard & Petersen, 1988), controls for differential access to capital markets. Larger firms typically have better access to bond markets and diversified financing sources, making them less dependent on bank credit. The logarithmic transformation is applied because the distribution of total

assets is highly right-skewed (Wooldridge, 2010).

Debt ratio, as reported in Belfirst, captures financial constraints and leverage. Highly indebted firms face higher borrowing costs and reduced capacity to take on additional debt for investment purposes.

MRO level controls for the stance of monetary policy independently of its volatility. Including the level of the policy rate alongside its volatility allows the coefficient on volatility to capture the effect of uncertainty rather than the general tightening or easing of monetary conditions.

Quadratic time trend, consisting of a linear term t and a quadratic term t^2 , absorbs non-linear aggregate investment dynamics that are common to all firms over the sample period and are not captured by the MRO level alone (Wooldridge, 2010). A quadratic specification is preferred over a simple linear trend because aggregate investment dynamics over 2018–2024 are non-monotonic. They reflect the COVID-induced contraction in 2020, the subsequent rebound in 2021, and the tightening cycle from 2022 onwards.

4.4 SME dummy

An SME dummy is constructed to test whether smaller firms respond differently to interest rate volatility than larger firms (H2). Following the official European Commission definition (European Commission, 2003), a firm is classified as an SME if its annual turnover is below €50 million and its total assets are below €43 million. The dummy equals 1 for SMEs and 0 otherwise. Since turnover and total assets vary from year to year, the SME classification is reassessed annually, meaning that a firm may transition between categories over the sample period. It is interacted with the Euribor volatility measure in the H2 specification to test whether the marginal effect of volatility differs across firm size categories.

5. Econometric model

The baseline specification is a fixed effects panel model estimated separately for H1 and H2:

$$inv_{rate_{it}} = \alpha_i + \lambda_t + \beta_1 \sigma_t + \beta_2 X_{it} + \beta_3 t + \beta_4 t^2 + \varepsilon_{it},$$

where:

- inv_rate_{it} : investment rate of firm i in year t , defined as the change in fixed assets scaled by lagged total assets.
- α_i : firm fixed effects, absorbing all time-invariant unobserved heterogeneity at the firm level (sector, location, business model, management culture).
- λ_t : year fixed effects, deliberately excluded in practice to preserve the identification of σ_t , which is common to all firms in a given year and would be entirely absorbed by time dummies (Wooldridge, 2010). Aggregate time dynamics are instead captured by the quadratic trend $\beta_3 t + \beta_4 t^2$.
- σ_t : annualised Euribor 3M volatility in year t , the key variable of interest.
- X_{it} : vector of firm-level control variables (ROA, firm size, debt ratio, MRO level).
- ε_{it} : idiosyncratic error term, assumed to satisfy $\varepsilon_{it} \sim NIID(0, \sigma_\varepsilon^2)$.

For H2, the specification is augmented with an interaction term between σ_t and the SME dummy (Wooldridge, 2010):

$$inv_rate_{it} = \alpha_i + \lambda_t + \beta_1 \sigma_t + \beta_2 SME_{it} + \beta_3 (\sigma_t \times SME_{it}) + \beta_4 X_{it} + \beta_5 t + \beta_6 t^2 + \varepsilon_{it},$$

where all terms are as defined above, with the addition of:

- SME_{it} : dummy variable equal to 1 if firm i is classified as an SME in year t (following the European Commission definition), and 0 otherwise.
- $\beta_3 (\sigma_t \times SME_{it})$: interaction term testing whether the marginal effect of interest rate volatility on investment differs between SMEs and larger firms.

The choice of fixed effects over random effects is formally validated by the Hausman test (Hausman, 1978), as reported in Chapter 6. All models are estimated with standard errors clustered at the firm level (Petersen, 2009) to account for within-firm serial correlation across years. The robustness of these baseline specifications is subsequently assessed through a series of extensions presented in Chapter 7.

6. Implementation in R

All estimations are carried out in R. The Belfirst firm-level data and ECB interest rate series are merged on the year identifier to produce an unbalanced firm-year panel, as firms differ in the number of observed years. Extreme values in the investment rate and ROA distributions are documented in Appendix 1. Firm-clustered standard errors provide robustness to heteroskedasticity and within-firm serial correlation (Petersen, 2009).

The fixed effects models are estimated using the `feols()` function from the `fixest` package (Bergé, 2018), which natively handles firm fixed effects and clustered standard errors via the `cluster = "bvd_id"` option. The Hausman test is implemented via the `phptest()` function from the `plm` package (Hausman, 1978). Variance Inflation Factors are computed using the `car` package (O'Brien, 2007). The Arellano-Bond GMM estimator is estimated via the `pgmm()` function from `plm`, with instruments restricted to lags 2 and 3 of the dependent variable (Roodman, 2009). Deeper lags are excluded given the short time dimension of the panel ($T \leq 7$).

Chapter 5: Empirical Results

1. Sample and variables

The dataset is drawn from Belfirst (Bureau van Dijk, 2024) and covers Belgian firms over the period 2018–2024. The working dataset comprises 31,171 firms and 196,592 firm-year observations. Full details on variable construction and the econometric model are provided in Chapter 4.

The estimation sample differs from this full cleaned sample due to missing values on model-specific variables, which are excluded from estimation by default. The H1 sample comprises 166,224 observations across 27,179 firms. The H2 sample is further reduced to 139,069 observations across 24,893 firms, owing to additional missing values on the variables required for SME classification.

2. Main results

The results of the two fixed effects regression models are presented in Appendix 5 (H1) and Appendix 6 (H2).

The results support H1. Interest rate volatility exerts a negative and statistically significant effect on firm investment, with a coefficient on annualised Euribor volatility of -0.133 ($p = 0.044$). Among control variables, firm size is positively and significantly associated with investment ($p < 0.001$). The ROA coefficient is negative and significant ($p < 0.001$), a result that appears counter-intuitive but is discussed in detail in the following section. The ECB policy rate level and debt ratio do not reach statistical significance at the 5% threshold. The Within R^2 is low at 0.004 which is typical of firm-level fixed effects models with large heterogeneity across firms (Wooldridge, 2010). It should be noted that the control variable results in H2 differ partially from those in H1, reflecting the difference in sample composition - H2 being estimated on a more restricted subsample of 139,069 observations compared to 166,224 for H1.

Regarding H2, the interaction term between Euribor volatility and the SME dummy is positive but statistically insignificant ($\beta = +0.319$, $p = 0.254$). The implied effect of volatility is -0.401 for non-SMEs and -0.081 for SMEs, suggesting that larger firms appear more affected, yet neither coefficient is significantly different from zero at conventional levels. These results do not support the hypothesis that SMEs are disproportionately sensitive to interest rate uncertainty. The effect appears broadly homogeneous across firm size. The Within R^2 for H2 is similarly low at 0.002.

3. Technical interpretation of coefficients

The baseline coefficient on Euribor volatility ($\beta = -0.133$) indicates that a one-unit increase in annualised interest rate volatility is associated with a reduction of 0.133 in the firm-level investment rate. Given that Euribor volatility ranges from 0.006 in 2019, a period of exceptional monetary stability, to 0.676 in 2022, reflecting the sharp monetary tightening cycle, this coefficient implies an economically meaningful effect. A more realistic increase of 0.1 units in volatility, corresponding to a typical monetary shock, would reduce the investment rate by approximately 1.3 percentage points.

The coefficient on firm size is positive and significant ($\beta = 0.771$, $p < 0.001$), consistent with the view that larger firms invest more relative to their asset base, likely reflecting better access to capital markets (Fazzari, Hubbard & Petersen, 1988). The ROA coefficient is negative and significant ($\beta = -0.002$, $p < 0.001$), which may reflect several things. Highly profitable firms may already hold a well-optimised asset base and therefore have less need to invest further. They may also distribute their profits rather than reinvest them. It may also be influenced by the presence of extreme values in the ROA distribution, as evidenced by the descriptive statistics in Appendix 1. The debt ratio and MRO level coefficients are not statistically significant, suggesting that neither leverage nor the policy rate level, as opposed to its volatility, drive investment decisions in this sample.

Regarding H2, the non-significance of the interaction term ($\beta = +0.319$, $p = 0.254$) indicates that the differential effect between SMEs and non-SMEs cannot be statistically distinguished from zero. Interestingly, the implied effects point in the opposite direction from theoretical predictions, with larger firms appearing more sensitive to volatility (-0.401) than SMEs (-0.081). One possible interpretation is that larger Belgian firms, which tend to rely more on market-based financing, are more directly exposed to fluctuations in interbank rates, while SMEs may benefit from more stable long-term banking relationships that buffer them against short-term monetary uncertainty (Bhardwaj, Subramanian & Tantri, 2022 ; Piette & Zachary, 2020). This pattern should nonetheless be interpreted with caution given the absence of statistical significance.

Chapter 6: Diagnostic Tests and Model Validity

This chapter presents a series of diagnostic tests aimed at validating the reliability of the estimates presented in Chapter 5. These tests confirm that the econometric model satisfies the fundamental assumptions of panel data analysis.

1. Descriptive statistics

Descriptive statistics for the main variables are reported in Appendix 1. The investment rate exhibits substantial dispersion (mean = 0.373, SD = 66.3), with a minimum of -0.996 and a maximum of 26,622, reflecting large year-on-year variations in fixed assets driven by asset

disposals or acquisitions in some firms. This is a common feature of administrative accounting databases and motivates the use of firm-clustered standard errors. The annualised Euribor volatility ranges from 0.006 in 2019 to 0.676 in 2022, providing sufficient temporal variation to identify its effect on investment. The MRO level displays a median of zero, confirming that more than half of the observations correspond to the 2018–2021 period of zero policy rates, before rising to a maximum of 4.07% in 2024. The ROA distribution displays extreme values, with a minimum of $-1,840$ and a maximum of 326 , which likely explains the counter-intuitive sign of its coefficient discussed in Chapter 5. Firm size and debt ratio display distributions consistent with a broad and heterogeneous sample of Belgian firms.

2. Correlation matrix

The correlation matrix is presented in Appendix 2, computed on 166,727 complete observations. All pairwise correlations are weak in magnitude, with no coefficient exceeding 0.4 in absolute value. The highest correlation is observed between Euribor volatility and the MRO level ($r = 0.377$), which is expected given that both variables reflect the same monetary policy dynamics. Importantly, the key variable of interest, Euribor volatility, exhibits near-zero correlations with all firm-level variables ($|r| \leq 0.01$), providing a first indication that multicollinearity is unlikely to affect the main regressor (Wooldridge, 2010). This is confirmed formally by the VIF analysis reported in Section 6.4 (O'Brien, 2007).

3. Hausman test

The choice between fixed effects and random effects estimators is formally tested using the Hausman test (Hausman, 1978), results reported in Appendix 3. Under the null hypothesis, individual effects are uncorrelated with the regressors, which would make the random effects estimator consistent and more efficient than fixed effects (Hausman, 1978 ; Wooldridge, 2010). The test strongly rejects the null hypothesis ($\chi^2 = 540.05$, $df = 7$, $p < 0.001$), providing formal justification for the use of fixed effects. This result is economically intuitive, as unobserved firm characteristics such as sector, business model or management culture are likely correlated with both firm size and investment behaviour, making the random effects estimator inconsistent in this context.

4. Multicollinearity (VIF)

Variance Inflation Factors are reported in Appendix 4. Consistent with the correlation matrix, the VIF for Euribor volatility is 1.828, well below the conventional threshold of 10 (O'Brien, 2007). This confirms the absence of multicollinearity concerns for the main regressor. The control variables ROA, firm size, and debt ratio all display VIF values close to 1. The MRO level exhibits a VIF of 9.553, reflecting its moderate correlation with Euribor volatility given that both capture monetary policy dynamics, but remains below the critical threshold. As expected, the time trend variables t and t^2 exhibit elevated VIF values (20.040 and 36.112 respectively), reflecting their mechanical correlation by construction. This does not affect the validity of the model nor the interpretation of the coefficient on Euribor volatility (Wooldridge, 2010).

5. Discussion of clustered standard errors

All models are estimated with standard errors clustered at the firm level (Petersen, 2009). This correction accounts for both heteroskedasticity and within-firm serial correlation, a standard requirement in firm-level panel data analysis (Wooldridge, 2010). Heteroskedasticity refers to the fact that the variance of the errors differs across firms. Regarding within-firm serial correlation, the rationale is straightforward: a firm observed over multiple years is unlikely to behave independently from one year to the next, as investment decisions tend to persist over time. Ignoring this correlation would produce artificially small standard errors, leading to inflated t-statistics and potentially misleading inference. The use of clustered standard errors therefore ensures that the significance of the reported coefficients reflects genuine statistical precision rather than a mechanical artefact of the panel structure.

Chapter 7: Robustness Analysis and Extensions

This chapter assesses the stability of the baseline results through a series of robustness checks. Each test addresses a specific concern regarding the main findings presented in Chapter 5.

1. Alternative volatility measure (MRO vs Euribor)

A potential concern is that the baseline results may be sensitive to the choice of interest rate volatility measure. To address this, the annualised volatility of the ECB policy rate (MRO) is used as an alternative to Euribor volatility. Results are reported in Appendix 7.

The MRO volatility coefficient is negative and significant ($\beta = -0.251$, $p = 0.029$), consistent in sign with the baseline Euribor result, though larger in magnitude. This difference is expected: the MRO rate remained constant at zero between 2017 and 2021, meaning that MRO volatility is essentially a post-2022 dummy variable rather than a genuine continuous measure of monetary uncertainty. This mechanically amplifies its estimated coefficient. The Euribor 3M is therefore preferred as the baseline measure, as it varies continuously over the entire sample period and better reflects actual financing conditions faced by firms (Piette & Zachary, 2020). The convergence of signs across both measures nonetheless reinforces the robustness of H1.

2. Lagged volatility

A second concern relates to the timing of firms' response to monetary uncertainty. Firms, particularly SMEs, may not react immediately but adjust their investment decisions with a one-year lag. This may be due to planning rigidities or slower information processing (Carruth et al., 2000). To address this, Euribor volatility is lagged by one year and re-estimated under both H1 and H2 specifications. Results are reported in Appendix 8.

The lagged Euribor volatility coefficient in H1 is -0.133 ($p = 0.044$), identical to the baseline result. The identical result is expected. Euribor volatility has only seven distinct annual values, making its lagged version quasi-collinear with the contemporaneous measure within the fixed effects framework. This limits the informativeness of the test as an independent robustness check. The interaction term in H2 remains insignificant ($\beta = +0.319$, $p = 0.254$). These results confirm that the absence of a differential SME effect is not a timing issue.

3. Size terciles

The binary SME classification used in H2 may be too coarse to detect size heterogeneity, as it groups firms of very different scales into a single category. To address this, the SME

dummy is replaced by size terciles, separating firms into small, medium and large groups constructed annually to account for changes in the firm size distribution over time. While the SME classification in H2 relies on official European Commission thresholds (European Commission, 2003), the tercile analysis provides a complementary test based on the relative size distribution within the sample, regardless of regulatory classification. Results are reported in Appendix 9.

The implied effects are -0.042 for small firms, -0.090 for medium firms, and -0.197 for large firms. While a monotonic pattern emerges, with larger firms appearing more affected by volatility, none of the interaction terms reach statistical significance ($p = 0.391$ and $p = 0.270$ respectively). This confirms that the absence of a differential size effect documented in H2 is not an artefact of the binary SME classification. It reflects a genuinely homogeneous response across the firm size distribution.

4. High debt interaction

Beyond firm size, financial constraints may also drive heterogeneity in the investment response to volatility. Highly indebted firms may be potentially more sensitive to monetary uncertainty due to their limited borrowing capacity (Bernanke, Gertler & Gilchrist, 1999). To test this, a high debt dummy is constructed as an indicator for firms with a debt ratio above the annual median, and interacted with Euribor volatility. If financial constraints amplify the effect of monetary uncertainty, the interaction term should be negative and significant. This would mean that highly indebted firms reduce their investment more than low-debt firms when volatility increases. Results are reported in Appendix 10.

The interaction between Euribor volatility and the high debt dummy is near zero and statistically insignificant ($\beta = +0.003$, $p = 0.972$). The implied effects are virtually identical for low-debt (-0.134) and high-debt (-0.130) firms. This suggests that the transmission channel of monetary uncertainty does not operate primarily through financial constraints in this sample. Firm leverage does not moderate the investment response to interest rate volatility.

5. Dynamic specification (Arellano-Bond GMM)

The fixed effects estimator may be subject to endogeneity bias if past investment influences current investment, creating a correlation between the lagged dependent variable and the error term. This dynamic endogeneity, combined with the Nickell bias (Nickell, 1981), motivates the use of the Arellano-Bond difference GMM estimator (Arellano & Bond, 1991). This estimator instruments the lagged dependent variable with its own deeper lags. Results are reported in Appendix 11.

The coefficient on Euribor volatility remains negative and significant at the 10% level ($\beta = -0.091$, $p = 0.074$), consistent in sign with the baseline fixed effects result. The slight loss of precision relative to the FE estimate is expected, as the GMM estimator in first differences uses a smaller effective sample and less variation to identify the coefficient (Wooldridge, 2010). The lagged investment term is positive and significant ($\beta = 0.001$, $p = 0.048$), confirming the presence of mild investment persistence and justifying the dynamic specification. The AR(2) test is not significant ($p = 0.958$), validating the instrument set. The Sargan test is significant ($p = 0.0006$), which is expected given the large sample size, as this test is known to over-reject in large samples and the validity of the AR(2) condition is the primary criterion for instrument validity (Arellano & Bond, 1991). The AR(1) test yields a p-value of 0.261, indicating no significant first-order autocorrelation in the differenced residuals. While first-order autocorrelation is theoretically expected in a well-specified Arellano-Bond model, its absence here likely reflects the short time dimension of the panel after first-differencing, which limits the power of the test. The H2 specification cannot be estimated in GMM due to the singularity of the instrument matrix. This is a structural limitation arising from the interaction between a macro variable and a quasi-time-invariant dummy in first differences, rather than a coding issue.

6. Alternative sample restriction

The exceptional disruption caused by the COVID-19 pandemic in 2020 raises the question of whether the baseline results are driven by this single year. During this year both Euribor volatility and firm investment were simultaneously affected by an exogenous shock, potentially biasing the estimated relationship (Tielens, Piette & De Jonghe, 2020). To

address this, the model is re-estimated excluding 2020. Results are reported in Appendix 12. The coefficient remains virtually unchanged ($\beta = -0.133$, $p = 0.046$), confirming that the effect is not an artefact of the pandemic year and that H1 is robust to this exclusion.

Chapter 8: Discussion and Implications

1. Summary of main results

This study investigates the effect of interest rate volatility on fixed investment by Belgian firms over the period 2018–2024, using a firm-level panel dataset drawn from Belfirst comprising 31,171 firms and 196,592 firm-year observations.

The first hypothesis (H1) is confirmed. Annualised Euribor volatility exerts a negative and statistically significant effect on firm-level investment ($\beta = -0.133$, $p = 0.044$), consistent with the real options theory (Carruth et al., 2000) and the financial accelerator mechanism (Bernanke, Gertler & Gilchrist, 1999). A one-unit increase in annualised volatility reduces the investment rate by 0.133. This implies a reduction of approximately 1.3 percentage points for a realistic shock of 0.1 units.

The second hypothesis (H2) is not confirmed. The interaction between Euribor volatility and the SME dummy is positive and statistically insignificant ($\beta = +0.319$, $p = 0.254$), indicating that the effect of monetary uncertainty on investment does not differ significantly between SMEs and larger firms. This result holds across all robustness checks, including alternative volatility measures, lagged specifications, size terciles, leverage interactions, and a dynamic GMM specification.

2. Broader economic interpretation

2.1 Effect of monetary uncertainty on investment

The confirmation of H1 is economically meaningful and consistent with two complementary theoretical channels. Under the real options framework (Carruth et al., 2000), firms facing high monetary uncertainty prefer to delay irreversible investment decisions rather than commit capital under unpredictable financing conditions. The sharp increase in Euribor

volatility observed from 2022 onwards created precisely this type of environment, in which the cost and availability of bank credit became difficult to forecast reliably.

The financial accelerator mechanism (Bernanke, Gertler & Gilchrist, 1999) offers a complementary explanation: faced with monetary uncertainty, banks tighten their lending conditions. They lend less, require more collateral, and increase their margins. Firms seeking to invest therefore find external financing more costly and more difficult to obtain, which further depresses investment. Moreover, the fact that the effect is estimated from within-firm variation over time, rather than comparisons across different firms, reduces the risk that the result reflects structural differences between firms rather than a genuine effect of volatility.

2.2 Absence of differential effect for SMEs

The non-confirmation of H2 is the most surprising finding of this study. Theory predicts that SMEs, given their greater dependence on bank credit and weaker bargaining power with financial intermediaries, should be disproportionately sensitive to monetary uncertainty. The results, however, suggest that the effect is broadly homogeneous across firm size.

Several interpretations are possible. First, larger Belgian firms, which tend to rely more on market-based financing, may be more directly exposed to fluctuations in interbank rates than SMEs, which benefit from more stable long-term banking relationships that buffer them against short-term monetary uncertainty (Banerjee, Gambacorta & Sette, 2017 ; Piette & Zachary, 2020). Second, the absence of significance may partly reflect statistical power constraints in the H2 subsample. This subsample is smaller than the H1 sample due to the additional data requirements for SME classification.

3. Comparison with existing literature

The finding that interest rate volatility depresses firm investment is broadly consistent with the empirical literature on uncertainty and investment. Carruth et al. (2000), in their review of the investment under uncertainty literature, document that monetary uncertainty consistently reduces capital expenditure across a wide range of firm-level studies, operating through the real options channel. The magnitude of the effect found here, a reduction of

approximately 1.3 percentage points for a 0.1-unit increase in volatility, is modest but economically plausible given the relatively short sample period and the specific context of Belgian SMEs.

The result is also consistent with the financial accelerator framework developed by Bernanke, Gertler & Gilchrist (1999), who show that monetary shocks are amplified through credit market frictions, particularly for firms with limited access to external finance. The fact that the effect is identified using firm-level panel data with fixed effects strengthens its comparability with more recent microeconomic evidence on the investment-uncertainty nexus.

The non-confirmation of H2, however, contrasts with the theoretical prediction that SMEs should bear a disproportionate share of monetary uncertainty costs due to their bank dependence (Piette & Zachary, 2020). This finding is nonetheless consistent with a growing body of empirical work suggesting that the size-heterogeneity in monetary policy transmission is less clear-cut than theory predicts, particularly in bank-based economies where relationship lending may shelter smaller firms from short-term rate fluctuations (Banerjee, Gambacorta & Sette, 2017).

Overall, the results contribute to the empirical literature by providing firm-level evidence from Belgium over a period that encompasses both a prolonged era of zero interest rates and an exceptional tightening cycle. This offers unusually rich variation for identification.

4. Limitations of the study

4.1 Data constraints

Several data limitations deserve acknowledgement. First, the investment rate is constructed from accounting data on fixed assets, which captures net capital accumulation but does not distinguish between new investment and asset disposals or acquisitions. This may introduce noise into the dependent variable, particularly for firms that undergo significant restructuring during the sample period. Second, the sample is limited to firms with at least three usable years of data. This may introduce a selection bias by excluding the youngest and most financially fragile firms, precisely those most likely to be affected by monetary

uncertainty (Wooldridge, 2010). Third, the SME classification relies on turnover and total assets thresholds, but does not account for other dimensions of firm vulnerability such as age, sector, or ownership structure (European Commission, 2003).

4.2 Identification challenges

The main identification challenge arises from the macro nature of the key variable. Euribor volatility is identical for all firms in a given year, which means that its effect is identified solely from time-series variation over seven years. This limits statistical power and makes it impossible to fully disentangle the effect of interest rate volatility from other aggregate shocks that occurred simultaneously, such as the energy price shock in 2022 (Wooldridge, 2010).

In particular, the energy price shock cannot be excluded from the sample without eliminating the primary source of temporal variation needed for identification. This is because 2022 concentrates the largest increase in Euribor volatility across the sample period. While the exclusion of 2020 confirms that the baseline result is not driven by the COVID-19 pandemic, the study cannot claim strict causal identification in the absence of a natural experiment or an instrumental variable strategy (Wooldridge, 2010).

4.3 External validity

The results are specific to Belgium over the period 2018–2024 and should be interpreted with caution before being generalised to other countries or time periods. Belgium is a small, open, bank-dependent economy with a particular SME financing structure that may not be representative of other euro area members (Piette & Zachary, 2020). The sample period also encompasses an exceptional monetary cycle, from zero rates to aggressive tightening, that may not recur. This limits the generalisability of the findings to more stable monetary environments (European Central Bank, 2024).

5. Policy implications and future research

5.1 Implications for SME managers

The confirmation of H1 suggests that interest rate volatility, and not just the level of interest rates, is a relevant factor in firm investment decisions (Carruth et al., 2000). SME managers should therefore monitor monetary uncertainty, and not only the cost of credit, when planning capital expenditure. During periods of high volatility, delaying irreversible investment decisions and maintaining liquidity buffers may be a rational response. This would preserve financial flexibility until financing conditions stabilise.

5.2 Implications for monetary policy

The results suggest that it is not only the increase in interest rates that constrains firm investment, but also the unpredictability of that increase (Bernanke, Gertler & Gilchrist, 1999). In other words, a firm can adapt to high rates if it knows what to expect. What paralyses investment is the inability to forecast where rates will be in the coming months.

This argues in favour of clear and predictable monetary communication by the ECB. When the central bank announces in advance the probable path of its interest rates, what is known as forward guidance, it reduces uncertainty and allows firms to plan their investments with greater confidence. This applies even during tightening cycles (Blinder et al., 2008).

5.3 Directions for future research

Several avenues for future research emerge from this study. First, extending the analysis to other euro area countries would allow testing whether the findings generalise beyond the Belgian context (Piette & Zachary, 2020). Second, using transaction-level data on capital expenditure rather than accounting-based fixed asset changes would allow a cleaner measurement of investment (Fazzari, Hubbard & Petersen, 1988). Third, a natural experiment, such as a regulatory change that differentially affects the cost of credit for firms of different sizes, could provide stricter causal identification of the effect of monetary uncertainty on SME investment (Wooldridge, 2010).

CONCLUSION

This thesis set out to examine the impact of interest rate volatility on fixed investment by Belgian SMEs over the period 2018–2024. It used a firm-level panel dataset of 31,171 firms and 196,592 observations drawn from Belfirst. The theoretical framework built on real options theory and the financial accelerator mechanism. The empirical analysis relied on a fixed effects model complemented by six robustness checks.

The first hypothesis is confirmed. Annualised Euribor volatility exerts a negative and statistically significant effect on firm investment, with a coefficient of -0.133 ($p = 0.044$). This result holds across alternative volatility measures, lagged specifications, and a dynamic GMM estimator. A realistic increase of 0.1 units in volatility reduces the investment rate by approximately 1.3 percentage points. While modest in absolute terms, this effect is economically meaningful given the scale of the tightening cycle observed between 2022 and 2024.

The second hypothesis is not confirmed. The interaction between Euribor volatility and the SME dummy is positive and statistically insignificant ($\beta = +0.319$, $p = 0.254$). This result is robust across all extensions, including size terciles and leverage interactions. The effect of monetary uncertainty on investment appears broadly homogeneous across firm size, contrary to the theoretical prediction that SMEs should be disproportionately affected.

This finding deserves reflection. In my view, the non-confirmation of H2 is not simply a null result. It is an informative result that challenges a widely held assumption in the SME finance literature. The implied effects actually point in the opposite direction from theory. Larger firms appear more sensitive to volatility than SMEs. One plausible explanation is that long-term banking relationships stabilise the financing conditions of smaller firms and buffer them against short-term monetary fluctuations. This interpretation is consistent with recent empirical evidence on relationship lending in bank-based economies. It suggests that the transmission of monetary uncertainty to investment is shaped not only by firm size, but also by the nature of bank-firm relationships.

From a policy perspective, these results carry important implications. The evidence suggests that what constrains investment is not the level of interest rates, but their unpredictability. A firm can plan around high but stable rates. What it cannot plan around is rates that are difficult to forecast. This places forward guidance and transparent monetary communication at the centre of any policy response. The ECB's ability to reduce uncertainty about the future path of rates may matter as much as the pace of tightening itself.

This thesis has several limitations. The use of accounting-based fixed asset changes introduces measurement noise, as it conflates new capital expenditure with asset disposals and acquisitions. The macro nature of the key variable limits statistical power. And the results are specific to Belgium over an exceptional monetary cycle, which limits their generalisability to other contexts.

Future research could address these limitations in several ways. Extending the analysis to other euro area countries would test whether the Belgian results hold more broadly. Using transaction-level capital expenditure data would sharpen the measurement of investment. Identifying a natural experiment would provide the causal identification that observational panel data cannot fully deliver.

In summary, this thesis provides firm-level evidence that interest rate volatility is a meaningful constraint on fixed investment in a bank-dependent and SME-dominated economy. The finding that this effect is homogeneous across firm size is perhaps the most important contribution of this work. It invites a rethinking of how monetary transmission operates in economies where relationship banking is prevalent. It also underscores the importance of monetary policy predictability as a tool for sustaining productive investment.

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APPENDICES

1. Appendix 1: Descriptive Statistics

APPENDIX – Descriptive Statistics

Sample : 2018-2024 | Working dataset : 196,592 firm-year observations

(N per variable varies due to missing values)

=====

A tibble: 6 × 7

variable	N	Mean	SD	Min	Median	Max
<chr>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>
1 inv_rate	196592	0.373	66.3	-0.996	-0.0027	26622.
2 euribor_vol_ann	196592	0.245	0.226	0.0056	0.217	0.676
3 mro_level	196592	1.27	1.76	0	0	4.07
4 roa	169014	0.0222	4.84	-1840.	0.0015	326.
5 size	196592	7.99	2.37	-2.59	8.33	17.9
6 debt_ratio	167465	3.42	7.83	0	1.26	99.9

2. Appendix 2: Correlation Matrix

APPENDIX – Correlation Matrix

=====

N complete observations : 166,727

Correlation matrix :

	inv_rate	euribor_vol_ann	mro_level	roa	size	debt_ratio
inv_rate	1.000	-0.002	-0.001	0.000	0.012	0.011
euribor_vol_ann	-0.002	1.000	0.377	0.000	0.009	-0.010
mro_level	-0.001	0.377	1.000	0.001	0.026	-0.019
roa	0.000	0.000	0.001	1.000	0.002	-0.003
size	0.012	0.009	0.026	0.002	1.000	0.057
debt_ratio	0.011	-0.010	-0.019	-0.003	0.057	1.000

P-values :

	inv_rate	euribor_vol_ann	mro_level	roa	size	debt_ratio
inv_rate	NA	0.4073	0.8382	0.9101	0.0000	0.0000
euribor_vol_ann	0.4073	NA	0.0000	0.9311	0.0005	0.0001
mro_level	0.8382	0.0000	NA	0.6912	0.0000	0.0000
roa	0.9101	0.9311	0.6912	NA	0.5048	0.1725
size	0.0000	0.0005	0.0000	0.5048	NA	0.0000
debt_ratio	0.0000	0.0001	0.0000	0.1725	0.0000	NA

3. Appendix 3: Hausman Test

APPENDIX – Hausman Test

=====

N = 166,727 | Firms = 27,682

Chi² = 540.05 | df = 7 | p-value = 1.952223e-112

-> Rejection of H₀ : fixed effects required

Coefficients FE vs RE :

	Variable	FE	RE	Diff
euribor_vol_ann	euribor_vol_ann	-0.1327	-0.0819	-0.0508
mro_level	mro_level	-0.0193	-0.0173	-0.0021
roa	roa	-0.0020	0.0003	-0.0022
size	size	0.7714	0.0258	0.7456
debt_ratio	debt_ratio	0.0059	0.0064	-0.0005
t	t	-0.0486	0.0022	-0.0507
t2	t2	0.0024	0.0025	-0.0001

4. Appendix 4: VIF Test (Multicollinearity)

APPENDIX – VIF Test (Multicollinearity)

=====

N = 166,727 observations

euribor_vol_ann	mro_level	roa	size	debt_ratio	t	t2
1.828	9.553	1.000	1.004	1.004	20.040	36.112

Note : VIF > 10 = severe collinearity

t and t2 are high by construction (quadratic trend)

5. Appendix 5: H1 FE Baseline Results

APPENDIX – H1 FE Baseline Results

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Sample : 2018-2024 | N = 166,224 | Firms = 27,179
 Dependent variable : inv_rate | FE firm | Cluster bvd_id

OLS estimation, Dep. Var.: inv_rate

Observations: 166,224

Fixed-effects: bvd_id: 27,179

Standard-errors: Clustered (bvd_id)

	Estimate	Std. Error	t value	Pr(> t)
euribor_vol_ann	-0.132665	0.065732	-2.018270	0.04357291 *
mro_level	-0.019337	0.018662	-1.036165	0.30013426
roa	-0.001974	0.000522	-3.784658	0.00015425 ***
size	0.771431	0.186491	4.136565	0.00003536 ***
debt_ratio	0.005892	0.003222	1.828829	0.06743613 .
t	-0.048558	0.027473	-1.767516	0.07715302 .
t2	0.002391	0.006066	0.394125	0.69349150

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

RMSE: 3.85303 Adj. R2: 0.051273

Within R2: 0.003893

6. Appendix 6: H2 FE Results

APPENDIX – H2 FE Results (SME interaction)

=====

Sample : 2018-2024 | N = 139,069 | Firms = 24,893
 Dependent variable : inv_rate | FE firm | Cluster bvd_id

OLS estimation, Dep. Var.: inv_rate

Observations: 139,069

Fixed-effects: bvd_id: 24,893

Standard-errors: Clustered (bvd_id)

	Estimate	Std. Error	t value	Pr(> t)
euribor_vol_ann	-0.400580	0.305036	-1.313221	0.1891206
smeTRUE	-0.220880	0.289104	-0.764016	0.4448649
mro_level	-0.031743	0.014853	-2.137105	0.0325992 *
roa	-0.001655	0.002021	-0.818670	0.4129825
size	0.631045	0.207589	3.039875	0.0023692 **
debt_ratio	0.005062	0.001835	2.758432	0.0058122 **
t	-0.020430	0.030985	-0.659331	0.5096896
t2	0.001941	0.005739	0.338230	0.7351927
euribor_vol_ann:smeTRUE	0.319296	0.280197	1.139544	0.2544872

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

RMSE: 3.71595 Adj. R2: 0.023474

Within R2: 0.002472

--- Marginal effects ---

Vol effect (non-SME) : -0.4006

Vol effect (SME) : -0.0813

7. Appendix 7: Robustness MRO vs Euribor

APPENDIX – Robustness : MRO vs Euribor

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Model H1 Euribor (baseline) :

OLS estimation, Dep. Var.: inv_rate

Observations: 166,224

Fixed-effects: bvd_id: 27,179

Standard-errors: Clustered (bvd_id)

	Estimate	Std. Error	t value	Pr(> t)
euribor_vol_ann	-0.132665	0.065732	-2.018270	0.04357291 *
mro_level	-0.019337	0.018662	-1.036165	0.30013426
roa	-0.001974	0.000522	-3.784658	0.00015425 ***
size	0.771431	0.186491	4.136565	0.00003536 ***
debt_ratio	0.005892	0.003222	1.828829	0.06743613 .
t	-0.048558	0.027473	-1.767516	0.07715302 .
t2	0.002391	0.006066	0.394125	0.69349150

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

RMSE: 3.85303 Adj. R2: 0.051273

Within R2: 0.003893

Model H1 MRO :

OLS estimation, Dep. Var.: inv_rate

Observations: 166,224

Fixed-effects: bvd_id: 27,179

Standard-errors: Clustered (bvd_id)

	Estimate	Std. Error	t value	Pr(> t)
mro_vol	-0.250490	0.114476	-2.188148	2.8667e-02 *
mro_level	-0.019019	0.018560	-1.024766	3.0548e-01
roa	-0.001968	0.000521	-3.778616	1.5804e-04 ***
size	0.772412	0.186858	4.133694	3.5805e-05 ***
debt_ratio	0.005890	0.003222	1.828076	6.7549e-02 .
t	-0.055520	0.026409	-2.102306	3.5536e-02 *
t2	0.004210	0.006198	0.679222	4.9700e-01

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

RMSE: 3.85301 Adj. R2: 0.051278

Within R2: 0.003899

--- Summary comparison ---

Key variable	Euribor	MRO
Coefficient	-0.1327	-0.2505
P-value	0.044 *	0.029 *
N	166,224	166,224
Within R ²	0.003893	0.003899

8. Appendix 8: Robustness Lagged Volatility

APPENDIX – Robustness : Lagged Volatility

=====

H1 lagged :

OLS estimation, Dep. Var.: inv_rate

Observations: 166,224

Fixed-effects: bvd_id: 27,179

Standard-errors: Clustered (bvd_id)

	Estimate	Std. Error	t value	Pr(> t)
euribor_vol_ann_l1	-0.132665	0.065732	-2.018270	0.04357291 *
mro_level_l1	-0.019337	0.018662	-1.036165	0.30013426
roa	-0.001974	0.000522	-3.784658	0.00015425 ***
size	0.771431	0.186491	4.136565	0.00003536 ***
debt_ratio	0.005892	0.003222	1.828829	0.06743613 .
t	-0.048558	0.027473	-1.767516	0.07715302 .
t2	0.002391	0.006066	0.394125	0.69349150

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

RMSE: 3.85303 Adj. R2: 0.051273

Within R2: 0.003893

H2 lagged :

OLS estimation, Dep. Var.: inv_rate

Observations: 139,069

Fixed-effects: bvd_id: 24,893

Standard-errors: Clustered (bvd_id)

	Estimate	Std. Error	t value	Pr(> t)
euribor_vol_ann_l1	-0.400580	0.305036	-1.313221	0.1891206
smeTRUE	-0.220880	0.289104	-0.764016	0.4448649
mro_level_l1	-0.031743	0.014853	-2.137105	0.0325992 *
roa	-0.001655	0.002021	-0.818670	0.4129825
size	0.631045	0.207589	3.039875	0.0023692 **
debt_ratio	0.005062	0.001835	2.758432	0.0058122 **
t	-0.020430	0.030985	-0.659331	0.5096896
t2	0.001941	0.005739	0.338230	0.7351927
euribor_vol_ann_l1:smeTRUE	0.319296	0.280197	1.139544	0.2544872

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

RMSE: 3.71595 Adj. R2: 0.023474

Within R2: 0.002472

--- Summary comparison ---

	H1 lagged	H2 lagged
euribor_vol_ann_l1	-0.1327 *	-0.4006
Vol p-value	0.044	0.189
InteractionxSME	-	+0.319
Interaction p-value	-	0.254
Non-SME effect	-	-0.4006
SME effect	-	-0.0813
N	166,224	139,069

9. Appendix 9: Robustness Size Terciles

APPENDIX – Robustness : Size Terciles

OLS estimation, Dep. Var.: inv_rate

Observations: 166,224

Fixed-effects: bvd_id: 27,179

Standard-errors: Clustered (bvd_id)

	Estimate	Std. Error	t value	Pr(> t)
euribor_vol_ann	-0.041841	0.063492	-0.658990	5.0991e-01
size_qmid	0.767885	0.184575	4.160296	3.1881e-05 ***
size_qlarge	1.215290	0.283285	4.289991	1.7930e-05 ***
mro_level	-0.015530	0.018811	-0.825562	4.0906e-01
roa	0.000369	0.000434	0.849286	3.9573e-01
debt_ratio	0.011072	0.003391	3.265069	1.0957e-03 **
t	-0.017678	0.025112	-0.703938	4.8148e-01
t2	0.004027	0.006108	0.659273	5.0973e-01
euribor_vol_ann:size_qmid	-0.047724	0.055666	-0.857332	3.9127e-01
euribor_vol_ann:size_qlarge	-0.155456	0.140973	-1.102734	2.7015e-01

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

RMSE: 3.85846 Adj. R2: 0.048573

Within R2: 0.001081

--- Marginal effects by tercile ---

Tercile	Vol effect	P-value
Small	-0.042	ref
Mid	-0.090	0.391
Large	-0.197	0.270

-> Increasing trend but not significant

10. Appendix 10: Robustness High Debt

APPENDIX – Robustness : High Debt

Sample : 2018-2024 | N = 166,224 | Firms = 27,179
Dependent variable : inv_rate | FE firm | Cluster bvd_id

OLS estimation, Dep. Var.: inv_rate

Observations: 166,224

Fixed-effects: bvd_id: 27,179

Standard-errors: Clustered (bvd_id)

	Estimate	Std. Error	t value	Pr(> t)
euribor_vol_ann	-0.133606	0.103313	-1.293216	1.9595e-01
high_debtTRUE	0.001948	0.044599	0.043677	9.6516e-01
mro_level	-0.019241	0.018652	-1.031580	3.0228e-01
roa	-0.002061	0.000525	-3.923547	8.7469e-05 ***
size	0.780836	0.188053	4.152200	3.3030e-05 ***
t	-0.049608	0.027492	-1.804420	7.1177e-02 .
t2	0.002337	0.006060	0.385617	6.9978e-01
euribor_vol_ann:high_debtTRUE	0.003285	0.094759	0.034663	9.7235e-01

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

RMSE: 3.85311 Adj. R2: 0.051226

Within R2: 0.003852

--- Marginal effects ---

Vol effect (low debt) : -0.1336

Vol effect (high debt): -0.1303

11. Appendix 11: GMM Arellano-Bond H1

APPENDIX – GMM Arellano-Bond H1

Sample : 2018-2024 | N = 141,430 | Firms = 27,254

Observations used after differencing : 85,396

Coefficients :

	Estimate	Std. Error	Pr(> z)
lag(inv_rate, 1)	0.0010	0.0005	0.0475
euribor_vol_ann	-0.0907	0.0507	0.0735
mro_level	-0.0222	0.0158	0.1611
roa	-0.0326	0.0158	0.0391
size	2.9964	1.3734	0.0291
debt_ratio	-0.0159	0.0096	0.0989
t	-0.1852	0.1017	0.0687
t2	0.0098	0.0090	0.2794

Validity tests :

AR(1) p-value : 0.2613 -> not significant

AR(2) p-value : 0.9577 -> not significant (valid instruments)

Sargan p-value : 0.0006 -> significant (large sample)

Wald test : Chi2(8) = 22.41, p-value = 0.004 -> model globally significant

H2 GMM : estimation not feasible

-> singular instrument matrix

-> structural limitation (macro x quasi-fixed interaction)

12. Appendix 12: Robustness Alternative Sample

APPENDIX – Robustness : Alternative Sample

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Sample : 2018-2024 excluding 2020 | N = 142,752 | Firms = 27,078

Dependent variable : inv_rate | FE firm | Cluster bvd_id

OLS estimation, Dep. Var.: inv_rate

Observations: 142,752

Fixed-effects: bvd_id: 27,078

Standard-errors: Clustered (bvd_id)

	Estimate	Std. Error	t value	Pr(> t)
euribor_vol_ann	-0.132489	0.066294	-1.998494	0.04567312 *
mro_level	-0.021714	0.019110	-1.136217	0.25587600
roa	-0.002592	0.001659	-1.562203	0.11825186
size	0.685399	0.194886	3.516914	0.00043731 ***
debt_ratio	0.006394	0.003443	1.856954	0.06332853 .
t	-0.048360	0.031570	-1.531839	0.12557373
t2	0.003861	0.006598	0.585197	0.55841995

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

RMSE: 3.81428 Adj. R2: 0.048262

Within R2: 0.003237

--- Summary comparison ---

	Model	N	Beta_vol	Pvalue_vol
1	Baseline	166224	-0.1327	0.0436
2	Excluding 2020	142752	-0.1325	0.0457

Interest rates are rarely stable. They rise, they fall, and sometimes they shift so rapidly that firms lose any ability to plan ahead. Small and medium-sized enterprises feel this instability more than anyone. They depend on bank credit to finance their growth, and when borrowing conditions become hard to predict, investment decisions become genuinely difficult. This thesis explores that relationship and raises a fundamental question: what is the impact of interest rate volatility on fixed investment by SMEs?

To answer this question, the thesis first builds a theoretical foundation. When uncertainty rises, waiting becomes rational. A firm that does not know what its future borrowing costs will look like has every reason to delay an investment rather than commit to an irreversible expenditure. Banks respond by making credit harder to obtain. When rates become unpredictable, they tighten their lending conditions, making credit more costly and harder to get. SMEs rely almost entirely on bank loans and have no other way to raise money. They are in theory the most exposed to these pressures.

The empirical analysis puts these ideas to the test. Using accounting data from Belgian firms over the period 2018 to 2024 and a fixed effects regression model, the results confirm that interest rate volatility reduces fixed investment. The effect holds across every alternative specification tested. What is perhaps more surprising is what the data do not show. SMEs do not appear to suffer more than larger firms.

Taken together, these results carry a clear message for policymakers. Firms can adapt to high rates, but they struggle to adapt to unpredictable ones. The way a central bank communicates its intentions may matter as much as the decisions it actually takes.

UNIVERSITÉ CATHOLIQUE DE LOUVAIN
Louvain School of Management

Place des Doyens, 1 bte L2.01.01, 1348 Louvain-la-Neuve
Boulevard Emile Devreux 6, 6000 Charleroi, Belgique
Chaussée de Binche 151, 7000 Mons, Belgique

www.uclouvain.be/lsm