Corporate Hedging and Default Risk: A Multinational Perspective

Thesis submitted to the University of Nottingham for the degree of Doctor of Philosophy

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Abstract

This thesis discusses three topics regarding hedging by non-financial companies and its impact on default probability with insights from a multinational analysis. The first paper investigates the impact of derivatives on firm's default probability with a sample of European non-financial firms. The second paper studies the influence of currency hedging strategies with foreign exchange derivatives and foreign debts on default risk. The third paper examines the effect of long-term and short-term interest rate derivatives on the likelihood of default.

The first paper explores the influence of the use of derivative on the risk of default among non-financial firms with a cross-country approach. By using a unique sample of hand collected derivative usage of non-financial firms in nine different European countries, including the UK, France, Germany, Denmark, Italy, Norway, the Netherlands, Spain and Sweden, over the period of 1999 to 2015, our findings suggest that derivative hedging reduces default probability. Our study also shows that the reduction of default risk is more intensive under the use of interest rate (IR) derivatives compared to foreign exchange (FX) and commodity (CP) derivatives. Additionally, our paper records evidence that derivative usage has a statistically bigger negative influence on short-term than long-term default risk. The negative correlation of derivatives and default risk stays robust after performing a wide range of robustness test for possible endogeneity emerging from derivative usage and probability of default. Moreover, our study documents some new evidence that firms with extremely high financial distress may hedge less, as evidenced by the increase in default likelihood. As for the role of creditor rights on the effect of derivative use toward default risk, our results support the notion that firms would hedge more and reduce more risk in countries where creditor protection is strong. Furthermore, we present findings indicating that the efficacy of derivatives diminishes in the presence of lower economic risk within a country.

In the second paper, we investigate the effect of different currency hedging strategies, from foreign exchange (FX) derivatives and foreign currency (FC) debt, used by non-financial firms on default probability with a sample of non-financial firms in six countries including France, Germany, Italy, Norway, Spain and the United Kingdom from 1999 to 2015. Our results show that hedging with FC debt does not reduce and may even increase default probability. Furthermore, generally, we find that linear

derivative strategies (FX forwards or swaps) reduce probability of default better than a non-linear strategy (FX options), contrary to our expectation. However, we record that non-linear strategy is more optimal, in terms of default risk reduction, for firms with high growth, whereas low growth firms benefit more from linear strategies. In addition, our results show that currency forwards reduce short-term default likelihood better than swaps, while currency swaps impact more on long-run default risk. Moreover, we document evidence that the effect of foreign debt on default risk is more positive as debt enforcement is more efficient. Interestingly, our findings demonstrate that FC debt could be an effective tool for reducing the likelihood of default, especially for companies operating in countries with weak debt enforcement efficiency and a significant proportion of foreign sales. The empirical analysis employs a battery of robustness tests to control for dynamic endogeneity issues. These findings extend our knowledge of the risk reduction effects of various hedging methods.

The third paper compares the effectiveness of long-term (swaps) and short-term IR derivatives (forwards and options) in reducing default risk for non-financial firms in Germany, France, Spain, Italy, Denmark, Sweden, the Netherlands, Norway and the UK for the period from 1999 to 2015. Interestingly, we find that IR swap contracts are more effective than their short-term counterparts (IR forwards and options) in managing both short and long-term default probability. This could be explained by the fact that long-term derivatives are designed to hedge firm's total exposure, both short and long term. However. we document evidence that firms in countries which promote the use of short-term liabilities can benefit more, in terms of default risk reduction, from the use of short-term derivatives. In particular, German and Spanish firms that rely more intensively on short-term liabilities experience a larger decrease in the likelihood of default by using short-term IR derivatives compared to long-term contracts. In addition, our findings show that among the short-term derivatives, IR option derivatives reduce the probability of default more effectively than IR forwards. We also document evidence that firms of medium size tend to exhibit a more pronounced reduction in their default probability using IR swaps, while the impact on default risk is insignificant for the smallest and largest firms, potentially due to factors such as less access to derivative markets for small firms and access to fixed-rate borrowing options for large firms. Overall, our findings are novel and able to deliver significant contribution to corporate hedging literature.

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The culmination of this doctoral thesis marks the end of a challenging yet deeply fulfilling academic journey. As I reflect on this pivotal moment with a sense of achievement and gratitude, I would like to express my sincere appreciation to the many individuals whose unwavering support has been crucial to this accomplishment.

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Declaration of originality

I solemnly affirm that the work presented in this project is entirely my own original effort, and any external sources of information used have been properly cited and referenced.

I declare that I have meticulously referenced and acknowledged, both within the text and in the contents list, any quotes or information drawn from internet sources, published works, or unpublished materials. I fully comprehend that failure to adhere to proper citation practices will result in the failure of this project due to plagiarism concerns.

I am aware that I may be summoned to attend an oral examination (viva), and if such an occasion arises, I acknowledge my responsibility to ensure my availability during the designated viva period. I recognize that it is my obligation to verify whether my presence is required for the viva and to make the necessary arrangements to be present.

Signed: Khai Le

Date: 26/09/2024

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Abbreviation

BIS	Bank for International Settlements
CEM	Coarsened Exact Matching
CP	Commodity price
EDF	Expected Default Frequency
EPU	Economic Policy Uncertainty
ESMA	European Securities and Market Authority
EMIR	European Infrastructure Regulation
FRS	Financial Reporting Standard
FTT	Financial Transactions Tax
FX	Foreign exchange
ICRG	International Country Risk Guide
IR	Interest rates
IV	Instrumental Variable
OLS	Ordinary Least Squares
OTC	Over the counter
PSM	Propensity Score Matching
R&D	Research and Development
SGMM	System Generalised Method of Moments
UK	United Kingdom
US	United States

Chapter 1: Introduction

In the aftermath of the global financial crisis in 2008, there was a profound shift in the perception of derivatives, which were widely regarded as contributors to the catastrophic event. Two prominent figures, Warren Buffett, one of the greatest fundamental investors, and Alan Greenspan, the former Chair of the Federal Reserve of the United States, expressed contrasting views on derivatives. Buffett referred to them as "financial weapons of mass destruction," while Greenspan contended that they aid in risk mitigation[1]. This longstanding debate over whether derivatives offer greater advantages or pose greater risks has remained a contentious subject in the realm of financial literature.

Since derivatives play a major role in the worldwide economic system (Bamber and McMeeking, 2016), there has been substantial research on risk management using financial derivatives over the last three decades. Previous studies have demonstrated various benefits of hedging for firms. For example, Chen and King (2014) provide robust evidence linking hedging to reduced debt financing costs. Bartram et al. (2011) demonstrate a positive relationship between hedging activities and firm valuation. Huang et al. (2017) show that the use of derivatives significantly mitigates firm-specific risks, as evidenced by lower equity volatility and market beta. Furthermore, Ahmed et al. (2018) document that firms engaging in hedging benefit from a lower cost of equity compared to their non-hedging counterparts.

However, there is a lack of studies on the impact of derivatives on the probability of default, which is the risk firms ultimately want to mitigate. With the establishment of the European Infrastructure Regulation (EMIR) to restrain the use of over-the-counter (OTC) derivatives following the financial crash in 2008 along with the launch of the financial transaction tax (FTT), this question is now of high importance and necessity for research.

This thesis comprises three empirical essays exploring different facets of corporate hedging and its impact on default risk. The first essay investigates the influence of derivatives on a firm's default probability for European non-financial firms. The second essay delves into the effects of foreign exchange hedging strategies with

[1] Goodman, P.S. (2008) Taking hard new look at a Greenspan Legacy, The New York Times. Available at: https://www.nytimes.com/2008/10/09/business/economy/09greenspan.html.

currency derivatives and the use of FC debt on default risk. The third essay explores the impact of long-term and short-term IR derivatives on default probability.

The remainder of this chapter is organised as follows. Section 1.1 presents the motivation for this thesis. Section 1.2 discusses the objectives of this thesis along with the research questions for each essay. Section 1.3 summarises the findings and contributions of these essays. Finally, Section 1.4 provides the structure of this thesis.

1.1 Motivation for the thesis

The relationship between derivatives and default risk is a subject of paramount importance, yet one that has been surprisingly underexplored. The 2008 financial crisis highlights the risks associated with derivative instruments, leading to stricter regulations like the European Market Infrastructure Regulation (EMIR), which face opposition from non-financial companies arguing for exemptions due to their risk management strategies. Additionally, the implementation of a Financial Transaction Tax (FTT) further complicates the situation, as it could significantly increase costs for non-financial companies employing derivatives for hedging purposes. This ongoing debate underscores the tension between regulatory efforts to improve market stability and the desire of non-financial companies to maintain cost-effective risk management practices.

Generally, the motivation of the thesis stems from the lack of research and mixed evidence on derivatives and default risk, especially the effect of types of derivatives on default probability This dissertation aims to deliver a thorough analysis of the influence of corporate derivative adoption on the probability of default from several different angles. We examine derivatives in general in paper 1. In paper 2, we investigate hedging using foreign exchange (FX) derivatives and foreign currency debt, with the extension of research scope to linear and non-linear FX derivatives. In paper 3, we look at interest rate (IR) derivatives, particularly long-term and short-term perspectives. Additionally, the multinational setting allows us to examine how country-specific factors shape the relationship between corporate hedging and default risk. This allows stakeholders like regulators and creditors to better assess risks and make policies/decisions with an international viewpoint in mind.

1.1.1 The first essay

The first essay is entitled: “The impact of derivative use on default probability among non-financial firms: Evidence from European firms.” This essay is motivated by the hedging theory, which suggests that one of the main objectives firms utilize financial derivatives is to reduce their probability of bankruptcy and the associated costs (Smith and Stulz, 1985; Froot et al., 1993). While empirical studies have explored the link between corporate derivative use and firm risk, supporting the hedging theory (Nguyen and Faff, 2010; Bartram et al., 2011; Bartram, 2019), they typically rely on risk proxies derived from asset pricing frameworks, such as market risk measured by beta or total risk measured by standard deviation of stock returns, which may not accurately capture a firm's default risk – risk that firms ultimately want to mitigate. Additionally, other studies such as Campello et al. (2011), use Z-score to measure probability of default. Z-score, as an accounting-based metric for assessing default probability, primarily relies on historical financial statement data rather than prospective financial evaluations. Consequently, this measure may not comprehensively capture a firm's future financial trajectory. Moreover, given that derivative instruments influence future cash flows, a retrospective measure such as Z-score is less likely to adequately reflect their impact on a firm's default risk profile. To address this limitation, the thesis draws inspiration from the pioneering model of Merton (1974), which equates a firm's equity value to a call option on the firm's asset value, with the face value of the firm's debt serving as the strike price. Merton (1974) highlights that an increase in a firm's asset volatility is associated with a rise in the risk premium of its bonds, which is considered a proxy for default probability, consistent with the insights of Black and Scholes (1973). This fundamental approach has been widely adopted in academic research and practical applications, especially in the field of hedging such as Magee (2013) and Boyer and Marin (2013), providing a more direct measure of default risk. However, it is important to note that the studies mentioned employ the distance-to-default approach, which merely provides a relative ranking of default risks rather than quantifying the precise level of default risk. In contrast, this thesis utilizes the Expected Default Frequency (EDF) measure, which offers a more relevant and accurate representation by directly estimating the probability of default, as highlighted by Moody's Analytics (2016). Unlike the distance-to-default metric, which serves as an ordinal indicator, the EDF quantifies the explicit default rate, making it a more informative and applicable metric for the purposes of this research.

Additionally, this thesis is motivated by the mixed evidence from previous research. Magee (2013) shows that the extent of derivative usage (continuous variable) is linked with a reduction in a firm's probability of financial distress, but not the decision to hedge (binary variable). Magee (2013) uses only instrumental variable approach as the empirical method to address the simultaneity of default probability and hedging. We not only follow similar approach with the use of continuous variables for extent of derivative usage in instrumental variable method, but also incorporate various econometric models for the decision to hedge (dummy variable) to tackle endogeneity and selection bias issues. We are able to demonstrate that the decision to use derivatives is linked with a decrease in the probability of default.

Furthermore, it is noteworthy that the preponderance of empirical investigations regarding derivatives and default risk has been concentrating on single-country samples. For example, Magee (2013); Boyer and Marin (2013) and Marin (2013) all study US sample. Consequently, there remains a significant gap in our understanding of whether the inconsistencies observed in empirical evidence can be attributed to cross-national variations. Hence, our research is motivated by the dearth of research regarding the influence of country-specific factors on hedging. Financial markets operate within the broader context of national economies, regulatory frameworks, and geopolitical realities. However, previous research has often overlooked the impact of these unique environments on the relationship between derivatives and firm risk. Only a few papers look at the impact of country-level factors on hedging (Bartram et al., 2009; Lel, 2012; Allayannis et al., 2012, Lievenruck and Schmid, 2014 and Bartram, 2019). However, the approach is mostly on how the country factors influence hedging decisions. While Bartram (2019) lays the groundwork by examining the impact of hedging on firm risk in relation to country-level factors, our research offers a significant expansion in scope. Firstly, our study utilizes a considerably extended time period, encompassing data from 1999 to 2015, compared to the analysis of Bartram (2019) focusing on 2000-2001. Secondly, while the study of Bartram (2019) with 47 countries offers valuable insights, our research, in contrast, tackles the angle of how country-level factors influence the effect of corporate derivative usage on default risk by examining a sample of many different European nations. The inclusion of countries with substantial derivative activities, such as the United Kingdom and various European Union members, is a strategic choice. These countries represent diverse economic structures, regulatory frameworks, and market conditions, providing a rich setting for exploring the interaction between derivatives and default risk. Thirdly, Bartram (2019) finds that firms in countries with weaker creditor protection reduce risk more. The researcher argues that firms in those countries hedge more in response to the requirements by lenders without demonstrating a higher proportion of hedgers in countries with weaker creditor protection from his sample. We, however, find that firms reduce more risk in creditor-friendly countries and can demonstrate that with our sample.

1.1.2 The second essay

The second essay is named: "The impact of foreign exchange hedging strategies and default probability." This paper is motivated by the fact that research on hedging with FX derivatives and foreign currency (FC) debt presents mixed evidence. Some studies suggest that FC debt can be an effective hedging tool (Hagelin and Pramborg, 2004; Nguyen and Faff, 2006; Jong et al., 2006), while others find contrary results (Chiang and Lin, 2005). Bartram et al. (2010) even argue that financial hedging with FC debt has a more significant negative impact on exposure than the use of FX derivatives. Those studies test the impact of FC debt on FX exposure and immediately conclude that FC debt is a good hedging tool since it could reduce FX exposure. However, whether this can translate into a reduction in default probability remains an empirical question requiring further investigation. This is important as firms with FC debt possess higher leverage than firms without (Clark and Judge, 2009) and potentially have a higher likelihood of default. Moreover, since Stulz (1996) argues that diversified investors are more concerned with the probability of financial distress rather than fluctuations of cash flow volatility caused by foreign exchange rates, interest rates, and commodity prices, it is of high importance to conduct a test of currency financial hedging strategies using FX derivatives and FC debt on default probability. We show that FC debt is not an effective hedging instrument in terms of default risk reduction, compared with FX derivatives.

Furthermore, various studies have attempted to explain why firms choose specific types of derivatives such as forwards, options, or swaps (Gay et al., 2003; Bartram, 2006; Adam, 2009). Some researchers support the use of non-linear derivatives (Bartram, 2006; Adam, 2009), while others argue that linear derivatives are more effective (Fredstad, 2009). There has not yet been a definitive comparison of the effectiveness of different types of derivatives on default risk to determine which is superior for hedging purposes. This gap in the literature prompts us to examine the effectiveness of various types of derivatives on default risk. In the second paper, we compare FX linear and non-linear strategies, as well as forwards versus swaps among the linear derivatives. Our findings indicate that FX non-linear strategies are less effective at mitigating default probability compared to their linear counterparts. Additionally, forwards have a greater impact on short-term default risk, whereas swaps more significantly affect the long-term probability of default.

Furthermore, the inconclusive findings from previous studies on country-level factors provide additional motivation for this research. Bartram et al. (2009), for example, explore the hypothesis that firms operating in countries with more efficient legal and institutional frameworks are more likely to engage in hedging activities. However, their results show no significant evidence to support this claim. Their study primarily focuses on the use of FX, IR, and CP derivatives, while FC debt is treated merely as a control variable rather than being thoroughly examined in its own right. This leaves an important gap in the understanding of how country-level factors, particularly the legal environment, influence hedging practices that specifically involve FC debt.

Adding to this, research by Gatopolous and Louberg (2013) highlights the importance of country-specific factors in shaping hedging behavior, particularly in the context of foreign exchange derivatives and FC debt. Their findings suggest that the legal and regulatory environment within a country can significantly affect a firm's decision to hedge, particularly when it comes to managing foreign currency exposure. Despite these insights, there remains a lack of detailed investigation into how the legal framework—specifically the efficiency of debt enforcement mechanisms—affects the use of FC debt in corporate hedging strategies and its subsequent impact on default probability.

Our study, therefore, seeks to fill this critical gap by being the first to empirically examine the relationship between a country's debt enforcement efficiency and the effectiveness of FC debt as a hedging tool in reducing the likelihood of default. We delve deeper into the influence of country-level institutional factors, focusing particularly on the legal mechanisms surrounding debt recovery. By doing so, we aim to provide a more comprehensive understanding of how variations in debt enforcement efficiency across countries influence the risk outcomes of firms that use FC debt. This research not only expands the existing literature on country-level determinants of hedging but also introduces new insights into the role of legal environments in shaping the effectiveness of FC debt as a risk management tool.

1.1.3 The third essay

The third essay in this thesis is titled "The Impact of Long-Term and Short-Term Interest Rate Derivatives on Default Risk." A notable feature of the existing literature on derivatives and default risk is its predominant focus on foreign exchange (FX) derivatives. To the best of my knowledge, the three studies on hedging and default risk examine FX derivatives (Marin, 2013; Magee, 2013; and Boyer and Marin, 2013). This is largely due to the fact that FX derivatives are generally easier to quantify and interpret even though interest rate (IR) derivatives are the most frequently employed instruments in the global derivatives markets. The tendency to prioritize FX derivatives in empirical studies is understandable, given the complexities associated with managing and measuring interest rate risk, which tends to be more intricate than risks linked to foreign exchange or commodities (Faulkender, 2005).

A significant body of research has concentrated on IR swaps due to their widespread use and dominance in the market, and these swaps are often regarded as the primary or representative tool for hedging interest rate risk. Studies by Faulkender (2005), Chernenko and Faulkender (2011), Jermann and Yue (2018), and Hecht (2019) all emphasize the central role of interest rate swaps in the hedging strategies of firms. However, while swaps have been extensively examined, there is a relative scarcity of studies that investigate the comparative effects of other types of IR derivatives.

Given that interest rate risk is often more directly tied to a firm’s probability of default, this oversight in the literature presents a significant gap. The gap highlights a need for more detailed research on how various IR derivatives—beyond just swaps—impact default risk. This thesis, therefore, contributes to the literature by not only examining the overall effect of IR derivatives on default probability but also by conducting a comparative analysis between short-term IR derivatives (such as forwards and options) and long-term IR derivatives (like swaps). Previous research has generally shown IR forwards and options are better suited for managing short-term interest rate exposure, while IR swaps are more effective in mitigating long-term interest rate risks.

Nevertheless, this feature has not been rigorously tested in the context of default risk, and thus this study fills a crucial gap in understanding how different types of IR derivatives affect a firm's default probability.

In addition, it is important to highlight that the majority of empirical research investigating the relationship between derivatives and default risk has primarily focused on single-country datasets. Studies such as those by Magee (2013), Boyer and Marin (2013), and Marin (2013) have all concentrated on US firms, which has limited the scope of analysis to a single national context. Our research, therefore, seeks to address this critical gap by broadening the scope to include multiple European countries with distinct economic and regulatory systems. Particularly, we are the first to test the effect of long-term and short-term IR derivatives on default risk with respect to the financial system of a country.

1.2 Objectives and research questions

The overall objective of this research is to enhance our comprehension of the utilisation of financial derivatives by corporations. The individual goals of each empirical essay, along with their associated research questions, are delineated in the subsequent sections.

1.2.1 The first essay

This essay attempts to examine the relationship between derivative utilization and the likelihood of firm default. By posing the central question: "Does hedging with derivatives influence a firm's propensity for default?", we aim to shed light on a critical problem within the realm of financial risk management.

To answer this central question, a group of sub-questions illuminate the various facets of this complex relationship:

(a) Do derivatives reduce default probability?

(b) Are there any differences in the effect on default risk between various types of derivatives (currency, interest rates, and commodity price derivatives)?

(c) Does the effect of derivatives on default risk remain consistent for extremely distressed firms?

(d) How does creditor protection in a country influence the effect of derivatives on the probability of default?

(e) How does national economic risk influence the effect of derivatives on probability of default?

1.2.2 The second essay

This essay investigates the nexus between currency hedging strategies and firm default risk, posing the central question: "How do hedging with foreign debt and foreign exchange derivatives differ in their influence on default probability?" Examining this critical query sheds light on a crucial realm of corporate financial risk management.

To comprehensively address this central question, a series of sub-questions illuminate the diverse facets of this relationship:

(a) Is there any difference in the effects on default probability between currency derivatives and foreign-denominated debt?

(b) Is there any difference between non-linear (options) and linear (forwards or swaps) FX derivatives?

(c) Among the linear strategies, FX forwards or swaps, which one is better in mitigating default risk?

(d) How does debt enforcement efficiency influence the effect of currency hedging strategies on default risk?

(e) Do the effect of linear and non-linear FX derivatives on default risk differ between high-growth and low-growth firms?

1.2.3 The third essay

This essay examines interest rate (IR) derivatives, elucidating their influence on firm default risk. We pose the central question: "How do long-term (swaps) and short-term (forwards, options) interest rate derivatives differ in their impact on default probability?"

To comprehensively address this central question, a constellation of sub-questions illuminates the diverse facets of this complex relationship:

(a) Is there any difference between long-term and short-term IR derivatives over the impacts on the likelihood of default?

(b) Are IR options better than forwards at mitigating default probability?

(c) Do the financial systems of a country influence the effects of long-term and short-term IR derivatives on default likelihood?

(d) Does the effect of IR swaps on default risk differ with company size?

1.3 Data and methodologies

This thesis synthesizes data from various sources and utilizes an array of econometric approaches to investigate the research questions previously presented. The subsequent sections delineate the data acquisition process and analytical methodologies employed in this investigation.

The study delves into the connection between hedging practices and default risk, focusing specifically on non-financial companies. Drawing from existing literature, the research deliberately excludes financial institutions like banks, insurance firms, and investment firms from the sample. The rationale behind this exclusion stems from the distinct nature of derivative usage within these entities. Financial entities often use derivatives for trading purposes, potentially distorting the overall findings and hindering a clear understanding of how hedging impacts non-financial firms.

1.3.1 The first paper

This essay is the first empirical chapter and explores how hedging using derivatives affects the likelihood of default. We attempt to do that with a sample of nine countries including the UK, France, Germany, Denmark, Italy, Norway, the Netherlands, Spain, and Sweden from 1999 to 2015. The Expected Default Frequency (EDF), which measures firms' default probability, is obtained from Moody's Analytics database. Data pertaining to derivative usage is extracted through manual collection from corporate annual reports. Additional financial variables are sourced from Datastream and Yahoo Finance platforms.

This study focuses on European countries for several key reasons, distinguishing it from prior research, which often emphasizes the US. European countries generally face higher foreign exchange (FX) risk due to their more open economies, with greater international trade as a percentage of GDP compared to the US. Additionally, the European Union (EU) is a major global trading bloc, further contributing to its exposure to FX volatility. Europe also possesses a substantial derivatives market, with the UK being the largest center for over-the-counter (OTC) interest rate derivatives. Moreover, European countries often have more creditor-friendly legal systems (La Porta et al., 1998 and Djankov et al., 2007), which may incentivize firms to hedge more extensively to manage the risks of financial distress. In particular, countries like the UK and Germany have strong creditor protections, making risk management with derivatives crucial. Additionally, European firms face significant interest rate risks, given their reliance on bank financing, often tied to floating rates. As a result, this study seeks to explore how these institutional and economic factors influence corporate hedging practices in Europe.

The 1999-2015 timeframe of this study is carefully chosen to capture diverse economic and financial conditions, regulatory changes, and significant events impacting firms' risk management practices. The starting point of 1999 aligns with the introduction of Financial Reporting Standard (FRS) 13 in the UK, which mandated derivative disclosures, while the 2005 adoption of International Financial Reporting Standard 7 (IFRS 7) across the EU improved the consistency and availability of data on derivatives. The period also covers key economic events, including the 2000-2001 recession and the 2007-2009 financial crisis, during which corporate insolvencies surged across Europe. The study concludes in 2015 to avoid the economic uncertainties of Brexit and the effects of negative interest rates, which began to alter interest rate hedging dynamics in Europe, particularly after 2014. Altogether, including data beyond 2015 could introduce noise in the relationship between derivative use and default risk, potentially confounding the analysis with factors unrelated to the core focus of the study.

Following various previous studies (Magee, 2013; Boyer and Marin, 2013; Bartram, 2019), we conduct Ordinary Least Square (OLS) as the basic model. Then, to address the potential issue of reverse causality between derivatives usage and default risk, a lagged regression model was employed. By lagging the independent variables (related to derivatives usage) by one year, the analysis aims to mitigate the possibility that firms facing financial distress are more likely to adopt hedging strategies as a desperate measure rather than as a proactive risk management tool. Furthermore, we employ beta regression for the analysis since our dependent variable (Expected Default Frequencies – EDF) ranges from 0 to 1.

In particular, for the first essay, which investigates the impact of derivatives on the probability of default, we employ various other econometric techniques as robustness tests. We want to address the causality of derivatives and default probability, particularly the research question: “Do derivatives reduce the probability of default?”, which involves a comparison between groups of derivative users and non-users and explaining casual relationships. Hence, the econometrics models we employ in this chapter include Fixed effect, Heckman’s treatment effect model, Propensity score matching, Coarsened exact matching, Instrumental variable methods, and Difference-in-difference.

1.3.2 The second paper

In this second paper, we examine the impact of currency hedging tactics on the risk of default. This is done by scrutinizing hedging methods that incorporate both FC debt and FX derivatives. We delve deeper into the linearity of FX derivatives or specific kinds of FX derivatives. We examine a sample of six countries, including France, Germany, Spain, Italy, Norway, and the UK from 1999 to 2015. This study utilizes Expected Default Frequency (EDF) data from Moody's Analytics as the primary measure of corporate default probability. Information regarding firms' currency hedging strategies regarding FX derivatives and FC debt is manually compiled from their published annual reports. Other financial data is acquired from Datastream and Yahoo Finance databases.

This study focuses on European countries for several important reasons, setting it apart from previous research that often centers on the US. European nations generally experience greater foreign exchange (FX) risk due to their more open economies, with international trade comprising a higher percentage of GDP compared to the US. Additionally, the European Union (EU) is a significant global trading entity, which heightens its exposure to FX fluctuations. Europe also possesses a highly developed derivatives market. Furthermore, those countries have a well-established and mature financial market, which means that companies have a lot of options when it comes to financing their operations. They can issue debt in their own currency or in a foreign currency, depending on their needs and goals. The decision to issue FC debt is based on economic considerations, such as cost and availability, rather than limitations imposed by the capital market, such as restrictions on currency conversion or high transaction costs. Thus, it is easier and more straightforward to study the use of FC debt from non-financial firms in those countries.

Importantly, this essay addresses the research questions of whether there is a difference in the impact of FX derivatives and FC debt hedging on default risk. This involves multiple endogenous variables appearing in the model specifications. Zirgulis (2014), in his study regarding how countries compete by adjusting their taxes on capital to attract foreign investments, also encounters the situation of multiple endogenous variables and proposes the most optimal solution is the System Generalized Method of Moments (SGMM) model. Consequently, we follow Zirgulis (2014) in terms of using the SGMM model for this essay.

1.3.3 The third paper

This chapter examines the relationship between default probability and interest rate derivative usage, specifically analyzing both long-term and short-term instruments. The investigation further evaluates the comparative hedging efficacy of interest rate forwards versus options. The empirical analysis encompasses a comprehensive dataset spanning nine European nations—the United Kingdom, France, Germany, Denmark, Italy, Norway, the Netherlands, Spain, and Sweden—over the period 1999-2015. The study employs Expected Default Frequency (EDF) as the primary metric for default probability, with data obtained from Moody's Analytics. Information regarding firms' IR derivative positions is manually extracted from their published annual reports. Additional financial data are sourced from Datastream and Yahoo Finance databases.

The European countries selected for this study are highly relevant due to their substantial involvement in derivative market operations and their exposure to interest rate risk. The European derivative market was valued at €735 trillion in total notional amount outstanding by the end of 2018, making up a significant portion of the global derivatives market, particularly through over-the-counter (OTC) contracts. Countries like Germany, France, and the UK are key players, with the UK being the largest OTC interest rate derivative centre globally. Additionally, European companies face elevated interest rate risk due to their reliance on bank loans, which often carry floating interest rates. With bank assets in the euro area equalling 300% of GDP (compared to just 85% in the US), firms in the EU and the UK have a stronger need for derivatives to manage this risk. These factors make European countries a highly suitable setting for studying corporate hedging practices involving IR derivatives.

This essay addresses a fundamental research inquiry concerning the differential impacts of long-term versus short-term interest rate derivatives on default risk. The analytical framework necessarily incorporates multiple endogenous variables within its model specifications. The methodological approach draws upon the work of Zirgulis (2014), whose examination of international tax competition and capital flows encountered comparable challenges regarding multiple endogenous variables. Following Zirgulis's (2014) methodological insights, this study employs the System Generalized Method of Moments (SGMM) estimator as the optimal econometric approach.

1.4 Findings and contributions

1.4.1 First essay

The first essay is titled "The impact of derivative use on default probability among non-financial firms: Evidence from European firms". This essay examines the effect of hedging with derivatives on probability of default with a sample of nine European countries (the United Kingdom, France, Germany, Denmark, Italy, Norway, the Netherlands, Spain, and Sweden) from 1999 to 2015. It makes several notable contributions to the existing body of research on corporate risk management strategies and the impact of derivative usage on mitigating default risk. Distinctively, unlike previous studies, we employ a different default risk proxy (Moody's Expected Default Frequencies or EDF), which arguably reflects a more precise probability of default. Our study diverges from Bartram et al. (2011), who use a self-calculated EDF and find no difference in default probability between derivative users and non-users through mean difference tests. In contrast, we employ Moody's Analytics' more sophisticated EDF metric and conduct a rigorous empirical analysis, potentially yielding more definitive insights into the relationship between derivative usage and default risk. In addition, we undertake a comprehensive cross-country analysis of derivative and default risk, which deviates from the majority of prior studies, which have primarily focused on examining single-country contexts (Magee 2013; Boyer and Marin 2013). Mixed results in previous empirical studies could be argued to be due to cross-country differences.

Magee (2013) explores the connection between a firm's use of derivatives (measured as a continuous variable) and its financial distress. Their findings suggest that the extent of derivative usage is associated with a lower likelihood of financial distress, but the decision to hedge itself (measured as a binary variable) is not directly linked with a reduction in default risk. Notably, Magee (2013) employs only instrumental variables approach to address the potential issue of simultaneity between default probability and hedging behaviour. Our research builds upon this foundation by incorporating a similar approach. We also utilize a continuous variable to capture the extent of derivative usage within the instrumental variable framework. Furthermore, besides the instrumental variable approach, we extend the analysis by employing various econometric models, such as propensity score matching and coarsened exact matching to match users and non-users samples, treatment effect model to deal with self-selection bias and also difference-in-difference for better casual inference, to examine the decision to hedge (represented as a dummy variable). This approach allows us to tackle potential endogeneity concerns and selection bias that might influence the relationship between hedging and financial distress.

A key and compelling finding that emerges from our empirical investigation is that the utilization of derivatives does indeed substantially diminish the probability of default, with the magnitude of this impact ranging from a notable 14% to a substantial 20% reduction. Notably, our results indicate that interest rate (IR) derivatives exhibit a more pronounced capacity to mitigate default risk in comparison to foreign exchange (FX) and commodity price (CP) derivatives. Also, our findings suggest that the employment of derivative instruments exerts a more significant negative influence on short-term default risk than on long-term likelihood of default. Moreover, we document evidence that the combination of various types of derivatives, such as FX and IR derivatives together, does not yield a more pronounced reduction in default risk compared to the use of a single derivative type. This finding stands in contrast to the results reported by Huang et al. (2017), who observe a more substantial risk reduction among UK firms employing a combination of FX and IR derivatives. Huang et al. (2017) use interaction term to address the firms that use a combination of derivatives. We, on the other hand, use separate dummies for each combination of derivatives.

Furthermore, our research makes a distinct and invaluable contribution to the literature by empirically documenting that derivatives more effectively curtail default risk in countries characterized by robust creditor rights protections. Traditional hedging theory posits that firms can mitigate risk through the use of financial derivatives (Smith and Stulz, 1985; Froot et al., 1993). Consequently, one might expect firms in countries with stronger creditor rights to be more inclined to engage in hedging via these derivatives. This logic follows the idea that robust creditor rights create a more favourable environment for risk management strategies. Studies such as Lel (2012) and Lievenbruck and Schmid (2014) have not found any conclusive evidence of a direct relationship between creditor rights and corporate hedging. Bartram (2019) reports a more pronounced decrease in firm risk exposure in countries with weaker creditor rights, which is contrary to what the theory suggests. The author argues that firms in weaker creditor rights environments might be compelled to hedge more extensively as a precondition for securing loans from creditors. However, their study lacks empirical evidence from their dataset to directly support this claim. We, on the other hand, find that firms in countries with higher creditor protection reduce more default risk than those in weak creditor rights and are able to demonstrate in our dataset that there are more hedgers in creditor-friendly countries, compared to countries with weak creditor protection. In addition, Bartram (2019) uses a broad sample of 47 countries from 2000 to 2001. We, on the other hand, use a sample of nine European countries with notable derivative activities in an extended period from 1999 to 2015.

Additionally, following Bartram et al. (2009) which suggest that the economic risk of a country could motivate firms to hedge with derivatives (FX, IR, and CP derivatives), we test the role of country risk on the impact of hedging on default risk. We document that the effectiveness of derivatives in reducing default risk is less pronounced in countries with lower economic risk, particularly concerning FX derivatives. Interestingly, our results differ from Bartram et al. (2009) in the notion that the economic risk of a country only has an effect on FX derivatives. We find no evidence that IR or CP derivatives are influenced by a country economic risk.

Moreover, Purnanandam (2008) demonstrates empirical evidence for a non-linear, U-shaped relationship between hedging activities and financial distress costs. This finding suggests that the propensity to hedge initially increases as the level of financial distress rises, reaching its peak at an intermediate level of distress. However, as firms approach extreme levels of financial distress, their inclination to engage in hedging activities diminishes. We contribute more evidence of this theory to the common literature by showing that firms in severe financial distress experience an increase in default risk, compared with other firms. This may be due to that those firms reduce or abandon their hedging programs due to the perceived costs, and financially constrained companies are less likely to engage in hedging activities due to collateral constraints, leading to a trade-off between financing and hedging.

Overall, our empirical findings indicate a substantial reduction in the likelihood of default associated with derivative hedging, highlighting the importance of derivatives in corporate risk management strategies. The reducing effect on the probability of default is enhanced particularly in countries with stronger creditor rights, while the impact is less pronounced in nations with lower economic risk. Additionally, our study suggests that firms experiencing severe financial distress may hedge less, which has implications for risk management practices.

1.4.2 Second essay

The second essay of this thesis is entitled: "Foreign exchange hedging strategies and default probability". We test the effect of currency hedging strategies including both FX derivatives and FC debt on default risk with a sample of six European countries (France, Germany, Spain, Italy, Norway and the UK) from 1999 to 2015. We incorporate the System Generalized Method of Moment (SGMM) model to address endogeneity issue and the possibility that the current probability of default is influenced by its past values, whereas most of the previous papers on hedging and default risk relies on the instrumental variable technique which is not able to cover this angle (Marin, 2013; Boyer and Marin, 2013; Magee, 2013).

The empirical analysis of the essay yields several nuanced and impactful findings that enrich our understanding of corporate risk management dynamics. Firstly, our research reveals that FC debt does not significantly reduce default risk and could even exacerbate it, while FX derivatives demonstrate a capacity to diminish default probability. This implies that the combination of both strategies may not offer optimal default risk mitigation outcomes, despite being a prevalent approach among the firms surveyed. Our findings diverge from the conclusions drawn by several prior studies (Hagelin and Pramborg, 2004; Nguyen and Faff, 2006; Bartram et al., 2010) which posit that FC debt serves as an effective hedging instrument by mitigating firms' FX exposure. While our research acknowledges the potential of FC debt to reduce FX exposure, it does not automatically mean that it is a good hedging tool since firms using FC debt have higher leverage (Clark and Judge, 2009) and higher likelihood of default than firms without due to increased interest payment obligations.

Our results also differ from Boyer and Marin (2013) which show that currency risk management, involving the use of FX derivative or the issue of FC debt, could lower default probability. However, their methodological approach consolidates FX derivatives and FC debt into a single FX risk management variable, potentially obscuring the distinct effects of these two hedging strategies. In contrast, our study, following Hagelin and Pramborg (2004), employs a more granular methodology, utilizing separate variables for each hedging approach. We incorporate multiple variables representing various strategies derived from FX derivatives and FC debt, enabling us to assess both individual and potential combined effects on default probability.

Secondly, we conduct a comparative analysis of the effect of different types of FX derivatives on default risk in an attempt to clear the mixed evidence in the literature regarding which types of derivatives are more optimal in hedging risk. The extant literature presents divergent views on the efficacy of derivative instruments, with some scholars advocating for the use of non-linear derivatives (Bartram, 2006; Adam, 2009), while others posit that linear derivatives offer superior effectiveness (Frestad, 2009). Our research makes a significant contribution to the ongoing scholarly debate by providing empirical evidence on the effect of linear (FX forwards and FX swaps) and non-linear (FX options) hedging strategies on default risk. Specifically, our findings demonstrate the contextual nature of these strategies' effectiveness, revealing that their impact can be both beneficial and detrimental under different circumstances. In more detail, our analysis unveils that linear FX derivatives emerge as more effective in controlling risk than their non-linear counterparts. This empirical observation corroborates the theoretical perspective that the primary function of option contracts is to facilitate speculative trading activities and leverage market dynamics for potential capital gains, rather than serving as instruments for risk mitigation (Dash et al., 2007). Our results are also different from Bartram et al. (2011), who find little evidence that derivative types matter in terms of risk reduction. However, we particularly tackle FX linear and non-linear derivatives, whereas Bartram et al. (2011) test general linear and non-linear derivatives.

However, we also identify scenarios where non-linear derivatives outperform linear instruments in mitigating default probability. In particular, firms with high growth enjoy non-linear hedging strategies, whereas low-growth firms benefit more from linear strategies. The fundamental principle at play is that firms tend to align their cash inflows with capital expenditures when external capital is expensive. In instances where the firm's investment program is substantial, there is a higher probability of a mismatch between cash inflows and outflows, leading to non-linearity in expenditures. Thus, to adequately hedge against this non-linear exposure, employing a non-linear hedging strategy is optimal (Adam, 2009). Furthermore, our study elucidates the differential impact of short-term and long-term hedging instruments on default risk, revealing that short-term instruments, such as FX forwards, are more effective in mitigating short-term default risk, while long-term instruments, like FX swaps, exert a more pronounced impact on long-term default risk.

Finally, our research highlights the connection between currency hedging strategies, FC debt particularly, and the level of debt enforcement efficiency within a country, which has not been investigated by previous studies. Bartram et al. (2009) test the hypothesis that firms tend to hedge more in countries with more efficient legal systems but find no evidence. However, Bartram et al. (2009) mainly test FX, IR and CP derivatives and only include FC debt dummy as a control variable. On the other hand, following Gatopoulos and Louberge (2013), which show that country-specific factors could have an impact on firms' hedging strategies regarding FC debt, we conduct an investigation on how country-level aspects influence the effect of FC debt on default probability. Unlike Bartram et al. (2009), which test the general legal environment, we are particularly interested in the debt enforcement efficiency of a country. In more detail, our results show that in countries with more efficient debt enforcement, the effect of FC debt on default probability becomes more positive. Within environments where debt enforcement is highly efficient, the consequences of default are more severe for firms, as lenders are more inclined to pursue legal action to recover debts, potentially leading to bankruptcy. Consequently, firms that employ FC debt as a hedging strategy in environments with rigorous debt enforcement regimes are exposed to heightened default risk, owing to the more severe consequences associated with defaulting on their obligations. This underscores the need for firms operating in high debt enforcement environments to meticulously assess the suitability of FC debt as a hedging tool.

Interestingly, we also document an intriguing scenario wherein FC debt demonstrates the potential to mitigate default probability. This effect is particularly pronounced for firms that meet two specific criteria: firstly, they operate in countries characterized by less efficient debt enforcement mechanisms, and secondly, they generate a substantial level of foreign sales.

Altogether, our second essay finds that FC debt generally does not reduce default probability, and its effect on the probability of default is more positive in countries where debt enforcement efficiency is high. In addition, we also find that generally, linear FX derivatives are more effective than non-linear derivatives in reducing default risk. However, firms with high growth benefit more from hedging with non-linear strategies since non-linear derivatives are more efficient in hedging non-linear exposure.

1.4.3 Third essay

The third essay is entitled: "Long-term and short-term interest rate derivatives and default risk", which studies the effect of long-term and short-term IR derivatives on default risk with a sample of nine European countries (the United Kingdom, France, Germany, Denmark, Italy, Norway, the Netherlands, Spain and Sweden) in the period from 1999 to 2015.

The majority of literature on IR hedging focuses on IR swaps (Faulkender, 2005; Chernenko and Faulkender, 2011; Hecht, 2019) and treats them as a representative of IR derivatives since it is the dominant instrument on the market. However, since different types of IR derivatives are used for different hedging purposes, especially time-duration of exposure, it is arguable that each type will have a different impact on default risk. As a result, we take a different approach and examine the effects of long-term and short-term IR derivatives on the probability of default. Notably, our findings unveil that IR swap contracts (long-term IR derivatives) exhibit superior efficacy over their short-term counterparts, such as IR forwards and options, in managing both short and long-term default probability. This phenomenon could be attributed to the intrinsic design of long-term derivatives, which are tailored to hedge a firm's total exposure. Our results remain consistent through various model specifications including the System Generalized Method of Moment (SGMM) to account for the autocorrelation of the probability of default and endogeneity issue. Additionally, the results indicate that among short-term derivatives, IR option derivatives appear to mitigate the probability of default more effectively than IR forwards, a finding that aligns with Gamba and Triantis (2014), who posit that some companies may derive greater advantages from option contracts compared to linear derivatives like swaps and forwards. In contrast to Bartram et al. (2011), who conclude that the nonlinear payoff structure of derivatives has minimal impact on the reduction of firm risk associated with derivative usage, our findings suggest that the nonlinearity of IR derivatives matters.

On the other hand, since short-term IR derivatives are used to hedge short-term exposure, we suspect that firms operating in environments which foster the utilization of short-term liabilities may derive greater benefits, in terms of default risk reduction, from the deployment of short-term derivatives. Specifically, following Baum et al. (2006) which show that German firms rely more on short-term debts, we demonstrate that German and Spanish firms that experience a more pronounced reduction in the likelihood of default when employing short-term IR derivatives, in contrast to long-term contracts. This is because those countries have bank-based financial system (Cobham et al., 1999). To the best of our knowledge, there are no prior studies distinguishing the role of corporate hedging with respect to the financial system of a country.

The majority of existing literature suggests that large firms are more likely to hedge with derivatives (Allayannis and Ofek, 2001; Judge, 2006; Chernenko and Faulkender, 2011). However, it may not be the case when it comes to IR derivatives. According to Covitz and Sharpe (2005), larger corporations tend to utilize long-term fixed-rate debt to mitigate interest rate volatility, reducing their reliance on IR derivatives. In contrast, smaller firms, which mainly depend on floating-rate debt, are more inclined to employ IR derivative instruments as a hedging mechanism against interest rate fluctuations. To the best of our knowledge, there appears to be a gap in empirical evidence regarding the differential effects of derivative usage on default risk across various company sizes. We extend our analysis with the examination of the effect of IR swaps on the probability of default with respect to firm sizes. Unlike previous studies which suggest a linear effect of firm size on hedging, our results indicate a nonlinearity in the effect of IR swaps on default risk across different firm sizes. Particularly, we find that middle-size corporations tend to engage more actively in hedging activities with IR swaps, whereas smallest and largest firms engage less in hedging.

In short, the third essay documents that long-term IR derivatives (IR swaps) are effective in hedging both short and long-term default risk, indicating that they are generally better than their short-term counterparts. However, firms operating in bank-based countries such as Germany or Spain, benefit more from using short-term IR derivatives in terms of default risk reduction. Among the short-term instruments, IR options are better than IR forwards in default likelihood reduction.

1.5 Structure of the thesis

The structure of the thesis is as follows. Chapter 2 explores how hedging using derivatives affects the likelihood of default. We also test whether there is speculative activity within extremely distressed firms. The study further assesses the role of national factors, such as the level of creditor protection and economic risk, on the efficacy of derivatives. Various estimation techniques are employed to achieve the research goal. Chapter 3 examines the impact of currency hedging tactics on the risk of default. This is done by scrutinizing hedging methods that incorporate both FC debt and FX derivatives. We delve deeper into the linearity of FX derivatives or specific kinds of FX derivatives. We also examine how the enforcement of debt could affect the impact of currency hedging on the risk of default. Additionally, we explore whether there is a difference in hedging behaviours between low-growth and high-growth firms. Chapter 4 investigates the influence of both long-term and short-term interest rate derivatives on the likelihood of default. We also contrast the hedging effectiveness of IR forwards and options. We examine whether a country's financial system (bank-based or market-based) could affect the efficacy of IR derivatives in mitigating default risk. Furthermore, we explore whether the size of a firm has an impact on swap users. Chapter 5 serves as the culmination of this thesis, encapsulating the research findings. It delineates the implications of this investigation to policymakers. Furthermore, it addresses the limitations of the study and outlines potential avenues for future research that emerge from this work.

Chapter 2: The impact of derivative use on default probability among non-financial firms: Evidence from European firms

2.1 Introduction

There is no denial that derivatives are becoming increasingly popular among businesses as a hedging instrument. As reported by the Bank of International Settlement (BIS), in 1999, interest rates and foreign exchange derivatives used by non-financial firms had notional values of $5.56 trillion and $2.85 trillion, respectively[2]. The figures surged, in 2009, to $35.6 trillion for interest rate derivatives and $8.8 trillion for currency derivatives[3]. By 2021, the total market value of derivatives had reached $610 trillion worldwide[4]. In addition, Bartram et al. (2009), with a rich sample of more than 7000 companies from 50 countries in 2000 and 2001, discovered that approximately 60% of the firms use derivatives, including interest rates (IR), foreign exchange (FX) and commodity price (CP). Moreover, according to Campello et al. (2011), virtually all of the biggest companies around the globe hedge their business and financial risks with derivatives. Previous studies have demonstrated various benefits of hedging for firms. For instance, Chen and King (2014) find strong evidence that hedging is associated with a decrease in the cost of debt. Bartram et al. (2011) report that hedging increases firm value. Huang et al. (2017) provide evidence that derivative use significantly lessens firm risks, as measured by equity volatility and market beta. Ahmed et al. (2018), with a sample of German firms from 1999 to 2009, find that hedgers experience a 109 basic point lower cost of equity than non-hedgers. Recent studies such as Magee (2013), have started to look at the aspect of hedging and the likelihood of financial distress as this certain topic has been argued to be among the top concerns for researchers and investors. As argued by Smith and Stulz (1985), one of the incentives for firms to hedge is the need to mitigate the costs of financial distress. According to Stulz (1996), diversified investors are more concerned about the probability of financial distress rather than the cash flow volatility created by foreign exchange rates, interest rates, and commodity price fluctuation.

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[2] The global OTC derivatives market at end-December 1999 (2000) BANK FOR INTERNATIONAL SETTLEMENTS. Available at: https://www.bis.org/publ/otc_hy1605.pdf.
[3] *OTC derivatives market activity in the second half of 2009* (2010) *BANK FOR INTERNATIONAL SETTLEMENTS*. Available at: https://www.bis.org/publ/otc_hy1005.pdf.
[4] *OTC derivatives statistics at end-June 2021* (2021) *The Bank for International Settlements*. Available at: https://www.bis.org/publ/otc_hy2111.htm.

Our paper contributes to the common research conversation regarding corporate risk management as follows. Firstly, as far as we know, we are the first to investigate the impact of derivatives on the probability of default in a cross-country setting, unlike many previous papers that focus on single-country contexts, such as the US (Marin, 2013; Magee 2013; Boyer and Marin 2013). We argue that conducting research regarding derivative usage and default risk in international settings is necessary because US non-financial firms account for only a minor portion of derivative transactions worldwide. Secondly, the cross-country approach allows us to examine the impact of institutional and country macroeconomic factors on the impact of derivatives in reducing a firm's credit risk. These institutional and country factors, including a nation's economic stability, fiscal policies, and regulatory environment, could play a pivotal role in determining the use of derivatives. Specifically, the study examines the impact of creditor rights and economic conditions on the effectiveness of derivatives in mitigating credit risk. This approach builds upon the work of Bartram (2019) who demonstrates the importance of country-level factors in determining the impact of derivatives on firm risk by studying 47 countries in 2000-2001. However, this research expands on Bartram (2019) by utilizing a panel dataset from 1999 to 2015. Furthermore, in this study, our focus is on default probability because ultimately, this is the risk firms are trying to mitigate. To the best of our knowledge, we are the first to document that derivatives reduce default risk more in countries with stronger creditor rights. This is consistent with our expectations. Interestingly, our findings contradict Bartram (2019), who reports a more pronounced decrease in firm risk in countries with weaker creditor rights. Our cross-country setting also allows us to examine the role of country risk on the impact of hedging on default risk. We find that the impact of derivatives in reducing default risk is less pronounced in countries with lower economic risk, particularly in the context of FX derivatives.

In summary, we show that derivative hedging lowers the probability of default by 14-20%. Furthermore, our study underscores that the default risk mitigation effect is more pronounced when firms employ interest rate (IR) derivatives as opposed to foreign exchange (FX) and commodity (CP) derivatives. Moreover, our research identifies that derivative usage exerts a statistically greater negative impact on short-term default risk compared to its long-term counterpart. The negative correlation of derivatives and default risk stays robust after performing a wide range of models for possible endogeneity emerging from derivative usage and probability of default. Furthermore, our investigation suggests that firms experiencing severe financial distress may hedge less. Specifically, we define highly distressed firms as those with low Z-scores and negative returns on assets, and we observe a positive coefficient for the derivative user dummy among these distressed entities. The structure of this chapter is delineated as follows: Section 2.2 is the literature review. Section 2.3 elucidates the formulation of the hypotheses underpinning the empirical analysis. Section 2.4 describes the characteristics of the data and methodologies employed in the empirical investigation. Section 2.5 presents a descriptive analysis of the data. Section 2.6 reports the empirical findings obtained through the application of the employed methodological framework. Finally, Section 2.7 articulates the conclusions drawn from the research.

2.2 Literature review

2.2.1 Theories on corporate derivative usage drivers: Hedging and speculation rationales

Modigliani and Miller (1958) postulate that investors could diversify their portfolios under the assumption of perfect market conditions. Thus, firms lack incentives to engage in hedging practices. However, the Modigliani and Miller theorem rests on several unrealistic assumptions, including tax neutrality, the absence of transaction costs or bankruptcy expenses, and symmetric access to credit markets. While these assumptions may be theoretically unassailable, they do not hold true in practical scenarios. Consequently, several theoretical frameworks have been established in the domain of optimal hedging, aiming to elucidate the motivations driving firms to engage in hedging activities with derivatives. Traditional finance theory, as exemplified by Smith and Stulz (1985), defines hedging as the use of derivative instruments to actively mitigate risks arising from fluctuations in exposures. This conceptual framework forms the basis for much academic research in risk management. However, some theoretical perspectives posit that firms may also utilize derivative instruments not only for hedging risks but also for engaging in speculative activities aimed at generating profits.

2.2.1.1 Hedging

The core function of hedging within corporate finance enjoys widespread agreement among scholars. Smith and Stulz (1985) emphasize its risk-mitigating nature, defining it as the procurement of financial instruments to lessen the variability of a firm's cash flows. Similarly, hedging is conceptualized as a risk management tool that utilizes derivatives and other instruments to counteract the negative impacts of fluctuations in foreign exchange, interest rates, and commodity prices (Hentschel and Kothari, 2001). This definition explicitly connects hedging with the reduction of firm risk exposure. These consistent definitions from leading scholars highlight the established understanding of hedging as a strategy primarily aimed at mitigating risk within academic literature.

Hedging could help firms reduce the costs of financial distress. Shareholder diversification alone cannot mitigate all risks, particularly for companies highly dependent on foreign exchange rates (FX), interest rates (IR), or commodity prices (CP). Extreme volatility in these factors may significantly raise a firm's chances of bankruptcy despite shareholders holding diversified portfolios (Stulz, 1996). In such scenarios, an unhedged position might lead to a decline in a firm's assets relative to its debt, potentially necessitating bankruptcy filings. To avoid this distress, Smith and Stulz (1985) advocate corporate hedging. When fluctuations cause insufficient cash flows to cover debts, bankruptcy risks and associated costs heighten, which decreases market valuation for the firm. However, derivatives can curtail cash flow volatility, thereby reducing the cost of financial distress. Copeland and Joshi (1996) contend that hedging lowers the cost of financial distress by lessening cash flow volatility and enhancing a firm's ability to meet debt obligations, consequently improving creditworthiness and access to capital at more favourable terms.

Firms also come to hedging in response to tax incentives. Smith and Stulz (1985) highlight the tax-minimizing potential of hedging, suggesting that smoothing taxable income through different tax years can leverage the convexity of tax functions to reduce corporate tax liability. Similarly, Stulz (1996) posits that risk management practices, by mitigating fluctuations in taxable income, allow firms to maintain consistently lower taxable income levels across a business cycle. This positioning ensures their income falls within the most favourable tax brackets.

Hedging can play a crucial role in reducing underinvestment problems, especially when considering the agency conflict between shareholders and bondholders. This conflict often discourages companies from pursuing investments with a positive net present value (NPV). Shareholders, seeking higher returns, may push for riskier projects, while bondholders prefer stability to ensure debt repayment. As a result, firms might avoid taking on beneficial investments to maintain financial stability and appease bondholders. To address this, Froot et al. (1993) argue that companies facing difficulties in securing external financing may use derivatives to manage the risk of insufficient internal cash flow. This is particularly important when external capital is more expensive due to market inefficiencies, making internal cash flow crucial for financing new projects. By hedging against cash flow volatility, companies can ensure they have enough funds for planned investments. Supporting this, Copeland and Joshi (1996) emphasize how hedging stabilizes cash flows, helping firms manage the uncertainty of future expenses and revenues, and ensuring they can continue to invest in profitable projects. Similarly, Stulz (1996) points out that companies with weaker financial positions may face capital-raising difficulties, where high borrowing costs or lack of access to capital can lead to abandoning profitable projects. Moreover, risk-averse managers might forgo risky, positive NPV projects due to uncertainty. However, by reducing a firm’s overall risk through hedging, managers can feel more confident in pursuing such projects, knowing the firm's financial exposure is limited. In this way, hedging can help resolve the underinvestment problem by providing firms with more stability and access to funds, thus facilitating optimal investment decisions.

Moreover, hedging is used in a way that maximizes managerial wealth. In detail, Stulz (1984) delves into the complex relationship between managerial compensation and hedging behaviour. He argues that when executives have significant exposure to idiosyncratic firm risk through their compensation packages, they have a tendency to utilize derivatives for hedging. If the firm's equity value directly benefits from asset volatility, hedging might not be their preferred approach. However, if managers have an undiversified portfolio heavily invested in the company’s stock, they may hedge against non-diversifiable risks, even though this may not align with shareholders' interests.

In addition, hedging could reduce information asymmetry. Outsiders possess less information regarding firm performance than managers, making external funding more costly than internal financing. Many firms choose not to reveal fully or distort information because releasing information means more expenses. This information asymmetry impacts asset prices and expected rates of return by affecting investors’ analysis of the firm's future cash flows, increasing firm risk. Essentially, the more difficult it is to assess a firm's quality, the higher the chance of aggressive risk-taking activities will happen. And this will materialise into higher default risk. Vallascas and Keasey (2013) document this phenomenon with their study on information asymmetry and default risk in the bank industry. Hedging can decrease cash flow volatility, making cash flows more predictable. Thus, it can be said that the use of derivatives is connected to a lower level of information asymmetry between managers and stockholders (DaDalt et al., 2002).

However, a critical limitation emerges in prior studies examining these theories (Nance et al., 1993; Judge, 2006; Magee, 2013; Boyer and Marin, 2013). By solely focusing on financial derivative usage as an indicator of hedging, they overlook the potential for other activities through derivatives such as speculation. This raises concerns about the underlying assumption that all derivative use signifies risk reduction. The interplay between derivatives and firm risk is undoubtedly intricate, potentially driven by motives beyond pure hedging, such as personal wealth maximization, speculation, or competitive benchmarking. These alternative motivations can introduce unforeseen risks by increasing exposure and jeopardizing financial stability.

2.2.1.2 Speculation

On the contrary, speculation is distinguished by its capacity to increase risk rather than alleviate it. Szado (2011) characterizes speculation as a practice centered on acquiring assets (property, commodities, securities) with the primary intention of reselling them in the short term. This strategy aims to capitalize on anticipated price changes and generate quick profits or capital gains through high-risk financial trading. Speculative activities may often involve a lack of thorough research and a focus on price volatility as the sole source of income or capital appreciation, rather than the intrinsic value of the asset or potential dividend streams. The concept of risk is central to speculation, as the very act of anticipating price movements and profiting from such fluctuations embodies inherent risk. According to Rafikov and Saiti (2017), most definitions of speculation emphasize the assumption of risk associated with exploiting price differentials through buying and selling assets. O'Connor et al. (2011) highlight the employment of derivatives to capitalize on anticipated shifts in the prices of underlying assets.

Agency theory could explain why derivatives may be used for speculative purpose in the sense that speculation can be the consequence of agency cost in a firm (Stulz, 1984). Firm managers are motivated to increase firm risk using derivatives when they want to maximize their managerial compensation. Managers often use their predictions about future price changes to create hedging strategies and might only partially hedge the firm's risk exposure. However, when a derivative transaction does not have any real risk to offset, it essentially becomes a speculative bet without a counterbalancing hedge. Consequently, it will end up increasing the financial risk instead of reducing it.

As previously articulated, derivative instruments can be employed to either raise or diminish a firm’s financial risk. This duality necessitates an inquiry into the motivations behind non-financial firm managers' utilization of derivatives. Do they primarily employ these instruments to mitigate corporate financial risk, or are they driven by speculative intent? A firm deploying derivatives for hedging purposes should demonstrably exhibit a reduction in overall financial risk compared to its pre-hedging state. Conversely, firms utilizing derivatives speculatively should experience an increase in financial risk relative to their initial state.

2.2.2 Derivatives and financial risk

This section delves into the multifaceted relationship between derivatives usage and corporate financial risk. The central question revolves around whether derivatives primarily function as risk management tools (hedging) or instruments for speculation.

2.2.2.1 Derivatives reduce firm risk

As per Geczy et al. (1997), the companies in their study employ FX derivatives when confronted with elevated financial distress costs or significant cash flow volatility. This practice serves as a protective measure to shield companies from unforeseen fluctuations in foreign exchange rates. However, direct evidence supporting the idea that FX hedging reduces risk is not provided. Then, several studies provide empirical evidence to support the notion that hedging with derivatives reduces firm risk.

Guay (1999), studying 254 non-financial US companies commencing derivatives usage from 1990 to 1994, documents evidence that market risk, total risk, idiosyncratic risk, interest rate exposure, and foreign exchange exposure decline post-adoption. The reductions in various risk dimensions for these derivative users relative to controlled non-users support theories that firms deploy these instruments to actively hedge rather than speculate. Specifically, the author’s tests reveal a 5% decrease in stock return variability, alongside a 22% mitigation in interest rate exposure and an 11% dampening of exchange rate exposure for firms applying the respective derivatives. Collectively, the empirics affirm derivatives’ capacity to materially reduce corporate risk exposures. Similarly, by examining more than 40 companies in Sweden, Nydahl (1999) also finds evidence to support that using FX derivatives negatively influences FX risk exposure measured by foreign sales over total sales.

Following Guay (1999) to study US firms but using a different approach to FX derivative variable, Allayannis and Ofek (2001) analyse a sample of more than 300 non-financial firms from the S&P 500 in 1993 to investigate the influence of FX derivatives on a firm's vulnerability to FX fluctuations. Their research yields evidence that FX derivative usage leads to a reduction in a firm's FX exposure. Employing a continuous measure of FX derivative activity, the study reveals a clear negative correlation between these instruments and FX exposure. This finding aligns with the idea that firms primarily utilize derivatives for risk management purposes, aiming to mitigate FX volatility rather than engaging in speculative FX market activities. The study delves deeper, revealing that the extent of a firm's foreign sales and international trade plays a significant role in shaping its hedging decisions. This signifies that firms avoid basing their derivative usage on speculative market outlooks and instead focus on proactively managing their specific FX risks.

Similarly, also using continuous measures for hedging, Nguyen and Faff (2003) inquire into the effectiveness of FX derivatives in mitigating FX exposure for Australian firms with substantial foreign sales. Their findings indicate that these firms utilize FX derivatives primarily as a hedging tool to reduce short-term FX exposure, rather than for speculative purposes. This suggests that derivatives play a role in managing currency risk for these companies.

Additionally, with a different risk proxy, Huang et al. (2017) explore the effect of derivative hedging on stock return volatility. Examining a sample of firms in the UK from 2003 to 2009, the study demonstrates that derivative hedging is linked with a significant decrease in stock return volatility and systematic risk. This suggests that firms leveraging these instruments can achieve greater stability and resilience in the face of market fluctuations. Furthermore, the study reveals that firms employing a combination of FX and IR derivatives experience an even stronger decrease in risk compared to those employing a single type. The study does not find any significant reduction in equity volatility for firms that use CP derivatives. This finding suggests a potential synergistic effect, where diversification within derivative usage amplifies the risk-mitigating benefits.

Focusing on CP derivatives, Yang et al. (2023), with a sample of Chinese firms from 2010 to 2020, find that derivatives can reduce firm's idiosyncratic risk. In particular, CP derivatives can moderate the increase in firm's idiosyncratic risk caused by commodity financialization.

Patil (2024) examines the relationship between a firm's use of derivatives for risk management and its financial constraints, allowing for insights into the broader implications of derivatives on risk. By utilizing an event study and a difference-in-differences approach for a US sample, the study establishes a causal link between derivative hedging and a reduction in financial constraints. The findings indicate that firms using derivatives tend to increase net debt while reducing cash reserves and equity issuance. In situations where managers of non-financial firms anticipate liquidity shortages, they typically save more cash from cash flow as a precaution. However, after implementing hedging, both cash flow sensitivity and investment-cash flow sensitivity decrease. Moreover, the study reveals that loan spreads and the likelihood of covenant violations diminish once firms adopt derivative hedging practices.

Furthermore, out of the scope of a single-country context, Bartram et al. (2011), with a diverse sample of non-financial firms from 47 different countries, unveils robust evidence indicating that the adoption of financial derivatives plays a pivotal role in diminishing both total risk and systematic risk. Notably, the study highlights a positive association between hedging through derivatives and key performance indicators such as firm value, profits, and returns, strongly indicating a strategic focus on mitigating downside risk. Moreover, the authors also document little evidence that derivative types differ in effect on firm risk.

2.2.2.2 Derivatives increase firm risk

While some studies support the risk-alleviating benefits of derivatives, others highlight potential dangers associated with speculative use.

Purnanandam (2008) develops a model testing corporate risk management motivations at different financial distress levels. The study defines distress as an intermediate state between solvent and insolvent state, where firms face cash shortfalls and unprofitability but have not filed for bankruptcy. This conception underlies the model of the study. Examining a 1996-1997 dataset of more than 2000 US companies and incorporating a squared term for financial distress provides evidence of a U-shaped relation between hedging and financial distress costs. This means that, at an intermediate level of financial distress, the incentive to hedge heightens with financial distress level then attenuates at extreme distress. This could indicate that firms in extreme distress may speculate with derivatives in order to bet for their resurrection.

Also, regarding the nonlinearity of hedging, Nguyen and Faff (2010) analyse a large sample of Australian firms over a two-year period, investigating the relationship between derivatives usage (IR and FX derivatives) and firm risk. Their findings highlight a nuanced, nonlinear relationship between the two. While not all derivative users experience an absolute reduction in risk, firms using derivatives below 40% of their financial exposure display a decrease in risk. Conversely, extensive users, exceeding 40%, exhibit an increase in risk, potentially indicating speculative motives driving their high engagement. As a result, this points out that it may not be the use of derivatives that impacts firm risk, but rather the extent of derivative usage.

Similarly, using a novel, hand-collected dataset with granular data from French firms between 2010 and 2015, Hecht and Lampenius (2023) examine corporate FX exposure management. By analyzing publicly disclosed FX exposures before and after hedging, they determine firm-, year-, and currency-specific hedge ratios, distinguishing between risk-decreasing and risk-increasing/risk-constant hedging strategies. Their findings reveal that approximately 80% of FX exposures are managed with risk-decreasing strategies, while the remaining 20% involve risk-increasing or risk-constant approaches.

2.2.2.3 Derivatives and default risk

The studies discussed above encompass diverse facets of firm risk, including FX exposure, IR exposure, total risk, systematic risk, and stock price volatility. However, these investigations have not specifically addressed the critical aspect of default risk.

Default risk, being the ultimate risk that firms aim to mitigate through hedging strategies, represents a significant gap in the current body of research.

Fok et al. (1997) conduct a primary investigation into the determinants of hedging and report limited evidence supporting the hypothesis that hedging practices reduce the probability of financial distress. A study by Campello et al. (2011) explores the relationship between loan spreads and hedging within US firms, delving into its influence on external financing costs and investment expenditures. Leveraging comprehensive data on firm hedging activities, particularly in syndicated loan agreements, the study uncovers insightful findings. Firstly, the research reveals a significant reduction in external financing costs for firms actively engaged in hedging. This implies that managing risks through hedging strategies translates to lower borrowing costs for firms. Secondly, the study demonstrates that hedging firms tend to have fewer loan covenants in their contracts compared to non-hedging counterparts. This suggests that lenders perceive hedged firms as less risky, granting them more flexibility in their financial operations. It could be inferred that by effectively reducing the costs of debt, hedging decreases the likelihood of negative consequences, thereby lowering the associated financial distress costs. In fact, Campello et al. (2011) show in their dataset that hedgers possess lower default risk (measured by Z-score) than non-hedgers.

However, the methodology of the studies above is confined to a comparison of means. Moreover, the metrics employed to quantify the likelihood of financial distress are debt ratios or Z-score (an accounting-based default measure), which may not accurately reflect the true probability of default. Only a few recent scholarships have begun to explore the intersection between hedging practices and corporate default risk with a more proper measurement of default likelihood.

Bartram et al. (2011) employ a rudimentary approach to assess the impact of hedging on default probability. They utilize a self-calculated, simplified Expected Default Frequency (EDF) measure and conduct a mean difference test. Their findings reveal no significant disparity in EDF between firms that use derivatives and those that do not, suggesting that derivative usage may not affect default probability.

Via the use of complementary loglog hazard model to estimate the likelihood of firms to file for bankruptcy within one year and GMM model to control for endogeneity, Marin (2013) investigates the effectiveness of proactive risk management in enhancing firm survival rates. The study employs a matched sample of US firms, both those that have declared bankruptcy and those that have not between 1998 and 2005. The analysis reveals that firms, which actively engage in risk management (binary variable set to 1 if firms use FX derivatives and/or foreign-denominated debt and 0 otherwise), exhibit a demonstrably lower probability of bankruptcy compared to their non-hedging counterparts.

Using a different methodology, Magee (2013) explores the association between FX derivative usage and the risk of financial distress from 1996 to 2000 with a sample of 401 large US companies. Distance to default is employed to be a key indicator of financial distress and FX derivative has two measures: a continuous measure reflecting their overall usage and a binary measure indicating their presence or absence. The research yields an intriguing finding: firms with extensive FX derivative activity exhibit a lower likelihood of financial distress, even when considering the potential influence of leverage on hedging decisions. The economic significance of this result is emphasized by the observation that a one standard deviation increase in FX derivative engagement translates to a substantial increase in distance to default. This aligns with the concept of firms primarily utilizing FX derivatives for hedging purposes, aiming to mitigate foreign exchange risk exposure rather than engaging in speculative activities. However, the study does not identify a statistically significant impact of the choice to hedge (binary variable) with derivatives on default probability.

Similarly, but with more default risk measures, Boyer and Marin (2013), by studying 531 US manufacturing firms and using various proxies of financial risk, including asset volatility, moneyness of debt, and distance to default, reveal that firms hedging foreign exchange exposure exhibit lower financial distress risk. However, the researchers do not distinguish different FX hedging methods. They include the use of FX derivatives and also other methods like foreign operations and foreign currency (FC) debt into one FX risk management variable.

2.2.3 Country-level factors and derivatives

According to Shapiro et al. (2013), country risk is defined as a concept encompassing the general level of political and economic uncertainty within a nation. This uncertainty can significantly influence the value of investments made in that country.

Building on this foundation, Butler (2016) highlights that country risk essentially reflects the risk associated with unforeseen changes in a nation's environment. This risk can be further categorized into political risk and financial risk. Interestingly, Butler (2016) identifies a potential mitigation strategy for political risk: political risk insurance. They point out that such insurance contracts function similarly to put options, a type of derivative instrument. This observation sparks a compelling proposition – a firm's use of derivatives might be influenced by its exposure to country risk.

While research on derivatives has been extensive, only a few recent studies have begun to explore the interplay between country-level factors and derivative use. The diverse economic, financial, and political landscapes across nations offer a rich environment to examine existing and emerging theories in risk management. This is particularly timely given recent studies suggesting that derivative markets can contribute positively to a nation's economic growth (Aali-Bujari et al., 2016; Şendeniz-Yüncü et al., 2017). Consequently, a critical area of research lies in identifying the country-level factors that either encourage or hinder corporate adoption of derivative instruments. Understanding these factors is especially crucial if they are susceptible to policy interventions. This review aims to delve into this under-explored territory, examining the existing literature on country-level factors and derivative use by corporations.

Bartram et al (2009), using a sample of 7,319 firms across 50 countries in 2000 and 2001, sheds a light on firms' hedging decisions through derivatives. The large size of the analysed data grants the study exceptional strength. With such a robust statistical foundation, the researchers are able to examine the interplay between country-level and firm-level factors influencing hedging decisions. The research employs a simultaneous equations approach to investigate the impact of derivative usage on various corporate policies. The results demonstrate significant correlations between derivatives use and key financial attributes, including leverage, debt maturity structure, liquidity holdings, dividend strategies, and operational hedging practices. A particularly robust and noteworthy finding emerges regarding firms operating in less developed derivatives markets, typically found in middle-income economies. These firms exhibit a lower propensity for hedging. This finding gains additional significance when considered alongside our other results, which indicate that firms in countries characterized by higher economic and financial risk show a greater inclination towards hedging, all else being equal. The research suggests that financial policymakers, through the adoption of initiatives aimed at fostering the growth of derivative markets denominated in domestic currencies, can equip corporations with more effective tools for managing their financial risks.

Unlike Bartram et al. (2009) which test the influence of firm-level financial factors and size of the derivative market and some country risk factors on the decision to hedge, Lel (2012) examines the influence of corporate governance, encompassing both firm-specific and national-level governance structures, on firms' utilization of FX derivatives, measured in both continuous and binary variables. The study analyses a multinational sample of companies from 30 countries across a ten-year period (1990-1999). The research reveals that firms with robust corporate governance practices exhibit a tendency to use derivatives as a risk management tool to mitigate FX exposure. Conversely, companies characterized by weak governance structures appear to primarily use derivatives for purposes aligned with managerial incentives, potentially deviating from sound risk management principles. To assess national-level external governance, the study employs five distinct proxies: rule of law, efficiency of the judicial system, enforcement of shareholder rights (anti-director rights), creditor rights, and property rights. Interestingly, the research does not identify a significant correlation between creditor rights and the use of FX derivatives.

Similarly, considering both the company's own governance practices and the overall governance environment of its country, Allayannis et al. (2012) explore how currency derivatives impact a company's value. The research analyses companies from nearly 40 countries with significant exposure to exchange rate fluctuations. The findings indicate that, on average, engaging in FX derivative transactions enhances firm value. Corporate governance is associated with how investors interpret a company's use of FX derivatives. Strong internal or external governance practices signal the potential value of these derivatives for the firm, leading to a premium (positive impact) on firm value. Conversely, weak governance offers no such advantage. Notably, the positive association between a firm's use of FX derivatives and its market value is particularly strong when both internal firm-level governance and external country-level governance are robust. This suggests that robust governance structures at both the firm and national levels create an environment that fosters effective utilization of foreign currency derivatives, ultimately contributing to enhanced firm value.

Interestingly, Lievenruck and Schmid (2014) explore a novel angle in understanding corporate hedging behaviour: culture. Focusing on energy utilities, where exposure to foreign exchange, interest rates, and commodity prices is inherent, the study ensures consistency across a substantial sample of over 500 firms from over 50 countries from 2000 to 2009. The results show that long-term orientation emerges as a powerful force. In cultures that prioritize long-term planning and delayed gratification, firms are less likely to hedge and tend to hedge with smaller volumes of derivatives compared to their counterparts in short-term-oriented societies. Masculinity, reflecting societal values of assertiveness, materialism, and heroism, reveals an intriguing connection to hedging strategies. Cultures with high masculinity scores exhibit a reduced preference for option derivatives. Similar to Lel (2012), the authors are unable to establish a consistent and significant relationship between creditor rights and hedging activities.

In addition, the study by Bartram (2019) explores the connection between firms' usage of financial derivatives and various risk metrics. This analysis aims to determine whether non-financial companies use derivatives mainly to hedge or to speculate. Examining a dataset of 6,896 firms across 47 countries, the research reveals evidence consistent with corporations using derivatives to mitigate risk. The study finds no indication of widespread corporate speculation using derivatives, regardless of the specific country or type of derivative instrument employed. Interestingly, the research suggests that the effectiveness of derivatives for risk reduction appears independent of a nation's corporate governance structures or the ease of access to derivatives markets. However, unlike Lel (2012) and Lievenruck and Schmid (2014), the study does identify a nuance: firms using derivatives in countries with strong creditor rights protection exhibit a smaller decrease in stock return volatility compared to firms in countries with weaker creditor rights. Conversely, the risk-alleviating effect of derivatives is amplified in countries with more readily available derivatives markets.

2.3 Hypothesis development

Several studies investigate the impact of hedging with derivatives, on default risk (Magee, 2013; Marin, 2013; Boyer and Marin, 2013). Since hedging with derivatives could lower cash flow volatility, and allow access to internal funds, we hypothesize that derivative usage should lead to a reduction in the probability of default if firms use derivatives for hedging purposes. Thus, we anticipate the hypothesized relationship between the two researched subjects to be negative.

H2-1: If firms use derivatives to hedge, the probability of default is reduced.

Purnanandam (2008) puts forward and tests a theory regarding corporate risk management in the context of financial distress. Financial distress, as defined by the researcher, refers to a state where firms are in between solvency and insolvency, characterized by low cash flows and losses but not yet bankruptcy. Using a dataset of over 2000 US firms from 1996-1997 and including a squared term for financial distress in the model, the study reveals robust evidence of a nonmonotonic relationship, a U-shape particularly, between financial distress and the motivation to hedge. This implies that at an intermediate level of financial distress, the incentive to hedge increases with the level of distress. However, this relationship reverses for extremely high levels of financial distress. This suggests that firms facing severe financial distress may change their risk management approach since they are already at a high risk of going bankrupt. If those firms hedge less, we could witness a smaller impact of derivatives on default risk. As a result, the proposed hypothesis is as follows.

H2-2: Hedging by extremely distressed firms is less effective in reducing default risk.

Creditor rights, which exist to safeguard creditors from defaulting debtors, can significantly influence a firm's risk behaviour. In countries with robust creditor rights, firms might be more motivated to reduce risk by using derivatives for hedging. This is because, in such nations, there is a greater likelihood of power shifting from a firm's management to creditors if the firm fails to meet its debt obligations (Cho et al. 2014). In countries with strong creditor protection, bankruptcy costs for firms can be high as bondholders have more power over firms. They closely monitor risk factors, like exchange rate, interest rate, or commodity price fluctuations, which could lead to defaults and wealth transfer from bondholders to shareholders. Thus, firms in such creditor-friendly nations are inclined to employ risk mitigation strategies, including hedging with derivatives. However, Bartram (2019) conducts a similar test for firm’s total risk and exposure and documents opposite results where firms in countries with weak creditor rights reduce risk (stock volatility) more than their strong creditor rights counterparts. The explanation is that creditors in these countries, before lending money, want firms to commit to practical risk management. So, it is essential to study how creditor rights affect a firm's hedging. We hypothesize that hedging in these countries results in a more substantial reduction in default probability. Our hypothesis is as follows:

H2-3: The default probability is reduced more in countries with stronger creditor protection.

Bartram et al. (2009) provide findings suggesting that companies operating in regions with elevated economic risks tend to utilize derivatives for hedging more frequently due to their heightened risk exposure. Conversely, in environments characterized by greater economic stability, firms might encounter a reduced effect of derivatives on the likelihood of default because their risk exposure is inherently lower. Consequently, we formulate the following hypothesis:

H2-4: The default probability is reduced more in countries with higher economic risk.

2.4 Data, methodology, and variable construction

2.4.1 Sample countries

We attempt to study the impact of derivative use and default risk with a sample of nine countries including the UK, France, Germany, Denmark, Italy, Norway, the Netherlands, Spain, and Sweden. The rationales for selecting those particular countries for our sample are explained in this section. Many previous studies (Magee, 2013; Marin, 2013; Boyer and Marin, 2013) concentrate on the US as it is currently the second largest exporters in the world[5]. Hence, it is easy to understand that the US faces a large degree of foreign exchange volatility, possibly leading to an increasing need of hedging with derivatives. However, we focus on various European countries as our research setting since we believe that European countries deserve more attention in the field of corporate derivative research for several reasons.

First of all, many European countries experience higher FX exposure than the US. For example, when comparing the percentage of international trade over GDP, the UK economy is more open than the US, indicating that the FX risk exposure in the UK is higher than that in the US. In more detail, according to a report from the Organisation for Economic Co-operation and Development (OECD) in 2016, the UK's value of

[5] *Exports of goods and services (BOP, current US$)* (2023) *World Bank Open Data*. Available at: https://data.worldbank.org/indicator/BX.GSR.GNFS.CD?most_recent_value_desc=true

exports and imports as a percentage of GDP were 28.4 and 30.3, while the figures for the US were 13.5 for exports and 16.6 for imports[6]. In addition, the European Union (EU) is a major economic force, surpassing the United States as the world's largest economy and trading bloc. The EU maintains strong trade relationships with a significantly larger number of countries compared to the US, serving as the top trading partner for 80 nations[7]. According to data from World Bank[8], France is ranked 5th of the top exporters of the world in 2023 and 3rd place in Europe. Ranked 3rd place in the biggest exporters of the world and top of the list in the Euro area in 2023, Germany even surpassed the US in terms of exporting at the end of 2016. The Netherlands, Italy, and Spain are also among the biggest exporters in the EU. Additionally, in 2023, Norway is ranked as the sixth most substantial trading partner for the EU in terms of merchandise exchange [9]. It is also among the largest trading partners with the UK, Sweden, or Denmark. Hence, it is understandable that European firms have more incentive to use derivatives to hedge due to the high foreign exchange volatility they face, and this explains why the derivative market in Europe is bigger than other counterparts.

Secondly, the chosen European countries possess huge derivative market operations. The European derivative market was valued at €735 trillion in total notional amount outstanding at the end of 2018, with a climax at €900 trillion during the second quarter of the same year, according to a 2019 report from the European Securities and Market Authority (ESMA). In US dollar terms, this equated to a notional value of $530 trillion at the end of 2018. Notably, 90% of the outstanding notional amount came from OTC contracts, totalling $477 trillion. In comparison to the global notional amount outstanding of $544 trillion at the end of 2018[10], it is evident that the EU derivatives market represents a substantial portion of the global derivatives market. Furthermore, approximately four-fifths of the firms engaged in derivative trading operations in the

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[6] *OECD Factbook 2015-2016* (2016) *OECD iLibrary*. Available at: https://www.oecd-ilibrary.org/economics/oecd-factbook-2015-2016_factbook-2015-en.
[7] *EU position in World Trade (2024) European Commission. Available at: https://policy.trade.ec.europa.eu/eu-trade-relationships-country-and-region/eu-position-world-trade_en.*
[8] *Exports of goods and services (BOP, current US$)* (2023) *World Bank Open Data*. Available at: https://data.worldbank.org/indicator/BX.GSR.GNFS.CD?most_recent_value_desc=true
[9] *EU trade relations with Norway* (2023) *Trade*. Available at: https://policy.trade.ec.europa.eu/eu-trade-relationships-country-and-region/countries-and-regions/norway_en.
[10] *Statistical release: OTC derivatives statistics at end December 2018* (2019) *BIS*. Available at: https://www.bis.org/publ/otc_hy1905.pdf.

Euro zone are domiciled in five countries: Germany, Italy, France, Spain, and the Netherlands[11]. Also, as reported by Triennial Survey from BIS in 2019, the global OTC interest rates turnover was $7340 billion in 2019, of which 50% belongs to derivative activity in the UK[12]. This has made the UK the biggest OTC interest rate derivative centre in the globe.

BIS survey on foreign exchange trading turnover and OTC derivative transactions in 2022 has identified Germany and France as the leading players in foreign exchange trading and OTC interest rate derivative trading within the euro area[13]. This increase in trading and derivative activity in Germany and France can be primarily attributed to the relocation of certain business operations from the UK to these continental European countries following Brexit. Additionally, the reported notional amount of IR derivatives traded in the UK was 75.8% of the total European IR derivative traded notional, whereas the EU interest rate derivative traded notional was 24.2%[14]. Also, as reported by ESMA (2021)[15], regarding counterparty exposure for IR derivatives, France, Germany, and the Netherlands have the highest proportion of counterparty exposure for interest rate derivatives. Denmark, Spain, and Italy also have significant exposures to the UK, although they are smaller in size.

Thirdly, leveraged firms in many European countries could be more motivated to hedge thanks to the creditor friendliness of the bankruptcy law in those countries. As reported by La Porta et al. (1998), with a scale of 0 being the weakest creditor protection and 4 for the strongest one, the US is one of the most anti-creditor countries with a creditor right score of 1, while most of the countries in our sample, including Denmark, Germany or Italy, possess higher scores or stronger creditor protection. The UK has the highest score of 4. In addition, take the UK’s bankruptcy code as an

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[11] Benatti, N. and Napolitano, F. (2018) *An insight into the derivatives trading of firms in the Euro Area*, *BIS*. Available at: https://www.bis.org/ifc/publ/ifcb49_20.pdf.
[12] *OTC interest rate derivatives turnover in April 2019* (2019) *The Bank for International Settlements*. Available at: https://www.bis.org/statistics/rpfx19_ir.htm.
[13] Mcguire, P. (2022) *Triennial Central Bank Survey of Foreign Exchange and over-the-counter (OTC) derivatives markets in 2022*, *The Bank for International Settlements*. Available at: https://www.bis.org/statistics/rpfx22.htm.
[14] *Research note - Interest Rate Derivatives Trading Activity Reported in EU, UK and US Markets: January 2022* (2022) *ISDA*. Available at: https://www.isda.org/a/yQPgE/Interest-Rate-Derivatives-Trading-Activity-Reported-in-EU-UK-and-US-Markets-January-2022.pdf.
[15] *EU derivatives markets* (2021) *ESMA*. Available at: https://www.esma.europa.eu/sites/default/files/library/esma50-1652001_emir_asr_derivatives_2021.pdf

example, creditors are more legally protected under the UK bankruptcy code because they can benefit from the decision to liquidate firms in the event of financial distress. To be more precise, the UK bankruptcy code is stronger in terms of protecting creditors than that of the US. The US Bankruptcy Code, in Chapter 11, promotes keeping the business as a going concern. On the other hand, the main goal of the UK Bankruptcy Code is to encourage repayment of creditors' claims. This support of early liquidation of the UK Bankruptcy Code could motivate firms to hedge more since the expected costs of financial distress for UK firms are more intense than those of the US. Thus, one could argue that firms hedge more in countries with strong creditor protection and the effect of hedging on default risk is larger in those countries. However, other people could also argue that, due to the weak creditor rights in some countries, firms are required to commit to careful risk management scheme, such as hedging with derivatives, before receiving funding from lenders. Thus, firms in those countries may hedge more. An example is the case of France in our sample, in spite of having the lowest scores of creditor rights scaled by La Porta et al. (1998), the use of derivatives in France is still substantial. As a result, it is interesting to examine the effects of institutional factors such as creditor protection on derivative usage and its impact on default likelihood.

Fourthly, it can be contended that many countries in Europe are susceptible to elevated levels of interest rate risk. This susceptibility prompts companies to engage in a more substantial use of derivative instruments. Bank loans have conventionally served as the predominant source of financing for non-financial firms in both the EU and the UK. In Europe, banks have traditionally supplied approximately 80% of the capital required. Data from the International Monetary Fund (IMF) reveals that bank assets in the euro area are equivalent to 300% of the Gross Domestic Product (GDP), whereas in the United States, this figure stands at only 85% of GDP[16]. Given that bank funding is primarily associated with floating interest rates, it can be inferred that European firms are exposed to greater interest rate risk compared to their US counterparts. Consequently, they possess a stronger incentive to employ derivatives as a risk management tool. With all of the reasons being discussed, it follows then that

[16] Thomsen, P.M. (2019) *On capital market finance in Europe, IMF*. Available at: https://www.imf.org/en/News/Articles/2019/06/25/sp061419-on-capital-market-finance-in-europe (Accessed: 31 August 2024).

European countries are of high relevance as a research context to study corporate hedging activity.

2.4.2 Sample period

This study's 1999-2015 timeframe is carefully chosen to capture diverse economic and financial conditions, to balance data availability, and regulatory changes. The starting point of 1999 coincides with the implementation of the Financial Reporting Standard (FRS) 13 in the UK, which mandated derivative disclosure for British firms (Dunne et al., 2004). While other countries in the sample had varying levels of disclosure before 2005, this period allows for the inclusion of early voluntary disclosures (Grant and Marshall, 1997). The adoption of International Financial Reporting Standard 7 (IFRS 7) in 2005 across the European Union countries in the sample marked a crucial point, significantly improving the consistency and quality of derivative reporting and enhancing data availability for research (Tahat et al., 2016). Furthermore, significantly, this period encompasses both the 2000-2001 global recession and the 2007-2009 financial crisis. These events were characterized by heightened macroeconomic uncertainty and corporate financial distress, especially during the latter crisis. To illustrate, the European Commission (2011) reports that in 2009, corporate insolvencies in Western Europe increased by 22%, reaching a total of 185,111 cases. This marked the worst year for corporate insolvencies in over a decade for several countries, including Sweden (since 1996), the United Kingdom (since 1993), and Norway (since 1992). Additionally, it set an all-time high for insolvency rates in countries such as France, Spain, the Netherlands[17].

The decision to conclude the sample period in 2015 for this study is primarily driven by two significant economic factors: Brexit uncertainties and the proliferation of negative interest rates in Europe. The lead-up to the UK's EU membership referendum, which occurred in June 2016, began to create substantial economic uncertainty[18]. This period likely influenced firms' risk management and hedging strategies, particularly those with significant cross-border operations between the UK and EU.

[17] *A Second Chance for Entrepreneurs: Preventing Bankruptcy, Simplifying Bankruptcy Procedures, and Supporting a Fresh Start* (2011) *European Commission*. Available at: https://ec.europa.eu/docsroom/documents/10451/attachments/1/translations/en/renditions/pdf.

[18] *In focus - uncertainty and Brexit* (2019) *Bank of England*. Available at: https://www.bankofengland.co.uk/monetary-policy-report/2019/november-2019/in-focus-uncertainty-and-brexit.

Simultaneously, the landscape of interest rates in Europe is undergoing a fundamental shift. While the European Central Bank first introduced negative interest rates in June 2014, their impact became more pronounced and widespread in the following years. By 2015, several countries in the sample, including Denmark and Sweden, had implemented negative rates, with others considering similar policies. According to Ehlers and Eren (2016), the negative interest rates in the Eurozone have contributed to a decline in demand for IR derivatives. This phenomenon can be attributed to the additional costs imposed on investors due to the negative returns generated by cash deposits required for margin purposes. Hence, the negative interest rate environment in the Eurozone could significantly alter the dynamics of interest rate hedging, complicate derivative pricing, and potentially change firms' risk perceptions and default risk profiles. Altogether, including data beyond 2015 could introduce noise in the relationship between derivative use and default risk, potentially confounding the analysis with factors unrelated to the core focus of the study.

Therefore, the chosen sample period offers a valuable opportunity to test the relationship between corporate hedging and firm default risk. This timeframe is particularly compelling, as it arguably represents a period when the benefits of derivatives are most pronounced.

2.4.3 Methodology

In order to examine the impact of derivative usage on the likelihood of default, regression analysis is implemented. The model is illustrated as follows:

$$\begin{aligned} Default_{it} &= \beta_0 + \beta_1 Derivative\ User_{it} + \beta_2 Leverage_{it} + \beta_3 Liquidity_{it} \\ &+ \beta_4 Firm\ Size_{it} + \beta_5 Equity\ Volatility_{it} + \beta_6 Profitability_{it} + \beta_7 Excess\ Return_{it} + \\ &Industry\ Dummies + Year\ Dummies + Country\ Dummies + \varepsilon_{it} \end{aligned} \quad [1]$$

In which Default is the probability of default measured by EDF in one-year or five-year horizon as explained in previous sections. The Derivative User variable is the dummy for the use of derivatives.

The initial model specification adopts a pooled OLS approach. This approach combines data from all firms within the sample, without explicitly accounting for potential variations in characteristics across individual firms (firm-specific heterogeneities). Furthermore, reverse causality in the context of derivatives and default risk implies that there might be a causal relationship running from the dependent variable (default likelihood) to the independent variable (derivative usage), rather than the other way around. In simpler terms, it suggests that firms in financial distress might be more likely to adopt derivative strategies as a desperate attempt to improve their financial situation. This would create a spurious correlation between derivative usage and default risk, as the derivatives are a consequence of financial distress rather than a cause of it.

To mitigate concerns of reverse causality in our analysis, we employ lagged independent variables as a key methodological approach. This technique involves using the values of our explanatory variables from previous time periods rather than their contemporaneous values (Bellemare et al., 2017). The underlying rationale is that while current default risk might influence current derivative usage, it is less likely to affect a firm's past decisions regarding derivatives. This approach helps to disentangle the direction of the relationship between derivative usage and default risk. For instance, if we find that lagged derivative use is significantly associated with current default risk, it strengthens the argument that derivative usage influences default risk, rather than the other way around.

In this essay, we examine the relationship between derivatives usage and default risk. Thus, it is crucial to account for factors that might influence both the decision to use derivatives and the likelihood of default but are not directly observed in the data. These unobserved factors, often referred to as firm-specific effects, can bias the estimated relationship between derivatives and default risk if not properly addressed. For instance, consider two firms in the same industry with similar financial characteristics. One firm might have a strong risk management culture, leading to higher derivative usage and lower default risk. By employing fixed effects (FE) model and including a firm-fixed effect in the model, we can account for this unobserved difference between the firms and isolate the impact of derivatives usage on default risk beyond these firm-specific characteristics. When unobservable firm-specific effects remain constant over time, the FE estimation method becomes a powerful tool to address this issue (Dougherty, 2016).

We also use Beta regression, which is a statistical technique proposed for modelling rates, proportions, and other continuous variables that are naturally bounded between

0 and 1, introduced by Ferrari and Cribari-Neto (2004). These types of fractional response variables frequently arise in fields like economics, biology, medicine, and social sciences. Examples include rates of mortality, employment, or tax compliance. In our thesis, it is the probability of default, measured by EDF. Traditional regression methods such as OLS are not appropriate for bounded data between 0 and 1, as OLS can produce fitted values outside the unit interval and violates assumptions about the error distribution.

Moreover, there are a few crucial problems in the above equation. Firstly, endogeneity issue could arise due to simultaneous casualty between the use of derivative and default probability. Secondly, that firms, based on their own benefits, could self-select to use derivatives can cause self-selection bias. We employ various models for robustness check for our study. In particular, the Heckman treatment effect model and difference-in-difference technique tackle self-selection bias; propensity score matching (PSM) and coarsened exact matching (CEM) and instrumental variable (IV) techniques deal with the problem of endogeneity.

We also look at the effect of derivative usage on default risk in terms of firms with extremely unhealthy financial situations. The model is as follows:

$$Default_{it} = \beta_0 + \beta_1 Derivative\ User_{it} + \beta_2 Derivative\ User*Distressed\ Firm_{it} + \beta_3 Distressed\ Firm_{it} + \beta_4 Leverage_{it} + \beta_5 Liquidity_{it} + \beta_6 Firm\ Size_{it} + \beta_7 Equity\ Volatility_{it} + \beta_8 Profitability_{it} + \beta_9 Excess\ Return_{it} + Industry\ Dummies + Year\ Dummies + Country\ Dummies + \varepsilon_{it} \quad [2]$$

In which *Distressed Firm* is a binary variable, taking the value of 1 for any firm that has a Z-score belonging to the first 20^{th} percentile and also possesses a negative return on assets.

Additionally, we investigate the influence of creditor protection on the effect of derivatives on default likelihood with the following model:

$$Default_{it} = \beta_0 + \beta_1 Derivative\ User_{it} + \beta_2 Derivative\ User*High\ creditor_{it} + \beta_3 High\ creditor_{it} + \beta_4 Leverage_{it} + \beta_5 Liquidity_{it} + \beta_6 FirmSize_{it} + \beta_7 EquityVolatility_{it} + \beta_8 Profitability_{it} + \beta_9 Excess\ Return_{it} + Industry\ Dummies + Year\ Dummies + Country\ Dummies + \varepsilon_{it} \quad [3]$$

Where *High creditor* is a dummy variable with the value of 1 being the countries with the highest creditor rights index, and 0 otherwise.

We also look at how the economic risk of a country influences the relationship between hedging and default likelihood with the following model:

$$Default_{it} = \beta_0 + \beta_1 Derivatives_{it} + \beta_2 Derivatives*Economic\ Risk_{it} + \beta_3 Economic\ Risk_{it} + \beta_4 Leverage_{it} + \beta_5 Liquidity_{it} + \beta_6 Firm\ Size_{it} + \beta_7 Equity\ Volatility_{it} + \beta_8 Profitability_{it} + \beta_9 Excessreturn_{it} + Industry\ Dummies + Year\ Dummies + Country\ Dummies + \varepsilon_{it} \quad [4]$$

Where *Economic Risk* represents the economic risk rating from ICRG.

2.4.4 Variable description

The following section outlines the variables employed within this chapter's empirical analysis. The dependent variable, default risk, will be defined. Subsequently, the key explanatory variables central to the investigation will be presented. Finally, the control variables incorporated into the model to account for extraneous factors will be outlined.

Our paper studies the influence of hedging with derivatives on default likelihood by using data within the period of 1999 to 2015 for nine countries including the UK, France, Germany, Denmark, Italy, Norway, the Netherlands, Spain, and Sweden. Our sample is drawn from non-financial firms listed on each of these countries' stock exchanges. The number of firms represented in the dataset fluctuates annually, attributable to factors such as mergers, delistings, acquisitions, or the unavailability of financial data. Cumulatively, the dataset encompasses 15,778 firm-year observations across the sample period.

2.4.4.1 Dependent variable: EDF

We attempt to examine the connection between hedging with derivatives and the probability of default by using Moody's Expected Default Frequencies (EDF) as the default risk proxy. EDFs are based on Merton (1974) 's distance-to-default model, which is reliable over different credit cycles and robust to model misspecification (Crossen et al. 2011; Berndt et al. 2018). Using EDFs gives us precise default probabilities, unlike the distance-to-default model used by many other papers, which only provides a ranking of default risks (Moody's Analytics 2016). This choice enhances the robustness and precision of our analysis, especially since our data cover the 2007-2008 global financial crisis.

2.4.4.2 Main explanatory variable

- *Dummy variable*

Data pertaining to a firm's usage of financial derivative contracts is extracted from annual reports for firms in each country manually. Specifically, the financial review section is examined for relevant information such as the company's risk management policies, potentially including discussions on derivatives. Additionally, the 'Financial Notes' section, under the subheading 'Financial Risk,' may offer more details concerning the firm's use of derivatives as a risk management tool. This section can potentially disclose the types of derivatives employed (currency, interest rate, commodity), their maturity dates, and their notional values. By doing a keyword search, for example, “derivatives” or “hedging”, we could easily locate those sections in the annual reports. In instances where annual reports lack any mention of derivative usage, the corresponding firm is categorized as a non-derivative user. Based on the data collected, our dummy variable for all derivatives equals to 1 if the firm is a derivative user and 0 otherwise. The same principle is applied for other hedging variables, for example, if the company uses foreign exchange, interest rates or commodity price derivatives or any combination of those three. This data collection approach aligns with established methodologies employed in prior studies that have similarly relied on annual reports for extracting data on derivative usage (Magee, 2013; Marin 2013; Boyer and Marin, 2013).

- *Continuous variable*

We also employ continuous variable as the second measurement for derivative. We use the year-end notional amount of derivative instrument disclosed in the company’s financial reports divided by the total assets of the firm, following Allayannis and Ofek (2001). This will be employed in the instrumental variable model in robustness check section.

2.4.4.3 Control variables

Accurately assessing the influence of derivatives usage on a firm's risk profile necessitates the isolation of its effects from those of other contributing factors. To achieve this objective, we incorporate control variables into our multivariate analysis framework. This approach draws upon established research in the field such as Nguyen and Faff, 2010 and Magee, 2013. Those studies reveal that various firm-specific characteristics exhibit correlations with measures of financial risk. The inclusion of these control variables aims to mitigate the potential for confounding influences and enhance the robustness of our findings.

- *Leverage*

Scholars have navigated the relationship between firm risk and leverage with evidence through countless studies. According to the hedging theory posited by Smith and Stulz (1985), firms with higher leverage are deemed to have an elevated likelihood of default, consequently incurring greater anticipated financial distress costs.

A substantial body of research underscores the positive correlation between a firm's leverage and its overall risk profile. Pioneering work by Hentschel and Kothari (2001) establishes a direct link between leverage and increased stock return volatility. Notably, Bartram (2019) suggests that even absent hedging activities, firms utilizing derivatives inherently exhibit greater risk exposure due to their elevated leverage levels. This aligns with the findings of Campbell et al. (2008), who quantify a significant increase in the probability of firm failure with rising leverage.

The significance of leverage as a control variable is further emphasized by Nguyen and Faff (2010). Similarly, Bartram et al. (2011) highlight the established connection between leverage and both total and systematic risk. Marin (2013) delves deeper, illustrating how leverage intensifies a firm's vulnerability by increasing the likelihood of bankruptcy, amplifying asset volatility, elevating default probability, and simultaneously reducing the distance to default. These findings resonate with Magee (2013), who demonstrates a negative correlation between leverage and distance to default, suggesting that firms with higher leverage are positioned closer to the brink of financial distress. In our research, we employ the ratio of total debt to adjusted book value of assets to compute leverage.

- *Profitability*

Firms with healthy profits enjoy several advantages in this risk-fraught environment. Firstly, their robust earnings enable them to effortlessly service their debt obligations, significantly reducing the chance of bankruptcy. This financial strength also allows them to tap into internal resources for funding needs, avoiding the higher costs associated with external financing through banks or capital markets. By relying less on external debt, they further mitigate the risk of default. This protective power of profitability has been extensively documented by scholars like Guay (1999), Chava and Jarrow (2004), Campbell et al. (2008), and Bartram et al. (2009, 2011, 2012). Their research consistently demonstrates that firms with higher profitability exhibit remarkably lower risk profiles. Consequently, this research postulates that firms exhibiting higher levels of profitability are inclined to exhibit lower overall risk profiles in comparison to their less profitable counterparts. The ratio of earnings before interest, taxes, depreciation, and amortization (EBITDA) to total assets is employed as the metric to gauge profitability.

- *Volatility*

Extensive research has established a robust link between a firm's equity return volatility and its susceptibility to financial distress. Notably, Campbell et al. (2008) quantify a substantial increase in default risk associated with heightened volatility. This association is further corroborated by Magee (2013), whose findings reveal that higher volatility leads to lower distance to default. In simpler terms, firms experiencing significant fluctuations in stock returns are positioned closer to the brink of financial collapse. Consequently, companies with higher equity return volatility will exhibit a significantly greater likelihood of default, underscoring the financial risks inherent in unpredictable stock performance. To measure volatility, we employ the standard deviation of daily stock returns over a one-year fiscal period.

- *Firm size*

The relationship between firm size and overall risk exposure remains a topic of debate within financial research. The potential for larger corporations to diversify their product offerings and geographical reach suggests a mitigating effect on firm risk. This proposition finds support in certain studies. For instance, Hentschel and Kothari (2001) and Chava and Jarrow (2004) report a negative correlation between firm risk and firm size, implying that larger firms may exhibit lower risk profiles. However, some studies present contrasting findings. Guay (1999) observes that larger firm size increases total risk. Additionally, Bartram (2019) reports mixed results on the influence of firm size on risk. More recent research seeks to reconcile these inconsistencies. Marin (2013) and Magee (2013) present evidence aligning with a lower probability of default, reduced asset volatility, and a greater distance to default for larger firms.

In recognition of the ongoing debate, we incorporate firm size as a control variable in our analysis. The calculation of firm size is the natural logarithm of total assets, following Campello et al. (2011); Boyer and Marin (2013); Magee (2013); Hagelin and Pramborg (2014).

- *Liquidity*

Firms blessed with abundant liquidity enjoy several advantages that act as a shield against financial peril. Firstly, ample cash holdings facilitate the efficient management of short-term liabilities and debt repayments. This reduces reliance on external financing sources, potentially avoiding the high interest rates and volatility associated with external debt markets (Nance et al., 1993). Furthermore, research by Copeland and Joshi (1996) establishes a positive correlation between low liquidity and the likelihood of financial distress. This aligns with findings by Magee (2013) and Marin (2013) who demonstrate a positive link between liquidity and distance to default.

We employ the quick ratio as a proxy for liquidity. This ratio is calculated as the difference between total current assets and the sum of inventory and work in progress, divided by total current liabilities.

- *Excess return*

Prior research suggests a potential link between a firm's historical excess return and its susceptibility to financial distress. Studies by Shumway (2001) and Chava and Jarrow (2004) identify that a higher level of excess return decreases bankruptcy risk. Likewise, Campbell et al. (2008) demonstrate a statistically significant inverse correlation, with a one-standard-deviation increase in excess return translating to a 28% reduction in the probability of failure. However, Magee (2013) presents findings suggesting that higher excess return increases the distance to default or lower chance of default.

To investigate this relationship within our analysis, we employ a calculated measure of excess return. This metric is derived by subtracting the annual return of a country-specific stock index from a firm's annual equity return. Specifically, we utilize the following national indices: FTSE 100 (the UK), OMX Copenhagen All-share (Denmark), CAC All Share (France), DAX 40 (Germany), FTSE Italia All Share (Italy), AEX All-share (the Netherlands), IBEX 35 (Spain), OMX Stockholm All-share (Sweden) and Oslo Børs All-share (Norway).

- *Other variables*

Additional variables to serve the purpose of pre-derivative risk metrics and instruments for certain robustness-checking models are also used in the study. These supplementary variables will be expounded upon prior to their implementation in the corresponding chapters.

2.4.4.4 Country-level variable

In this study, we examine the potential impact of country-level factors on the relationship between hedging and default probability. The following national-level variables are explored:

- *Creditor rights index*

In Chapter 4, to better understand how country and institutional factors may impact the relationship between derivatives usage and default risk, we incorporate a creditor rights index into our analysis. When borrowers default on their obligations to repay interest and principal, it can be detrimental for lenders. Regulations pertaining to creditor rights serve as a protective buffer for lenders against potentially defaulting firms. In environments with robust creditor rights, lenders can readily exercise power over companies to ensure repayment, since they are well-shielded in cases of default. Consequently, firms in countries with strong creditor protection are argued to use derivatives for risk reduction to a greater degree relative to nations with weaker creditor safeguards (La Porta et al., 1998). We include the creditor rights index, originally proposed by La Porta et al. (1998) and updated by Djankov et al. (2007), in our estimations. This index gauges the relative power of creditors versus borrowers within a given country. The creditor rights index is calculated based on four components. First, whether there are restrictions on a debtor filing for reorganization, such as requiring creditor consent. Second, whether secured creditors can seize their collateral after a reorganization petition is approved, or if there is an 'automatic stay' imposed by the court. Third, whether secured creditors are given priority for payment from liquidating a bankrupt firm. Fourth, whether an administrator rather than management runs the business during reorganization. One point is added to the index for each power provided to secured lenders under a country's laws. The aggregate score varies from 0 for weak creditor rights to 4 for strong creditor rights. As a result, the creditor rights index ranges from a minimum of 0 indicating weak creditor rights to a maximum of 4 denoting robust protection. With a score of 0, France has the least creditor-friendly environment among our sample countries. Italy, Norway, the Netherlands, and Sweden receive a score of 2. Denmark, Spain, and Germany possess an index of 3. Finally, the UK has the highest score of 4, making it the country with the strongest creditor rights.

- *Economic risk index*

Chapter 4 delves deeper by exploring the potential effect of a nation's economic risk on the association between derivatives usage and default risk. Our hypothesis centers on the notion that firms operating in countries characterized by heightened economic or financial risk exhibit a higher propensity to engage in the utilization of derivative instruments for risk mitigation incentives. Conversely, in nations with a more robust economic environment, the impetus for such hedging activities is likely to diminish. Consequently, we anticipate a corresponding reduction in the influence of derivatives on default risk within these economies. To empirically test this hypothesis, we introduce an interaction term into our model. This term captures the multiplicative effect between the derivative usage variable and the economic risk rating assigned to each country in our sample.

The economic well-being of a country is measured using the economic risk rating obtained from the International Country Risk Guide (ICRG), a well-established measure employed in prior research such as Erb et al. (1996), Gelos and Wei (2005), Bartram et al. (2009). Established in 1980, the ICRG model offers a comprehensive system for quantifying and comparing financial, economic, and political risks across nations. It incorporates both statistical modelling and expert analysis to provide a nuanced assessment of potential risks to international business operations. In 1992, the ICRG and its associated team transitioned to The PRS Group, becoming a cornerstone resource for the international business community.

Specifically, the Economic Risk Rating, a core component of the ICRG system alongside financial and political risk ratings, aims to evaluate a country's current economic strengths and weaknesses. A country with pronounced economic strengths relative to weaknesses translates to a low economic risk rating, while a country exhibiting greater weaknesses receives a higher rating. The ICRG methodology assigns risk points to predefined economic components, each receiving a score ranging from zero to a maximum value determined by its weight within the overall assessment. Generally, a lower total risk score indicates a higher level of economic risk, and conversely, a higher score signifies a lower risk profile. To ensure international comparability, these components rely on established ratios calculated from a nation's economic and financial data.

Points awarded to each component are based on a pre-defined scale ranging from zero to a specific maximum. In general terms, a component receives a "very high risk" designation if it scores less than 50% of its maximum potential points. The overall economic risk rating ranges from "very high risk" (0.0% to 24.5%) to "very low risk" (40.0% or more), with intermediate categories including "high risk," "moderate risk," and "low risk." It is important to note that this is a general guideline, as a superior rating in one component can offset a weaker rating in another. Additionally, a poor economic risk rating can be mitigated by favourable political and/or financial risk ratings.

The ICRG economic risk assessment incorporates various pivotal economic indicators, encompassing the per capita GDP, the real growth rate of the GDP, the annualized rate of inflation, the budgetary balance expressed as a percentage of the GDP, and the current account balance delineated as a fraction of the GDP.

- *Economic Policy Uncertainty index (EPU)*

Economic policy uncertainty indices (EPU), developed by Baker et al. (2016), have been used by several recent studies in the finance and economics field (Sharif et al., 2020; Brodeur et al., 2021; Xue et al., 2022; Ren et al., 2023). In Chapter 4, we employ the indices along with the ICRG's economic risk index in an attempt to examine the influence of a country's economic risk on the effect of derivatives on the likelihood of default. The difference between the EPU and the ICRG index is that a higher EPU value indicates a higher level of economic uncertainty. The following section explains how EPU is computed.

The indices are quantified through the analysis of newspaper coverage. The methodology aims to capture uncertainties surrounding economic policy decisions, their implementation, timing, and potential ramifications, including those stemming from non-economic policy matters. This text-based approach provides a systematic way to measure policy-related economic uncertainty as reflected in public discourse. EPU has been calculated for several countries, including those within the sample of this thesis. However, we take a closer look at the methodology with the example from the US.

The researchers' modern monthly EPU index for the United States is constructed using digital archives of ten leading newspapers, including prominent publications such as the New York Times, the Wall Street Journal, and the Washington Post. Their method involves searching these archives for articles containing specific combinations of terms related to uncertainty, the economy, and policy. To meet the criteria, an article must contain terms from all three categories, ensuring a focused capture of policy-related economic uncertainty.

Recognizing the potential bias introduced by variations in overall article volume across newspapers and time, Baker et al. (2016) employ a normalization process. They first scale the raw article counts by the total number of articles in each newspaper for each month. This scaled measure is then standardized for each newspaper to have a unit standard deviation from 1985 to 2009. The researchers then average these standardized series across the ten newspapers for each month, creating a composite index. Finally, this composite series is normalized to have a mean value of 100 over the 1985-2009 period.

This process results in a consistent, long-term measure of economic policy uncertainty. The methodology is designed to be both replicable and adaptable, allowing for its application to other countries and specific policy areas. By focusing on newspaper coverage, the index captures both near-term concerns, such as anticipated Federal Reserve actions, and longer-term issues like entitlement program funding.

2.5 Descriptive statistic

The summary statistics of the variables, in terms of the whole sample, are displayed in Table 2-1. In the first two panels, we display the variables for risk measurement. Panel A displays the data for Altman’s Z-score as a measure of distance to distress before the use of derivative. Similar to Bartram et al. (2011), we categorize those variables as pre-derivative or pre-hedging since they estimate the financial exposure which does not comprise the impact of the firm's risk management activities, such as hedging with derivatives, or it can be said that they are unaffected by derivative use. Our Z-score has a mean of 3.113 and a median of 2.339. The summary statistics of the Moody's EDF – the proxy for default probability in our analysis, are presented in panel B of Table 2-1. Being a market-based variable, it is regarded as a post-hedging measure of default risk, which accounts for the influences of hedging with derivatives. The mean and median of our expected default frequency one-year period (EDF1YEAR) are 1.821 and 0.298 respectively. Our average five-year expected default frequency (EDF5YEAR) is 1.747 and its median is 0.663. As can be seen from Table 2-1, EDF5YEAR has a bigger median value than that of EDF1YEAR. In the breakdown of data by country, presented in Table 4-2, EDF1YEAR and EDF5YEAR have means and median varies from country to country. The lowest means recorded is for Spain and the UK (0.93 for EDF1YEAR in the UK and 1.01 for EDF5YEAR in Spain), while the highest belongs to Sweden (3.77 for EDF1YEAR and 3.33 for EDF5YEAR).

The statistics displayed on panel C of Table 2-1 are the proxies for the degree of derivative usage, computed as the notional values of derivative used scaled by total assets. Since not all of the firms disclosed the information, we could not acquire the data for every firm in the sample, which explains why the number of observations for the degree of derivative use is only approximately one-third of derivative dummy observations. Following Allayannis and Ofek (2001), we scale the notional amount of derivatives by total assets. The average notional value of all derivatives is about 33% of total assets. Our statistics are 65% higher compared with Lel (2012) which yields an average of 20% hedge ratio for currency derivatives from a global sample. This shows that it is of high interest and necessity to study the impact of derivatives on default risk for the European setting.

Table 2-1: Summary statistics

This table summarizes the standard statistics for the variables used in this paper. The variables included are as follows. ***Z-SCORE*** *is Altman's z-score.* ***EDF1YEAR*** *is the Moody's expected default frequencies over one year period.* ***EDF5YEAR*** *is Moody's expected default frequencies in five-year time range. DP1YEAR is one-year Bloomberg's Default Probabilities. DP5YEAR is five-year Bloomberg's Default Probabilities.* ***THE DEGREE OF DERIVATIVES*** *is the ratio of notional values of all derivatives used by a firm over total assets.* ***THE DEGREE OF FX DERIVATIVES*** *is the notional values of FX derivatives scaled by total assets.* ***DEGREE OF IR DERIVATIVES*** *is the ratio of notional values of IR derivatives over total assets.* ***LEVERAGE*** *is the ratio of total debts over market values of assets.* ***PROFITABILITY*** *is measured as the ratio of EBITA over total assets.* ***FIRM SIZE*** *is the natural logarithm of total assets.* ***VOLATILITY*** *is the standard deviation of stock return in a fiscal year.* ***LIQUIDITY*** *is the quick ratio(total assets minus inventory over total liabilities).* ***EXCESS RETURN*** *is annual equity return minus annual return of the stock index representing each country.*

Variable	N	Mean	Median	Min	Max	Standard deviation
Panel A: Pre-derivative use measure of exposure						
Z-SCORE	12806	3.113	2.399	-13.615	38.141	3.966
Panel B: Post-derivative use measure of risk						
EDF1YEAR	15778	1.821	0.298	0.010	32.939	4.175
EDF5YEAR	15778	1.747	0.663	0.010	23.976	2.968
Panel C: Degree of derivative usage						
DEGREE OF DERIVATIVES	3808	0.334	0.019	0.000	4.739	0.928
Panel D: Control variables						
LEVERAGE	13792	0.217	0.175	0.000	0.901	0.192
PROFITABILITY	14264	0.084	0.102	-1.722	0.446	0.167
FIRMSIZE	14403	6.377	6.210	-1.793	12.620	2.436
VOLATILLITY	13597	40.688	33.846	0.000	316.495	25.885
LIQUIDITY	14345	1.410	0.964	0.059	10.636	3.726
EXCESS RETURN	13820	-0.028	-0.002	-0.679	0.269	0.115

Table 2-2 provides a frequency analysis of the entire sample; further details sorted by countries are presented in Figure 2-1. In Panel A of Table 2-2, we examine the statistics for overall derivative usage, including interest rate (IR), currency (FX), and commodity price (CP) derivatives. Across all countries in our sample, approximately 73% of firms are derivative users, while the remaining 27% are non-derivative users. As seen in Panels B and C, which provide statistics for FX and IR derivatives, these are the dominant derivative instruments in our entire sample. Approximately 57% of firms use FX derivatives, while 56% use IR derivatives. The proportion of FX derivative users is notably higher than the 27% observed in the US sample by Campello et al. (2011). However, Figure 2-1 indicates that some countries like Italy, Denmark, and Spain have more non-FX derivative users than users. This could be due to firms from these countries having relatively lower level of foreign sales compared to other countries in the sample, making FX derivatives less necessary for managing exchange rate exposure[19].

Similar country-level distinctions arise regarding uptake of IR derivatives as displayed in Figure 2-1. While IR derivatives prevail across most sample countries, firms in Sweden, Norway, Spain and Denmark demonstrate lower usage rates. By examining firm-level interest coverage metrics, those with higher coverage and therefore less inherent interest rate exposure are concentrated in the aforementioned countries[20]. Thus, firms in those countries experience congruently decreased risk management incentives to employ IR derivatives.

Table 2-2: Frequency distribution of derivative use

Derivative categories	**Frequency**	**Percentage**
Panel A: Derivative users and non-users		
DERIVATIVE USERS	11,466	72.67
NON-USERS	4,312	27.33
Total	15,778	100
Panel B: FX derivative users and FX non-users		
FX USERS	9,018	57.16
NON-FX USERS	6,450	40.88
UNABLE TO DETERMINE	310	1.96
Total	15,778	100
Panel C: IR derivative users and IR non-users		
IR USERS	8,875	56.25
NON-IR USERS	6,593	41.42
UNABLE TO DETERMINE	310	1.96
Total	15,778	100
Panel D: CP derivative users and CP non-users		
CP USERS	1,558	9.87
NON-CP USERS	13,910	88.17
UNABLE TO DETERMINE	310	1.96
Total	15,778	100

[19] Appendix 2.2
[20] Appendix 2.3

The usage of CP derivatives is relatively low, around 10% in our entire sample, making them the least popular derivative instruments. This could be explained by the fact that mining is a prominent industry, for example in the US, but not as much in European countries. These findings align with the 2019 report from ESMA[21], stating that the top two derivative types used in Europe by notional amount are IR and FX derivatives.

An examination of the Pearson correlation coefficients presented in Table 2-3 illuminates the interrelationships among default probability, derivative usage, and various independent variables considered in the study. A statistically significant inverse relationship emerges between the utilization of derivatives and the likelihood of default. This suggests that firms exhibiting higher levels of derivative usage tend to experience lower probabilities of default. Furthermore, the study also reveals positive associations between default probability and two key factors: leverage and equity volatility. This indicates that firms characterized by higher debt ratios or subject to more pronounced fluctuations in equity valuations face an elevated risk of default. Conversely, several variables demonstrate negative correlations with default probability, consistent with theoretical expectations. Specifically, firm size, profitability, liquidity, and excess return all exhibit inverse relationships with default risk. These findings suggest that larger corporations, those with superior profitability, entities maintaining robust liquidity positions, and firms generating higher excess returns tend to be less susceptible to default risk

[21] *EU derivatives markets* (2019) *ESMA*. Available at: https://www.esma.europa.eu/sites/default/files/library/esma50_157_2025_asr_derivatives.pdf

Figure 2-1: Frequency distribution of derivative usage sorted by countries

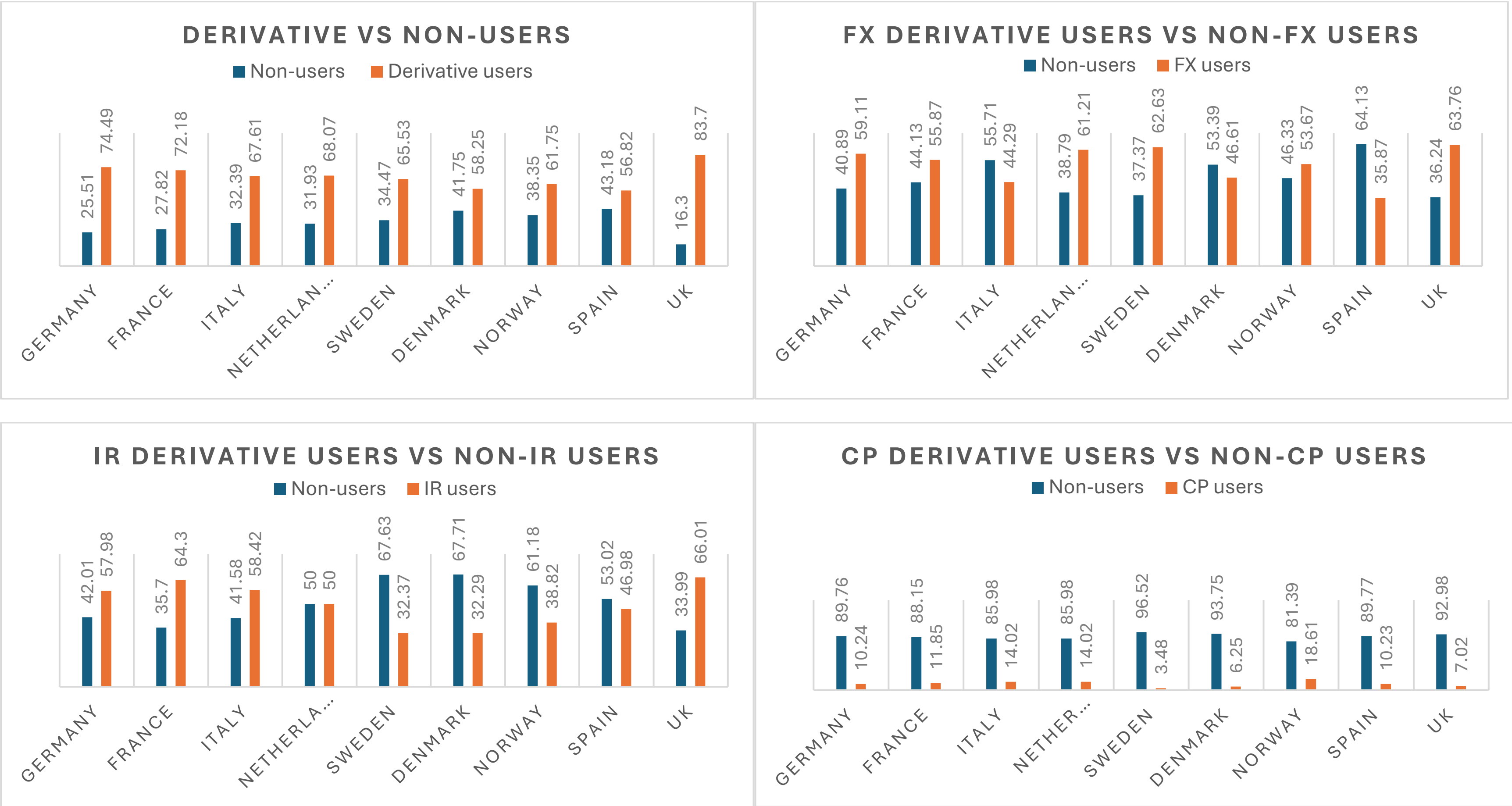

Table 2-3: Pearson Correlation coefficients

This table presents the correlation coefficients for the main variables used in this analysis. ***EDF1YEAR and ED5YEAR*** *are a proxy for the probability of financial distress sourced from Moody's.* ***DERIVATIVE USER*** *are dummy variables set equal to 1 if a firm using derivative and 0 otherwise.* ***IR USER*** *is a dummy variable set equal to 1 if a firms use interest rate derivative and 0 otherwise.* ***FX USER*** *is a dummy variable set equal to 1 if a firms using foreign currency derivatives and 0 otherwise.* ***CP USER*** *is a dummy variable set equal to 1 if a firm is using commodity price derivative and 0 otherwise.* ***LEVERAGE*** *is the ratio of total debt to the market value assets.* ***PROFITABILITY*** *is measured as EBITDA over total assets.* ***VOLATILITY*** *is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate.* ***FIRM SIZE*** *is the natural logarithm of the market value of assets.* ***LIQUIDITY*** *is the ratio of total current assets minus total stock and work in progress over total current liabilities.* ***EXCESS RETURN*** *is annual equity return minus annual return of the stock index representing each country.*

Variables	**DERIVATIVE USER**	**IR USER**	**FX USER**	**CP USER**	**EDF1YEAR**	**EDF5YEAR**	**LEVERAGE**	**PROFITABILITY**	**VOLATILITY**	**FIRM SIZE**	**LIQUIDITY**	**EXCESS RETURN**
DERIVATIVE USER	1.000											
IR USER	0.663***	1.000										
FX USER	0.649***	0.307***	1.000									
CP USER	0.179***	0.196***	0.171***	1.000								
EDF1YEAR	-0.130***	-0.113***	-0.102***	-0.063***	1.000							
EDF5YEAR	-0.145***	-0.131***	-0.121***	-0.076***	0.971***	1.000						
LEVERAGE	0.152***	0.006***	0.298***	0.081***	0.204***	0.202***	1.000					
PROFITABILITY	0.156***	0.103***	0.110***	0.037***	-0.258***	-0.276***	-0.074***	1.000				
VOLATILITY	-0.099***	-0.063***	-0.103***	-0.048***	0.477***	0.470***	0.079***	-0.330***	1.000			
FIRM SIZE	0.385***	0.363***	0.420***	0.325***	-0.258***	-0.306***	0.257***	0.247***	-0.306***	1.000		
LIQUIDITY	-0.168***	-0.119***	-0.151***	-0.048***	-0.007***	-0.004***	-0.208***	-0.078***	0.094***	-0.214***	1.000	
EXCESS RETURN	0.103***	0.081***	0.097**	0.018***	-0.097***	-0.102***	-0.095***	0.067***	-0.068***	0.089***	-0.018	1.000

2.6 Empirical result

2.6.1 Univariate test

Following Allaynnis and Ofek (2001) and Bartram (2019), we establish univariate tests for differences in mean and median to check whether there are deviations in the characteristics of hedgers and non-hedgers. We conduct the tests, particularly t-test for mean differences and the Wilxocon rank sum test for median differences, in two separate manners: (1) between firms with derivative contracts and firms without and (2) between firms that use only FX derivatives and the ones using only IR derivative instruments. We perform a pooled ordinary least squares (OLS) regression with EDF1YEAR and EDF5YEAR as the dependent variable and only one independent variable: DERIVATIVE USE in our univariate test.

Table 2-4 presents the comparison of means and medians of various firm characteristics along with default risk metrics. We show that derivative users are statistically more leveraged than non-users, which is consistent with findings from various papers such as Guay (1999), Lin et al. (2008), and Bartram et al. (2011). Firms that have a high level of leverage, demonstrating higher interest rate exposure, tend to utilize derivatives to hedge the exposure. Also, that firm turns to derivatives in an attempt to increase debt level could be an explanation for this. Additionally, we record that derivative-using firms are larger than non-users. Consistent with Hentschel and Kothari (2001), larger companies tend to use derivatives so that they can take advantage of the economies of scale of the derivative transaction costs. Moreover, based on mean and median difference tests, we document that derivative users are more profitable, less liquid, and less volatile compared to their non-user counterparts. These findings are statistically significant and considerably consistent with many previous studies such as Geczy et al. (1997), Nance et al. (1993), and Campello et al. (2011). More importantly, by mean and median differences tests, the default risk from derivative users is statistically and significantly smaller than the figures for non-users. In more detail, the median EDF in one-year and five-year terms for derivative-using firms are 0.25 and 0.60 respectively, while the corresponding numbers for non-users are 0.48 and 0.88.

Table 2-4: Mean and median difference test between derivative users and non-users

*The table presents the results of the mean differences and the Wilxocon Rank Sum test between derivative users and non-users on default risks and different firm characteristics. ***, **, * indicates the significance level of 10%, 5% and 1% respectively.*

Variable	Derivative users			Non-users			Difference test	
	N	Mean	Median	N	Mean	Median	Mean	Median
							T-test	Wilcoxon
		(1)	(2)		(3)	(4)	(1)-(3)	(2)-(4)
EDF1YEAR	11466	1.508	0.250	4312	2.653	0.480	-1.145***	-0.230***
EDF5YEAR	11466	1.491	0.600	4312	2.427	0.884	-0.936***	-0.284***
ZSCORE	9364	3.000	2.387	3442	3.388	2.435	-0.388***	-0.048
LEVERAGE	10150	0.235	0.197	3642	0.166	0.101	0.069***	0.097***
FIRMSIZE	10554	7.324	7.109	3849	5.367	4.978	1.956***	2.132***
LIQUIDITY	10518	1.206	0.875	3827	2.425	1.218	-1.219***	-0.344***
PROFITABILITY	10487	0.102	0.108	3777	0.044	0.081	0.059***	0.027***
VOLATILITY	10073	38.628	32.518	3524	46.032	38.087	-7.404***	-5.568***
EXCESS RETURN	10178	-0.025	-0.003	3642	-0.056	-0.009	0.031***	0.006***

We also include an accounting-based variable – Altman's Z-score – to measure default probability. When a firm has a lower Z-score, this means that the firm is having an unhealthy financial situation, hence, facing a higher chance of default. In accordance with our univariate tests, derivative users in our sample have lower average and median Z-scores compared to their counterparts. The results imply that firms with lower Z-score, in other words, higher default probability, tend to hedge with derivatives. Also, since non-users face a higher default risk (lower Z-score), this supports our idea that Z-score is indeed a pre-derivative measurement of the likelihood of bankruptcy. Our results are similar to some other studies such as Bartram et al. (2011). However, Campello et al. (2011) document the opposite of our findings when the Z-score for hedgers is higher, in other words, lower chance of bankruptcy than non-hedgers. Combining the results from the difference test for both Altman's Z-score, and Moody's EDF, it would seem that default risk for derivative users is higher than non-users when it is estimated by Z-score; and lower when it comes to EDF. This has further solidified our assertion that Z-score is more likely to measure the likelihood of default before the use of derivative and EDF is a post-derivative variable. Z-score does not take derivatives into the computation of default probability because, in line with the International Accounting Standard (IAS) 39, a firm's derivative transaction is off the balance sheet and, thus, not incorporated in the Z-score calculation.

As for the univariate regression, the results demonstrate that there exists a statistically significant relation between the use of derivative contracts and the probability of default. Hence, derivatives could be argued to be default risk-reducing for firms. Particularly, as shown in Table 2-5, both the coefficients for EDF1YEAR and EDF5YEAR are negative and significant at -0.84 and -0.73 respectively. This demonstrates that a firm using derivatives as hedging instrument would have 0.84 percent lower in short-term default probability and 0.73 percent lower in long-term one compared with non-users. Consequently, more rigorous tests are carried out in the following section.

Table 2-5: Univariate regression on derivatives and default probability

*This table presents the univariate results of the impact of derivatives use on the probability of default measured by **EDF1YEAR, EDF5YEAR**. **DERIVATIVE USER** is a dummy variable set equal to 1 if a firm uses derivatives and 0 otherwise. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%, 5%, or 10% levels, respectively. The regressions include industry, country and year dummies.*

Variables	**EDF1YEAR**	**EDF5YEAR**
DERIVATIVE USER	-0.840***	-0.733***
	(0.136)	(0.099)
Constant	1.883**	3.229***
	(0.791)	(0.932)
Observations	15,778	15,778
Industry fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Country fixed effects	Yes	Yes
R-squared	0.1391	0.157

2.6.2 Multivariate test

The preceding section outlines the findings of tests assessing disparities in means and medians between firms using derivatives and those not using them regarding diverse default metrics and company-specific attributes. Nonetheless, a limitation of univariate tests is their inability to consider the interrelations among different company characteristics. Consequently, they cannot reveal variations in these characteristics while maintaining the constancy of other company-level factors. Therefore, in this section, we employ different multivariate tests in accordance with our proposed model to gauge the full picture of the effect of hedging on the likelihood of default. In particular, we carry out the following regression methodologies: ordinary least square (OLS), one-year lag regressors (LAG), fixed effect (FE), and beta regression (BETA). Every regression specification is added with year, industry, and country fixed effect along with standard error clustering at firm level. The results are presented in Table 2-6, with panel A for one-year probability of default as the dependent variable, and panel B for five-year default risk. Our attention is upon the behaviour of the derivative user variable, which is binary base in this case.

2.6.2.1 Influence of derivatives on default risk

The findings presented in Table 2-6 indicate that firms using derivatives exhibit statistically significant lower default probabilities, consistent with our Hypothesis *H2-1*. This holds true even when we account for factors such as leverage and other company characteristics that are recognized to influence default probabilities. The estimate of the derivative use is negative and significant at 1% level, suggesting that, controlling for year, industry and country fixed effect, the use of derivative instruments is associated with a depletion in default probability. This aligns with the findings from the earlier univariate analysis, indicating that firms using derivatives exhibit lower EDF values than those that do not use derivatives. In more detail, the use of derivatives reduces the probability of default by 0.36 percent for the case of EDF1YEAR, which means an approximate 19.7% drop in default probability if we compare 0.36 with the mean EDF1YEAR of 1.821. This is consistent with the results from Boyer and Marin (2013) who show that the use of FX hedging instruments reduces firm's financial distress. While our findings contradict Magee (2013) who finds no connection between decision to use derivatives (derivative dummy) and default chance, they are in line with the notion that hedging mitigates financial distress. Magee (2013) still identifies a negative correlation between financial distress and FX derivatives when using the extent of derivative usage as an indicator of hedging.

In our model, there exists a possibility of reverse causality, hence, lagging all independent variables by one year helps solve this issue. The lagged version of those variables may arguably not have any correlation with the contemporaneous unnoticeable elements impacting the probability of default. As can be seen from column 2 of Table 2-6, the coefficient for the derivative variable is -0.248 for EDF1YEAR and statistically significant at 10% level, which corresponds to the results from OLS. Economically, the coefficient translates to a reduction in default probability of 13.6% (-0.248 divided by mean EDF1YEAR of 1.821). Overall, those results have strengthened our hypothesis that derivative use has a negative impact on the probability of default in both contemporaneous and lagged regressions.

We include the fixed effect (FE) model since the derivative use is unable to fully cover any unobservable determinant affecting the likelihood of default. In simpler terms, unobservable time-invariant factors with regard to derivative usage could affect the trustworthiness of the results. After controlling for firm fixed effect, the coefficient obtained for the derivative variable is -0.351 and significant at 10%, according to column 3 of Table 4-6. This is equivalent to a 19.2% decrease in the likelihood of default (-0.351 divided by mean EDF1YEAR of 1.821). In short, the results from the three specifications mentioned above (OLS, Lagged, and FE) suggest that the use of derivatives causes a drop from approximately 13.6% to 19.7% in one-year default probability.

We repeat the whole regression process with EDF5YEAR as the dependent variable. The outcomes for OLS, LAG, and FE are presented in columns 5, 6, and 7 of Table 2-6. It can be seen that, thanks to the statistically significant coefficient, hedging with derivatives negatively affects the long-term probability of default as it does on the short-term one. Particularly, the coefficients of derivative dummy in OLS, Lagged and FE models are -0.28, -0.21 and -0.34 respectively. The estimates for EDF5YEAR, especially from the OLS, indicate that the intensity of the impact of derivatives on longer-term default risk is statistically smaller than the ones recorded for the short-term default risk. This phenomenon of smaller effects of hedging on long-term probability of default could be explained by that firms prefer short-term instruments rather than long-term ones. According to an analysis from Sveriges Riksbank – the central bank of Sweden, more than half of derivatives on Swedish derivative market have shorter-term maturity (less than a year)[22]. It also indicates that this is consistent with the situation for the derivative market in the EU. Moreover, the foreign exchange derivative market has the shortest maturities, with over 90 percent having a maturity of less than a year. The reasons why Swedish firms prefer shorter maturities is because of (1) the flexibility in changing the size of these positions and (2) higher costs of undertaking longer maturity derivative contracts. The story is similar in the UK, according to a Bank of England's report in 2011, UK non-financial institutions regularly exercise short-term (less than twelve months) FX swaps and forwards in order to hedge currency exposure[23]. We document evidence that derivative instruments have bigger default risk-alleviating impact on short-term probability of default than longer-term default risk. As a result, they are considered as tools to control these short-

[22] Lavender, M., Rosenvinge, C.-J. and Fryxell, V.S. (2021) *The Swedish derivative market*, *riksbank.se*. Available at: https://www.riksbank.se/globalassets/media/rapporter/staff-memo/engelska/2021/the-swedish-derivative-market.pdf

[23] Bank of England. (2011) 'A review of the work of the London Foreign Exchange Joint Standing Committee in 2010.', Bank of England Quarterly Bulletin ,51 (2), pp. 158-162.

term financial risks. Overall, the results support our hypothesized negative relationship between derivative and probability of financial distress.

Given that the dependent variable represents a proportion, bounded from 0 to 1, there is a concern that the estimators might exhibit bias and inconsistency. To be more precise, data consisting of ratios, rates or probabilities intrinsically demonstrate uneven variance patterns: lower volatility proximal to maximal and minimal bounds, contrasting with heightened variability surrounding the mean. This mathematical compression of variability at the terminal interval limits results in non-normal distributions that violate core assumptions in regression modelling requiring constant variance. This heterogeneity requires correction to account for intrinsic heteroskedastic distortions innate to bounded unit interval metrics like percentages or probabilities. Therefore, beta regression, which assumes that the dependent variable follows "beta distribution", rather than normal distribution (Ferrari and Cribari-Neto, 2004), is employed as a method to address this concern. As reported in column 4 and 8 of Table 4-6, the results of beta regression imply that the use of derivatives lowers default risk, consistent with the findings from other models. In column 4 of Table 4-6, the coefficient of -0.094 for the derivative variable would be interpreted in terms of the odds ratio. To obtain the odds ratio, we take the exponential of the coefficient: $e^{-0.094} = 0.910$. An odds ratio of 0.910 means that firms that employ derivatives have 0.910 times (or approximately 9% lower) the odds of default compared to firms that abstain from derivative usage, holding all other variables constant. In other words, the use of derivatives is associated with lower odds (or lower probability) of default risk for firms in your sample. There is not much difference between the coefficients of short-term and long-term default probability: -0.094 and -0.091 for EDF1YEAR and EDF5YEAR.

Our findings align with previous research on various control variables and their influence on the likelihood of default. Leverage is positively related to short-term and long-term default risk, consistent with studies by Marin (2013) and Campell et al. (2008). Profitability is negatively correlated with default risk, in line with Magee (2013). Larger firms experience a lower chance of default, which is similar to the results of Bartram (2019). There is a significant positive relationship between equity volatility and default likelihood. Firms with higher liquidity exhibit lower default risk. Finally, a higher excess return leads to a lower probability of default. In summary, our test across different model specifications consistently indicates a decrease in the likelihood of default for companies that employ derivatives for risk management.

2.6.2.2 Combinations of different derivatives

Geczy et al. (1997) propose that it is more likely for hedgers to use different kinds of derivatives since companies that already use derivatives have more knowledge and experience and smaller transaction costs in undertaking derivative contracts. In fact, nearly 60% of companies in our sample employ at least two different types of derivatives combined. Moreover, the analysis of the impact of a single type of derivative on default probability could be invalidated by the presence of other derivative types used by the same firm. For instance, the effect of FX derivatives on default risk might be affected by firms that use FX derivatives in conjunction with IR or CP derivatives. To tackle this issue, we systematically identify all potential combinations of derivative users and introduce distinct dummy variables for each group of derivative users in our regression model.

Table 2-7 displays the regression results for our analysis of different types of derivatives and their combinations. We use three groups of derivative types: (1) using only one type of derivative including only FX derivative, only IR derivative and only CP derivative; (2) combining two types of derivatives involving FX and IR derivative, FX and CP derivative and IR and CP derivative; (3) combining all three types of derivatives. Our results for EDF1YEAR show that the effect of using only IR instrument on default risk is significantly larger compared with using only FX or only CP derivative (0.47 percent for IR compared with 0.24 for FX). No statistically significant influence from CP or FX instrument is recorded. However, when it comes to EDF5YEAR, FX derivative only has significant negative coefficient of -0.204, which is still lower than that of IR derivative only.

The next category is using two different types of derivatives. Shown in Table 2-7, the order of the effect on default risk is FXANDCP, FXANDIR and IRANDCP as the coefficients are -0.47, -0.61 and -0.72 respectively for EDF1YEAR (-0.31, -0.46, -0.49 in the case of EDF5YEAR). Although IRANDCP has the highest impact, we notice that since only a few firms use a combination of IR and CP instruments and CP derivatives do not have a significant influence on the default risk, the risk-reducing effect of IR and CP derivative on default likelihood could be solely caused by IR derivative. Thus, it can be seen that the common factor that makes these combinations generate the largest impact on default likelihood is IR derivatives. This could be explained by the fact that financial distress is the direct consequence of a company's incapability of paying the interest of its debt and returning the debt after its maturity, and IR derivatives can be used to manage this risk directly and hence reduce the likelihood of default.

The final category, which is using all three derivative instruments, has a negative and statistically significant coefficient for both default risk metrics. One noticeable thing is that the impact of combining various types of derivatives on default risk, compared with using one, is not significantly different, which differs from the evidence provided by Huang et al. (2017). In short, our results demonstrate that IR derivatives affect default probability to a greater extent than their counterparts such as FX or CP instruments. As a result, using IR derivatives or a hedging portfolio with the involvement of IR derivatives would yield the most impact on default probability.

Table 2-6: Multivariate regressions on derivatives and default probability (EDF)

*This table presents the results of the impact of derivatives use on the probability of default. In panel A the dependent variable is the probability of default for a one-year horizon (**EDF1YEAR**) and in panel B the dependent variable is the probability of default for a five-year horizon (**EDF5YEAR**). **DERIVATIVE USER** is a dummy variable set equal to 1 if a firm uses derivatives and 0 otherwise. **LEVERAGE** is the ratio of total debt to the market value assets. **PROFITABILITY** is measured as EBITDA over total assets. **VOLATILITY** is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate. **FIRM SIZE** is the natural logarithm of the market value of assets. **LIQUIDITY** is the ratio of total current assets minus total stock and work in progress over total current liabilities. **EXCESS RETURN** is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%, 5%, or 10% levels, respectively. The regressions include industry and year dummies.*

	PANEL A: EDF1YEAR				**PANEL B: EDF5YEAR**			
	OLS	Lag	FE	Beta	OLS	Lag	FE	Beta
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DERIVATIVE USER	-0.364***	-0.248*	-0.351*	-0.094***	-0.280***	-0.208**	-0.344***	-0.091***
	(0.126)	(0.146)	(0.187)	(0.020)	(0.087)	(0.097)	(0.132)	(0.019)
LEVERAGE	5.012***	5.157***	6.930***	1.813***	3.803***	3.929***	4.971***	1.639***
	(0.399)	(0.451)	(0.525)	(0.046)	(0.275)	(0.307)	(0.352)	(0.038)
PROFITABILITY	-0.733	-2.195***	-1.587***	-0.223***	-0.807**	-1.775***	-1.276***	-0.202***
	(0.523)	(0.642)	(0.472)	(0.044)	(0.358)	(0.421)	(0.320)	(0.037)
VOLATILITY	0.058***	0.048***	0.044***	0.009***	0.038***	0.033***	0.026***	0.008***
	(0.004)	(0.004)	(0.004)	(0.000)	(0.003)	(0.002)	(0.002)	(0.000)
FIRM SIZE	-0.205***	-0.171***	-1.160***	-0.093***	-0.202***	-0.171***	-0.871***	-0.110***
	(0.030)	(0.031)	(0.130)	(0.005)	(0.022)	(0.022)	(0.085)	(0.004)
EXCESS RETURN	-1.698***	-4.562***	-0.568	-0.508***	-1.190***	-3.236***	-0.430*	-0.455***
	(0.453)	(0.599)	(0.387)	(0.059)	(0.287)	(0.389)	(0.245)	(0.051)
LIQUIDITY	-0.058***	-0.078***	0.000	-0.029***	-0.048***	-0.059***	-0.007	-0.030***
	(0.028)	(0.021)	(0.022)	(0.005)	(0.020)	(0.015)	(0.016)	(0.004)
Constant	-0.382***	-0.173***	7.055***	-4.803***	0.523**	0.620**	6.158***	-4.370***
	(0.365)	(0.361)	(0.889)	(0.087)	(0.255)	(0.250)	(0.584)	(0.074)
Observations	11,917	10,488	11,917	11,917	11,917	10,488	11,917	11,917
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.368	0.354	0.248		0.395	0.393	0.274	
Log pseudolikelihood				44345				41286

Table 2-7: Impact of different combinations of derivative types on the probability of default

*This table presents the results of the impact of combinations of derivative types on the probability of default. The dependent variables are **EDF1YEAR, EDF5YEAR. FXONLY, IRONLY, CPONLY** are dummy variables set equal to 1 if a firm only uses FX, IR or CP derivatives and 0 otherwise. **FXANDIR, FXANDCP, IRANDCP** are dummy variables set equal to 1 if a firm uses FX and IR derivatives or FX and CP derivatives or IR and CP derivatives and 0 otherwise. **FXIRCP** is a dummy set equal to 1 if a firm uses all 3 derivatives and 0 otherwise **LEVERAGE** is the ratio of total debt to the market value assets. **PROFITABILITY** is measured as EBITDA over total assets. **VOLATILITY** is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate. **FIRM SIZE** is the natural logarithm of total assets. **LIQUIDITY** is the ratio of total current assets minus total stock and work in progress over total current liabilities. **EXCESS RETURN** is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%, 5%, or 10% levels, respectively. The regressions include industry and year dummies.*

Variables	EDF1YEAR	EDF5YEAR
FXONLY	-0.236	-0.204*
	(0.166)	(0.116)
IRONLY	-0.473***	-0.372***
	(0.161)	(0.109)
CPONLY	0.055	0.285
	(0.406)	(0.278)
FXANDIR	-0.616***	-0.463***
	(0.139)	(0.096)
FXANDCP	-0.470**	-0.311*
	(0.238)	(0.176)
IRANDCP	-0.721*	-0.494*
	(0.430)	(0.293)
FXIRCP	-0.667***	-0.452***
	(0.178)	(0.127)
(control variables included)		
Observations	11,917	11,917
Industry FE	Yes	Yes
Year FE	Yes	Yes
Country FE	Yes	Yes
R-squared	0.370	0.397

2.6.2.3 For extremely distressed firms

In this part, our aim is to test the impact of derivatives on default probability for extremely distressed firms. As we mentioned earlier in the paper that Z-score – an accounting-based risk proxy is a pre-hedging default measurement, we are, therefore, keen to investigate how derivatives impact default probability for firms with extremely high pre-hedging risk (low Z-score). In accordance with the theory of Purnanandam (2008), our hypothesis is that firms with extremely high pre-hedging risk will have a positive effect on default probability from derivative use. To create a sample of deeply distressed firms, we define distressed firms as those with a low Z-score (within the first 20^{th} percentile). To ensure that those firms are extremely financially distressed, we add negative returns on assets to the conditions of distressed firms. We attempt to test the hypothesis by running an OLS regression with an interaction term between the derivative variable and a new dummy, from the definition above, taking the value of 1 if the firm's Z-score is within the 20^{th} percentile and return on assets is negative and 0 otherwise. Hence, we expect a positive coefficient of the interaction term since it will offset the negative coefficient of the derivative variable when the extremely distressed firm dummy turns into 1. As shown in Table 2-8A, the interaction term has the expected sign with both EDF1YEAR and EDF5YEAR. For EDF1YEAR as the dependent variable, the coefficient of the interaction term is 1.852 and statistically significant. This indicates that when a firm is in deep financial distress, the use of derivatives increases default risk by 1.55 percent (1.852 – 0.298). With EDF5YEAR, the impact of derivative use on default probability turns into 1.14 percent. Moreover, in our dataset, roughly 53% of companies categorized as being in a state of deep financial distress employ derivatives, whereas this figure rises to about 70% for firms that are not facing significant distress. These results are consistent with the findings of Purnanandam (2008), indicating that companies in severe financial distress may scale back their investment in risk management, or even abandon their hedging programs entirely. This is primarily because hedging can be expensive, and for firms on the brink of bankruptcy, these costs may seem unjustifiable. Our findings also align with the notion that financially constrained firms tend to engage less or completely refrain from hedging (Rampini et al. 2014). This concept revolves around the connection between collateral constraints and the accessibility of funding for risk management. Essentially, when companies are required to possess adequate collateral to cover future obligations to both financiers and hedging counterparts, a trade-off emerges between financing and risk management. Financially distressed firms within our dataset exhibit significant levels of leverage, potentially leading to insufficient collateral to fulfil their derivative contract obligations. Consequently, they are compelled to discontinue their risk management initiatives.

We repeat the test with a split sample and achieve the same results, as displayed in Table 2-8B. In short, our empirical analysis provides evidence consistent with the notion that firms experiencing severe financial distress may be less likely to hedge.

Table 2-8A: Impact of derivatives use on the probability of default: Firms in financial distress.

*The table presents the results of effect of derivative use on the default probability for extremely distressed firms.The dependent variable is **EDF1YEAR** and **EDF5YEAR**. **DISTRESSED FIRM** is a dummy taking the value of 1 if the firm's Z-score is within the first 20% percentile and return on assets is negative and 0 otherwise. **DERIVATIVE USER*DISTRESSED FIRM** is the interaction term of the two variables. **DERIVATIVE USER** is a dummy variable set equal to 1 if a firm is a derivative user and 0 otherwise. **LEVERAGE** is the ratio of total debt to the market value assets. **PROFITABILITY** is measured as EBITDA over total assets. **VOLATILITY** is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate. **FIRM SIZE** is the natural logarithm of total assets. **LIQUIDITY** is theratio of total current assets minus total stock and work in progress over total current liabilities. **EXCESS RETURN** is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%,5%, or 10% levels, respectively. The regressions include industry and year dummies.*

VARIABLES	EDF1YEAR	EDF5YEAR
DERIVATIVE USER	-0.298***	-0.234***
	(0.106)	(0.076)
DISTRESSED FIRM	1.820***	1.309***
	(0.361)	(0.243)
DERIVATIVE USER * DISTRESSED FIRM	1.852***	1.371***
	(0.542)	(0.362)
LEVERAGE	3.836***	2.948***
	(0.366)	(0.250)
PROFITABILITY	0.235	-0.105
	(0.548)	(0.372)
VOLATILITY	0.051***	0.033***
	(0.004)	(0.003)
FIRM SIZE	-0.181***	-0.185***
	(0.029)	(0.020)
LIQUIDITY	-0.047**	-0.037**
	(0.023)	(0.016)
EXCESS RETURN	-1.669***	-1.168***
	(0.435)	(0.272)
Constant	-0.230	0.675***
	(0.355)	(0.251)
Observations	11,917	11,917
Industry FE	Yes	Yes
Year FE	Yes	Yes
Country FE	Yes	Yes
R-squared	0.404	0.434

Table 2-8B: Impact of derivatives use on the probability of default: Firms with deep financial distress (split sample approach)

*The table presents the results of effect of derivative use on the default probability based on whether a firm is a distressed or non-distressed one. We define distressed firms as those with Z-score falling within the first 20th percentile and negative return on assets. The dependent variable is **EDF1YEAR** and **EF5YEAR**. **DERIVATIVE USER** is a dummy variable set equal to 1 if a firm is a derivative user and 0 otherwise. **LEVERAGE** is the ratio of total debt to the market value assets. **PROFITABILITY** is measured as EBITDA over total assets. **VOLATILITY** is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate. **FIRM SIZE** is the natural logarithm of total assets. **LIQUIDITY** is the ratio of total current assets minus total stock and work in progress over total current liabilities. **EXCESS RETURN** is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%,5%, or 10% levels, respectively. The regressions include industry and year dummies.*

VARIABLES	**EDF1YEAR**		**EDF5YEAR**	
	Distressed firms	Non-distressed firms	Distressed firms	Non-distressed firms
DERIVATIVE USER	1.142**	-0.317***	1.058***	-0.253***
	(0.571)	(0.105)	(0.381)	(0.076)
LEVERAGE	7.270***	3.270***	4.808***	2.634***
	(1.506)	(0.295)	(0.989)	(0.211)
PROFITABILITY	0.830	-0.640	0.553	-0.753**
	(1.069)	(0.490)	(0.719)	(0.340)
VOLATILITY	0.069***	0.041***	0.041***	0.028***
	(0.008)	(0.004)	(0.005)	(0.003)
FIRM SIZE	-0.496***	-0.172***	-0.411***	-0.177***
	(0.160)	(0.023)	(0.106)	(0.017)
LIQUIDITY	-0.401***	-0.038*	-0.236**	-0.033***
	(0.146)	(0.022)	(0.100)	(0.016)
EXCESS RETURN	-3.768***	-0.875**	-2.300**	-0.656***
	(1.364)	(0.028)	(0.854)	(0.252)
Constant	0.904	0.020	2.251**	0.740***
	(2.091)	(0.304)	(1.279)	(0.222)
Observations	1,065	10,852	1,065	10,852
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
R-squared	0.405	0.298	0.396	0.335

2.6.2.4 Influence of creditor rights

Creditor rights are crucial in protecting lenders from potential defaults by borrowers. Strong creditor rights allow lenders to enforce repayment obligations more easily and in the event that these obligations are not met, the prospect of bankruptcy and ultimate liquidation becomes more likely. It follows then that firms in such countries have greater motivations to use derivatives for credit risk reduction compared to those in countries with weaker creditor protection.

As a result, we investigate whether variation in creditor rights has any influence on the effectiveness of derivatives in mitigating default risk. We employ creditor rights indexes, first developed by La Porta et al. (1998), and later refined and updated by Djankov et al. (2007), in our estimations. The index is created to gauge the strengths of creditors or lenders over borrowers in one country. It is calculated as the aggregate score from four different components: Restriction on reorganization, No automatic say, Secured creditor paid first and No management stay. If any form of creditor protection, related to each factor above, is found in the bankruptcy code of one country, the factor will have a score of one and zero otherwise. As a result, the creditor rights index has a minimum score of zero for poor lender protection and a maximum score of four for strong creditor rights. Following Bartram (2019), to test our hypothesis (*H2-3*), we introduce a variable called "HIGH CREDITOR" which is set to 1 for countries with strong creditor protection (a creditor rights index higher than the median) and 0 for others. We then combine this variable with derivative use (DERIVATIVE USER * HIGH CREDITOR) into the regression. We expect that in countries with strong creditor rights, the negative effect of derivatives on default probability would be more pronounced. This means that we predict a negative estimate of the interaction term between the derivative use and the creditor rights dummy. Table 4-9 presents the results for our specification. Both coefficients on the interaction terms are negative and the coefficient for the interaction term in the EDF5YEAR model is highly significant at less than 1 percent. The economic significance of the influence of high creditor rights on the effect of derivatives on default risk is noteworthy. In more detail, for firms in countries with strong creditor protection, the effect of derivatives on default risk is increased by approximately 27% more (-0.479 divided by the mean EDF5YEAR of 1.747), compared with firms in less creditor-friendly environments. This provides strong support for our prediction that the use of derivatives in countries with strong creditor protection has a more significant impact in reducing default risk compared to those with weaker creditor regulations. Interestingly, that creditor protection only impacts the effect of derivatives on long-term default risk aligns with the notion that creditor rights are associated with higher debt financing (Qi et al., 2016) and especially, has a long-term impact on the expansion of credit (Deakin et al., 2016).

The result is contrary to Bartram (2019), which shows a more substantial reduction in firm risk in countries with weaker creditor rights compared to those with strong protections. Bartram (2019) explains that in nations with weak creditor rights, lenders often demand firms to establish effective risk management programs as a prerequisite for loan approval, which could lead to an increase in derivative users. However, it is important to note that Bartram (2019) fails to provide evidence from his dataset demonstrating a significant increase in derivative usage by firms in countries with weak creditor rights as a condition for obtaining loans. On the contrary, our sample clearly illustrates a distinct pattern. We observe that firms tend to hedge more in countries with strong creditor protection. In fact, in our dataset, on average, over 70% of firms in countries with high creditor protection are derivative users, whereas this proportion is around 60% in countries with low creditor protection. Our findings also diverge from those of Lel (2012), who reports no correlation between creditor rights and corporate use of derivative instruments. In short, our sample and empirical results suggest that firms in an environment with strong creditor protections hedge more and reduce more default risk.

Table 2-9: Impact of creditor protection on the effect of derivatives on default probability

*The table presents the results of effect of derivative use on the default probability with the interference of creditor rights.The dependent variables are **EDF1YEAR, EDF5YEAR**. **DERIVATIVE USER** is a dummy variable set equal to 1 if a firm is a derivative user and 0 otherwise. **HIGH CREDITOR** is a dummy equal to 1 if creditor rights index is larger than median and 0 otherwise. **DERIVATIVE USER*HIGH CREDITOR** is the interaction term of the two variables mentioned above. **LEVERAGE** is the ratio of total debt to the market value assets. **PROFITABILITY** is measured as EBITDA over total assets. **VOLATILITY** is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate. **FIRM SIZE** is the natural logarithm of total assets. **LIQUIDITY** is the ratio of total current assets minus total stock and work in progress over total current liabilities. **EXCESS RETURN** is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%,5%, or 10% levels, respectively. The regressions include industry and year dummies.*

VARIABLES	EDF1YEAR	EDF5YEAR
DERIVATIVE USER	-0.265*	-0.094
	(0.147)	(0.099)
DERIVATIVE USER * HIGH CREDITOR	-0.009	-0.479***
	(0.199)	(0.155)
HIGH CREDITOR	-0.617***	0.123
	(0.201)	(0.157)
LEVERAGE	4.881***	3.664***
	(0.401)	(0.275)
PROFITABILITY	-0.903*	-0.963***
	(0.512)	(0.349)
FIRM SIZE	-0.229***	-0.228***
	(0.030)	(0.022)
EQUITY VOLATILITY	0.058***	0.039***
	(0.004)	(0.003)
LIQUIDITY	-0.061**	-0.046**
	(0.024)	(0.017)
EXCESS RETURN	-1.577***	-1.132***
	(0.474)	(0.300)
Constant	0.293	1.075***
	(0.273)	(0.196)
Observations	11,917	11,917
Industry FE	Yes	Yes
Year FE	Yes	Yes
R-squared	0.364	0.389

2.6.2.5 Impact of country economic risk

Differences at the country level, encompassing economic, financial, or political aspects, provide an opportunity to explore risk management theories concerning firms' utilization of derivatives. Bartram et al. (2009) present empirical findings suggesting that country-level factors, specifically economic and financial risk levels, can significantly influence a firm's propensity to engage in derivative hedging activities. In countries characterized by heightened economic or financial risk, firms tend to be more inclined to employ derivatives as risk mitigation tools due to their exposure to elevated levels of risk. Conversely, in nations with robust economic health, the imperative for hedging activities tends to diminish, and consequently, we posit that the impact of derivatives on default risk is correspondingly reduced. Recent empirical findings by Azad et al. (2012) provide evidence suggesting that firms exhibit a propensity to engage in more intensive utilization of derivative instruments when faced with an elevated degree of economic, financial, and political risks within their operating environment.

To empirically assess this hypothesis (*H2-4*), we introduce an interaction term linking the derivative usage variable with the economic risk rating for each country within our sample. We employ two proxies for the country's economic well-being. The first one is the economic risk index sourced from the International Country Risk Guide (ICRG) published by PRG Group, a metric widely adopted in previous research, such as Erb et al. (1996), Gelos and Wei (2005), Bartram et al. (2009). Given that higher scores on this index signify lower risk, it essentially operates as an inverse measure of country risk. Consequently, our expectation is a positive coefficient for this interaction term. The second proxy is the economic policy uncertainty index (EPU) developed by Baker et al. (2016). Since a higher value indicates higher uncertainty or risk, we expect a negative coefficient for the interaction term.

The outcomes of our analysis are shown in Table 4-10. The dependent variable is EDF5YEAR. In an unreported test with EDF1YEAR, we find no significant results. However, the interaction term involving derivative use and the economic risk index (both ICRG and EPU) attains significance solely in the context of EDF5YEAR (at the 1% and 10% significance level respectively). The sign of the coefficients of the interaction terms are as expected (positive for ICRG and negative for EPU). This finding implies that the impact of derivatives on default probability is attenuated in countries characterized by lower levels of economic risk, aligning with our initial hypotheses (*H2-4*). Our results show that in a less risky macroeconomic environment, the impact of hedging will be relatively subdued in contrast to its effect within a high-risk environment, as the need for risk mitigation is commensurately reduced due to the lower levels of risk exposure.

Furthermore, it is worth noting that this influence of a country's economic risk on derivative efficacy appears to be specific to long-term default probability (EDF5YEAR), with no analogous impact observed in the case of short-term default risk (EDF1YEAR). As a country's economic risk is long-term prospect, it is understandable that the economic risk of a country exerts an influence on the efficacy of derivative instruments in mitigating long-term default risk exposures. Furthermore, this empirical finding suggests that derivatives possess suitability for hedging short-term risk exposures, as their capacity to alleviate short-term expected default frequencies remains robust and undiminished by fluctuations in the prevailing economic risk conditions within a country. The results from this section align with the findings from the previous section on creditor protection (section 4.5.2.4) in the sense that country-level factors influence the effect of derivatives on default risk particularly on long-term prospect.

We extend our analysis by delving into specific categories of derivatives, replacing the primary derivative variable with binary indicators denoting firms' exclusive use of FX derivatives, IR derivatives, or CP derivatives. The results of this specific analysis are also presented in Table 2-10. Intriguingly, our findings suggest that only FX derivatives exhibit sensitivity to the economic risk profile at the country level. In contrast, we do not observe statistically significant results for IR and CP derivatives. This observation aligns with the established understanding that economic activities and fluctuations in exchange rates are intricately intertwined (Kandil and Mirzaie, 2002). Given that firms employ FX derivatives primarily to hedge against exchange rate exposures, it stands to reason that the stability of a country's economy would exert a more pronounced influence on FX derivatives in comparison to other derivative types.

Table 2-10: The influence of country economic risk on the effect of derivatives and default probability

*This table presents the results of the influence of country economic risk on the impact of derivatives use on the probability of default. The dependent variable is the probability of default for a five-year horizon (**EDF5YEAR**). **ECONOMIC RISK** is measured by either economic risk rating from ICRG or economic policy uncertainty index (EPU). Panel A is for ICRG and panel B is about EPU. **DERIVATIVE USER** is a dummy variable set equal to 1 if a firm uses derivatives and 0 otherwise. **LEVERAGE** is the ratio of total debt to the market value assets. **PROFITABILITY** is measured as EBITDA over total assets. **VOLATILITY** is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate. **FIRM SIZE** is the natural logarithm of the market value of assets. **LIQUIDITY** is the ratio of total current assets minus total stock and work in progress over total current liabilities. **EXCESS RETURN** is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%, 5%, or 10% levels, respectively. The regressions include industry and year dummies.*

	PANEL A: ICRG				**PANEL B: EPU**			
VARIABLES	All derivatives (1)	FX derivatives (2)	IR derivatives (3)	CP derivatives (4)	All derivatives (6)	FX derivatives (7)	IR derivatives (8)	CP derivatives (9)
DERIVATIVE	-1.502**	-1.320*	-0.724	-0.267	-0.006	0.314	-0.130	0.927
	(0.594)	(0.694)	(0.919)	(2.098)	(0.145)	(0.207)	(0.176)	(0.780)
DERIVATIVE * ECONOMIC RISK	0.032***	0.036**	0.011	0.017	-0.002*	-0.002*	-0.001	0.000
	(0.015)	(0.018)	(0.024)	(0.059)	(0.001)	(0.001)	(0.001)	(0.004)
ECONOMIC RISK	-0.010	-0.030	-0.038*	-0.055**	-0.003	-0.001	-0.001	0.001
	(0.017)	(0.021)	(0.023)	(0.024)	(0.002)	(0.002)	(0.002)	(0.003)
(control variables included)								
Observations	11,917	4,817	4,683	3,021	10,984	4,323	4,314	2,685
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R squared	0.387	0.389	0.390	0.397	0.373	0.368	0.378	0.385

2.6.2.6 Robustness tests

In this section, we ensure the robustness of our findings with various econometric models and tests. A significant concern is the potential endogeneity of the derivative usage variable, as it can create a loop of causality with default probability. For instance, derivative usage can affect default probability and vice versa. Selection bias is also a consideration due to our use of observational data, meaning we are observing firms that are already using derivatives, rather than randomly selecting companies, which might lead to biased estimates. To address these methodological challenges and mitigate potential concerns stemming from endogeneity and self-selection biases, we adopt a range of robust techniques employed in prior scholarly works by Bartram et al. (2011) and Boyer and Marin (2013). Specifically, we implement an array of methods encompassing treatment effect models, instrumental variable estimation strategies, propensity score matching, coarsened exact matching, and difference-in-difference analyses to enhance the reliability and validity of our empirical findings.

2.6.2.6.1 Heckman's treatment effect model

Our study adopts a treatment effects model to address the potential effect of self-selection bias. Self-selection bias arises when observations are not randomly assigned to treatment and control groups, but rather self-select into these groups based on unobserved characteristics (Wooldridge, 2009). In our context, this bias could occur if firms that choose to use derivatives (the "treatment") systematically differ from those that do not (the "control") in unobserved ways that are also correlated with the outcome variable (default probability). In simpler words, imagine firms that use derivatives are generally more experienced or have better management. These unobserved qualities could make them less likely to default, not just the fact that they use derivatives. As a result, if we only look at the use of derivatives, it could lead to wrong conclusion that derivatives alone reduce default risk, when it is actually these other hidden factors at play. Standard regression analysis might misinterpret these inherent differences as causal effects of derivative usage.

As a result, we apply the Heckman treatment effect model, following Bartram et al. (2011). The model encompasses a dual-equation framework. The initial equation, termed the selection equation, models the firm's choice to engage in derivative usage, accounting for an array of firm-specific determinants that exert a direct influence on this decision, complemented by the inclusion of instrumental variables. Consequently, the second equation, specifies a regression model for the firm's default probability, wherein the estimation is conditional on the results obtained from the preceding selection equation. A valid instrument must satisfy the criterion of being correlated with the regressors in the model while remaining orthogonal to the stochastic disturbance term. In other words, the instrumental variable should exert an indirect effect on the firm's probability of default, with this indirect influence manifesting through the channel of the firm's derivative usage decision.

In our study, we introduce a new set of instrumental variables. The first variable is based on the proportion of firms using derivatives in each industry within our sample, following Allayannis et al (2012). Our second instrumental variable is a binary indicator that specifies whether a company offers stock options to its managers. Smith and Stulz (1985) suggest that a manager's decision to employ derivatives for hedging can be significantly influenced by the expected utility of their wealth. In the context of stock options, this expected utility is a convex function of the firm's anticipated profits. Consequently, managers might opt to elevate the firm's risk by using fewer derivatives for hedging. Accordingly, Smith and Stulz (1985) propose a negative association between a firm's managerial stock options and the use of derivatives for hedging.

Table 2-11 presents the comprehensive findings from the treatment effect model. The first column displays the results of the selection equation, where derivative usage is the dependent variable. This equation incorporates various explanatory variables, including the previously mentioned instrumental variables. A key finding from the selection equation is that managerial stock options exhibit a negative effect on the firm’s decision to utilize derivatives. The industrial hedging level, however, does not demonstrate a statistically significant association. The second column showcases the results of the outcome equation. This equation examines the impact of derivatives on default probability. This step utilizes the estimated values of derivative usage obtained from the initial equation. A statistical test (Wald test) is then conducted to assess whether a correlation exists between the error terms in the two equations. The presence of such correlation implies that unobserved factors influencing a firm's derivative utilization are intrinsically linked to factors impacting default probability, independent of derivative usage itself. In other words, firms choosing to use derivatives might be different from firms that do not, even before the use of derivatives. For example, firms with high default risk are more likely to use derivatives, indicating selection bias. Table 2-11 reveals that we can reject the assumption of no correlation between the error terms, as evidenced by the chi-square statistics (χ^2 = 3.16 significant at the 10% level (EDF1YEAR) and 7.18 significant at the 1% level (EDF5YEAR)). These findings indicate the presence of self-selection bias within our model, justifying the application of the treatment effect model.

The results reveal statistically significant negative coefficients for the derivative use dummy variable in both short-term (EDF1YEAR) and long-term (EDF5YEAR) default risk models. This finding indicates that firms within our sample that actively engage in the utilization of derivative instruments demonstrate a diminished probability of encountering a default event. Quantitatively, the coefficient for the short-term model is -0.61 (significant at the 1% level), indicating that holding all other factors constant, derivative use reduces a firm's default likelihood by 0.61%. The long-term model presents a similar pattern, with a coefficient of -0.58% (significant at the 1% level). The remaining control variables in the models largely exhibit statistically significant coefficients with signs consistent with our expectations. In other words, firms with higher profitability, greater liquidity, stronger excess returns, and larger size tend to experience lower probabilities of default. Conversely, firms characterized by elevated levels of leverage and exhibiting greater equity volatility tend to manifest an amplified default likelihood.

Table 2-11: Regression results for Treatment effect model: MLE

The table presents the results of effect of derivative use on the default probability under Heckman Treatment effect model with maximum likelihood estimation. The dependent variable is ***EDF1YEAR*** *and* ***EDF5YEAR****. We report the results of the selection equation, where* ***DERIVATIVE USER,*** *which is a dummy variable set equal to 1 if a firm is a derivative user and 0 otherwise, is regressed on firm-level factors and instruments. In the adjacent column, we report results of the outcome regression where the dependent variable is regressed on the predicted values of Derivative User from the first stage regression and other firm-level factors. Instruments we employed are (1)* ***HEDGING LEVEL*** *as the percentage of firms using derivatives in each sector; (2)* ***DIRECTOR STOCK OPTION*** *is a dummy with value of 1 if a firm offers stock option for the managers and 0 otherwise. Firm-level factors include* ***LEVERAGE*** *is the ratio of total debt to the market value assets.* ***PROFITABILITY*** *is measured as EBITDA over total assets.* ***VOLATILITY*** *is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate.* ***FIRM SIZE*** *is the natural logarithm of total assets.* ***LIQUIDITY*** *is theratio of total current assets minus total stock and work in progress over total current liabilities.* ***EXCESS RETURN*** *is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%,5%, or 10% levels, respectively. The regressions include industry and year dummies.*

VARIABLES	EDF1YEAR		EDF5YEAR	
	DERIVATIVE USER	EDF1YEAR	DERIVATIVE USER	EDF5YEAR
DERIVATIVE USER		-0.611***		-0.582***
		(0.167)		(0.128)
HEDGING LEVEL	0.527		0.551	
	(0.421)		(0.422)	
DIRECTOR STOCK OPTION	-0.763***		-0.766***	
	(0.066)		(0.065)	
LEVERAGE	0.438**	5.052***	0.427**	3.850***
	(0.183)	(0.400)	(0.183)	(0.277)
PROFITABILITY	0.398	-0.733	0.392	-0.779**
	(0.253)	(0.520)	(0.253)	(0.357)
FIRM SIZE	0.295***	-0.191***	0.296***	-0.183***
	(0.020)	(0.030)	(0.020)	(0.022)
VOLATILITY	0.002*	0.057***	0.002*	0.037***
	(0.001)	(0.004)	(0.001)	(0.003)
LIQUIDITY	-0.036**	-0.065***	-0.036**	-0.052**
	(0.016)	(0.025)	(0.115)	(0.003)
EXCESS RETURN	0.672***	-1.606***	0.670***	-1.120***
	(0.147)	(0.456)	(0.148)	(0.290)
Constant	-1.344***	-0.097	-1.361***	0.785***
	(0.294)	(0.367)	(0.294)	(0.259)
Observations	11,850	11,850	11,850	11,850
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Lambda	0.151		0.187	
Wald test chi^2		3.16		7.18
Wald test p value		0.075		0.007

2.6.2.6.2 Propensity score matching

In the attempt to examine the causal relation between derivatives and default probability in this essay, various econometric concerns arise when analysing observational data. One significant issue pertains to the comparability of characteristics between treatment and control groups. At first, we rely on regression models, where default risk measures are regressed on derivatives usage and other control variables. However, a limitation of this approach lies in its potential to overlook imbalances in observed characteristics between firms that utilize derivatives (treated group) and those that abstain (control group). This lack of control for group comparability can lead to misleading results if the overlap in characteristics between the two groups is insufficient. Additionally, endogeneity presents another challenge in observational data analysis, which occurs when the predictor variable of interest (derivative use) is correlated with the error term in the model. This correlation can arise from various sources, including measurement error, simultaneity (where derivative use and default probability influence each other), or omitted variables (relevant factors not included in the model).

A key complexity in assessing the causal relationship between derivatives and default risk using observational data stems from the inherent limitations of such data. The core difficulty is constructing an unobserved counterfactual scenario for firms that utilize derivatives. For instance, what would their default risk be if they had not used derivatives? Observational studies inherently lack control over treatment assignment, potentially leading to substantial differences between treated and control groups on observed characteristics. These imbalances can introduce bias into estimates of the treatment effect (the impact of derivative usage on risk) if not appropriately addressed. While instrumental variable approaches are commonly used to address endogeneity, identifying valid instruments can be difficult.

Hence, following Bartram et al. (2011), we employ the propensity score matching (PSM) technique, developed by Rosenbaum and Rubin (1983). This approach aims to create a balanced comparison group by pairing firms that actively engage in derivative usage (the treated cohort) with their counterparts who abstain from such derivative utilization (the control cohort), with the matching criterion being founded upon the respective propensity scores of these firms. Propensity scores represent the predicted probability of a firm using derivatives, estimated through a probit model that incorporates variables known to influence derivative usage. Specifically, we utilize a nearest neighbour matching strategy without replacement. In this method, each treated firm (derivative user) is matched with a single control firm (non-user) that exhibits the closest propensity score. This matching process helps to mitigate selection bias by ensuring that the treated and control groups are comparable on relevant characteristics that might affect the outcome variable (default risk). Following the matching procedure, we conduct regression analysis on the newly formed subsample consisting solely of matched pairs. The probit model used to calculate propensity scores incorporates variables identified in existing literature as determinants of corporate derivative use. Finally, we employ the standardized bias (SB) technique to assess the balance achieved across strata of the covariates, verifying the effectiveness of the matching process.

A potential limitation of our study stems from the reliance on observational data to assess the causal effect of derivative usage on default risk. The majority of research on this topic utilizes regression analysis, where the probability of default (risk proxy) is regressed on a binary variable representing derivative use (derivative dummy) along with various control variables. Subsequently, researchers interpret the coefficient associated with the derivative dummy as a measure of the causal impact of derivatives. However, a key drawback of this regression approach lies in its potential disregard for the issue of overlap in the observed characteristics between the treatment and control groups. As highlighted by Oberst et al. (2020), establishing overlap between these groups is a fundamental requirement for drawing causal inferences. Consequently, studies employing solely simple regression on observational data might lead to misleading findings if the overlap between treatment groups (derivative users and non-users) remains uncontrolled.

Another issue in studying the influence of derivatives on default risk is insufficient information. For instance, we can observe whether a firm engages in derivative usage or refrains from it and the corresponding probability of default, but the real question is how to know the unobservable situation. In simpler terms, if a company is using derivatives, what would happen if it did not use derivatives? PSM could be a solution for this due to the ability to generate counterfactuals for treated groups by reconstructing the observational data, hence, reducing bias. Therefore, our study will not only use simple regression, but we will combine PSM and regression for a more powerful robustness check.

Table 2-12 displays the outcomes of our use of PSM with EDF1YEAR and EDF5YEAR. We run the regression for the matched sample created from one-to-one nearest neighbour matching, which is among the most common and widely used approaches. This type of PSM pairs one firm from the treated group with one firm from the control group which has the nearest propensity score. The outcome indicates that the derivative-using firms will decrease the default risk (EDF1YEAR) by 0.358 percent, significant at 5% level. Similarly, EDF5YEAR will be lower by 0.338 percent for derivative users, significant at 1% level.

Table 2-13 details the results of the balancing test conducted on the covariates employed to generate the propensity score. The table presents the means for each covariate before (ex-ante) and after (ex-post) the matching process for both the treated group (derivative users) and the control group (non-users). Furthermore, it presents the standardized bias (SB) statistics, which quantify the mean discrepancy between the treated and control groups, expressed as a percentage of the pooled standard deviation across both groups. Furthermore, the table shows the percentage decrease in bias achieved through matching, along with the results of t-tests and their corresponding p-values for each covariate. From the SB statistic, several covariates have significant bias (from 20 % and above) prior to matching. Rosenbaum and Rubin (1985) mention that if the absolute value of the difference across the categories among the treatment group is larger than 20, there is an imbalance among those categories. And when it is below 20, we can say that the balance is achieved. As can be seen from Table 4-13, after matching, the bias for the covariates drops from 62.9% up to 98.6%, making all bias statistics fall below 20. With this outcome, we can be certain that the balance on every component which is used to compute the propensity score has been reached. This implies that for firms exhibiting an equivalent propensity score, the likelihood of being categorized as either derivative users or non-users is equiprobable and evenly distributed.

Table 2-12: Regression results for propensity score matching methods and coarsened exact matching

*This table presents the results of the impact of derivatives use on the probability of default with propensity score matching and coarsened exact matching method. The dependent variables are **EDF1YEAR** and **EDF5YEAR**. **DERIVATIVE USER** is a dummy variable set equal to 1 if a firm uses derivatives and 0 otherwise. **LEVERAGE** is the ratio of total debt to the market value assets. **PROFITABILITY** is measured as EBITDA over total assets. **VOLATILITY** is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate. **FIRM SIZE** is the natural logarithm of the market value of assets. **LIQUIDITY** is the ratio of total current assets minus total stock and work in progress over total current liabilities. **EXCESS RETURN** is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%, 5%, or 10% levels, respectively. The regressions include industry and year dummies.*

	EDF1YEAR		**EDF5YEAR**	
	PSM	CEM	PSM	CEM
VARIABLES	(1)	(2)	(3)	(4)
DERIVATIVE USER	-0.358*	-0.414***	-0.338**	-0.373**
	(0.207)	(0.148)	(0.155)	(0.099)
LEVERAGE	5.223***	3.848***	3.838***	3.080***
	(1.049)	(0.553)	(0.769)	(0.379)
PROFITABILITY	-0.456	0.695	-1.274	-0.102
	(1.404)	(1.002)	(1.283)	(0.691)
VOLATILITY	0.070***	0.065***	0.049***	0.044***
	(0.009)	(0.007)	(0.007)	(0.004)
FIRM SIZE	-0.171**	-0.246***	-0.157**	-0.263***
	(0.087)	(0.040)	(0.066)	(0.031)
EXCESS RETURN	-0.369	-1.802**	-0.313	-1.147**
	(0.884)	(0.844)	(0.608)	(0.539)
LIQUIDITY	-0.519**	-0.19^{8**}	-0.406**	-0.133**
	(0.219)	(0.065)	(0.159)	(0.046)
Constant	-0.898	-1.169	-1.172	0.118
	(0.386)	(0.597)	(0.780)	(0.405)
Observations	3,086	4,620	3,086	4,620
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
R-squared	0.522	0.382	0.535	0.413

Table 2-13: Balancing test for covariates in propensity score matching

This table presents the balancing test results for the covariates that are used to calculate the propensity score before and after matching. ***Z-SCORE*** *is Altman's Z-score;* ***GROWTH*** *is measured by ratio of capex to NPPE,* ***INTEREST COVERAGE*** *is the ratio of earnings before interest and taxes to interest expenses on Debt;* ***LEVERAGE*** *is the ratio of total debt to market value of assets;* ***LIQUIDITY*** *is the ratio of total current assets minus total stock and work in progress over total current liabilities.* ***FIRM SIZE*** *is a natural logarithm of total assets;* ***FC DEBT*** *is a dummy variable set is equal to '1' if a firm uses Foreign Debt and '0' otherwise;* ***FOREIGN TRANSACTION*** *is a dummy taking value of 1 if the firm has operation involving foreign transaction and 0 otherwise.* ***TAX LOSS CARRYFORWARD*** *is a dummy set to 1 if firm has tax loss carry forward, 0 otherwise.*

Variable	Sample	Mean		Bias (%)	Reduction in bias (%)	t-test	p>t
		Treated	Control				
Z-SCORE	Unmatched	3.000	3.388	-8.9		-6.24	0.000
	Matched	2.717	2.706	0.3	97.1	0.19	0.848
GROWTH	Unmatched	-0.334	-0.504	26.5		15.06	0.000
	Matched	-0.303	-0.240	-9.9	62.9	-5.79	0.000
LEVERAGE	Unmatched	0.235	0.172	32.9		21.84	0.000
	Matched	0.237	0.247	-5.9	82.1	-2.15	0.031
FIRM SIZE	Unmatched	6.984	4.897	93.8		63.36	0.000
	Matched	7.187	7.256	-3.1	96.7	-1.58	0.114
LIQUIDITY	Unmatched	1.205	2.366	-25.6		-21.29	0.000
	Matched	0.942	0.891	1.1	95.6	3.49	0.000
INTEREST COVARGE	Unmatched	38.712	125.27	-27.0		-16.00	0.000
	Matched	28.091	36.918	-2.8	89.8	-2.57	0.010
TAX LOSS CARRYFORWARD	Unmatched	0.747	0.834	-21.5		23.48	0.000
	Matched	0.714	0.714	-0.1	98.6	0.26	0.799
FC DEBT	Unmatched	0.586	0.196	87.3		42.78	0.000
	Matched	0.636	0.571	14.5	83.4	4.99	0.000
FOREIGN TRANSACTION	Unmatched	0.828	0.647	42.0		23.48	0.000
	Matched	0.843	0.840	0.6	98.6	0.26	0.799

2.6.2.6.3 Coarsened exact matching

One disadvantage of the PSM approach is the requirement to keep checking for balance between treated and control groups. The balance must be checked after the algorithm is finished and rechecked until the researcher finds an optimal amount of balance. In order to overcome this, we present the use of the Coarsened Exact Matching (CEM) method in this section. CEM is a monotonic imbalance-reducing matching solution, in which the balance, instead of being figured out through a lengthy process of checking and respecifying, and re-estimating, is determined by the ex-ante researcher's decision.

CEM operates by first coaserning observed covariates into categorical bins. Subsequently, the matching process pairs treated observations (derivative hedgers) with control observations (non-hedgers) based on exact matches across these coarsened categories. This exact matching approach allows for the assessment of the causal effect of the treatment (derivative use) using the original, uncoarsened covariates after matching. CEM offers several potential advantages over PSM. First, CEM typically retains a larger number of observations in the matched sample compared to PSM. Second, research suggests that CEM can achieve a superior covariate balance between treatment and control groups relative to PSM (Wells et al., 2013). Third, CEM may lead to reduced variance and bias in treatment effect estimates compared to PSM, particularly for studies with limited sample sizes. Finally, unlike PSM which relies on propensity score approximations that can worsen covariate imbalance for large samples (King et al., 2011), CEM avoids this issue by directly matching the coarsened covariates themselves.

Similar to the propensity score matching method, derivative users and non-users are matched based on the following categories: Z-score, growth, leverage, size, liquidity, FC debt, foreign transaction, tax loss carryforward, and interest coverage.

- Balance statistic after CEM

This segment offers a thorough evaluation of covariate equilibrium between treatment and control cohorts, examining the state of balance both preceding and following the application of the CEM methodology. Our analysis focuses on the application of L1 statistics, encompassing both univariate L1 measures for individual covariates and the multivariate L1 statistic, as delineated by Iacus et al. (2011). These L1 metrics serve as invaluable tools for quantifying disparities in the empirical distributions of pre-treatment variables across the treated and control populations. Univariate L1 focuses on a single covariate at a time, while the multivariate L1 statistic encompasses all covariates simultaneously. L1 values range from 0 to 1, with 0 signifying perfect balance and 1 indicating complete imbalance. Larger L1 values correspond to greater imbalance, while smaller values reflect a higher degree of balance between the groups.

CEM solution results in fewer observations since it automatically deletes the unmatched observations and only keeps the observations that matched using exact matching. Table 2-14 displays the results of CEM balancing in our analysis. Before matching, the multivariate L1 is 0.99, indicating a nearly perfect imbalance. After matching, it becomes 0.71, which demonstrates a reduction in the imbalance of the covariates. Table 2-14 also breaks down L1 into univariate L1 for each category. The sample prior to matching is significantly unbalanced in all of the covariates with higher univariate L1 statistics. After the matching, the L1 figures drop considerably. For example, the L1 statistics for firm size is 0.495 prior to matching, and it changes to 0.066 after matching. Our findings indicate that the CEM technique effectively reduces imbalances between the treatment group (firms using derivatives) and the control group (firms not using derivatives) on pre-treatment covariates. In simpler terms, CEM successfully creates more comparable groups by ensuring they share similar characteristics before the introduction of the treatment (derivative use) in this study. This enhanced comparability strengthens the foundation for the subsequent phase of our analysis. Building upon the creation of comparable treatment and control groups through CEM, the subsequent section will delve into the causal effect of derivative usage on default risk. We will employ regression analysis to examine this relationship for both short-term (one-year) and long-term (five-year) default probabilities (EDF1YEAR and EDF5YEAR) within these matched samples.

Table 2-14: Balance of control covariates in coarsened exact matching

This table presents the balancing test results for the covariates before and after coarsened exact matching. ***Z-SCORE*** *is Altman's Z-score;* ***GROWTH*** *is measured by ratio of capex to NPPE,* ***INTEREST COVERAGE*** *is the ratio of earnings before interest and taxes to interest expenses on Debt;* ***LEVERAGE*** *is the ratio of total debt to market value of assets;* ***LIQUIDITY*** *is the ratio of total current assets minus total stock and work in progress over total current liabilities.* ***FIRM SIZE*** *is a natural logarithm of total assets;* ***FC DEBT*** *is a dummy variable set is equal to '1' if a firm uses Foreign Debt and '0' otherwise;* ***FOREIGN TRANSACTION*** *is a dummy taking value of 1 if the firm has operation involving foreign transaction and 0 otherwise.* ***TAX LOSS CARRYFORWARD*** *is a dummy set to 1 if a firm has tax loss carry forward and 0 otherwise.*

L1	Before CEM	After CEM
Z-SCORE	0.1788	0.0549
GROWTH	0.2406	0.0443
LEVERAGE	0.2554	0.0435
FIRM SIZE	0.4946	0.0663
LIQUIDITY	0.2920	0.0483
FC DEBT	0.4182	2.22e – 15
FOREIGN TRANSACTION	0.2379	1.3e – 15
TAX LOSS CARYFORWARD	0.0072	2.1e – 15
INTEREST COVERAGE	0.1638	0.0094
Multivariate L1	0.9969	0.7173

- *Influence of derivative use on default risk after CEM*

The following text will discuss the regression results after the matching from CEM is conducted. We successfully run regression based on the matched covariates. Table 2-12 displays the results of regressions after the use of CEM to compare the users of derivatives and non-users. As can be seen from Table 2-12, for both EDF1YEAR and EDF5YEAR, the derivative user dummy acquires a negative and statistically significant coefficient. In more detail, the use of derivatives decreases EDF1YEAR by 0.41 percent and 0.37 percent for EDF5YEAR respectively. These results are in line with those of PSM.

In general, the application of CEM effectively mitigates pre-existing imbalances in covariate distributions between firms that utilize derivatives (treatment group) and those that do not (control group). This enhanced balance strengthens the causal inferences drawn from our subsequent analysis. The findings from CEM add more evidence to show that there exists a negative influence of derivative usage on default risk.

2.6.2.6.4 Instrumental variable

To further reinforce the robustness of our findings, we employ the instrumental variable (IV) methodology, following Magee (2013). This section details our approach to addressing potential endogeneity issues using two established techniques: Two-Stage Least Squares (2SLS) and the Generalized Method of Moments (GMM). In these IV models, we utilize a continuous measure of derivative usage as the independent variable, replacing the original binary dummy variable. This continuous measure reflects the degree of derivative use, calculated by summing the notional value of all derivatives employed by the firm. The resulting sum is then scaled by the firm's total assets.

Similar as the treatment effect model, the industrial hedging level and managerial stock options are used as the instrumental variables. Table 2-15 also displays the results for the instrumental variable method. As can be seen in the table, the coefficient of the extent of derivative usage is statistically significantly negative, one more time showing that if the degree of derivative use rises by one standard deviation, the expected default frequency drops by 0.32 percent (EDF1YEAR) and 0.23 percent (EDF5YEAR). When normalizing the coefficients by the respective means of EDF1YEAR and EDF5YEAR, the analysis reveals substantial economic impacts, manifesting as reductions of 17.6% and 13.2% in short-term and long-term default probabilities, respectively. These findings demonstrate considerably greater economic significance compared to the analysis of US firms by Magee (2013), which documented a 0.4% reduction in one-year default probability corresponding to a one standard deviation increase in derivative usage.

Now, we discuss the validity of the instrumental variables above. There are two conditions to determine the validity of an instrument. The first condition is that the instrumental variable is uncorrelated with the error term. In order to test this condition, our study follow the Sargan-Hansen test of overidentifying restrictions, which has a joint null hypothesis that the instrumental variables are uncorrelated with the error term and are successfully excluded from the equation. The Hasen J statistics are a low 0.083 and possess a p-value of 0.77 for 2SLS and GMM respectively. Thus, the null hypothesis of the validity of the instruments could not be rejected. The second key requirement for valid instrumental variables pertains to their relevance. This condition stipulates that the IVs must exhibit a statistically significant correlation with the endogenous explanatory variable within the regression model. In our case, this translates to a requirement that the chosen IVs must be significantly correlated with derivative usage. However, this correlation should not directly influence the dependent variable (default likelihood). In other words, the IVs should only affect default risk indirectly through their impact on derivative usage. To verify this relevance condition, we employ under-identification tests using the Lagrange Multiplier (LM) statistic. The null hypothesis associated with this test states that the IVs are not correlated with the endogenous explanatory variable, rendering them irrelevant to the model specification. Rejecting the null hypothesis implies that the IVs are indeed relevant, satisfying the second condition for valid IV estimation.

The p-values for the LM statistics in both 2SLS and GMM are low at 0.033. As a result, the null hypothesis is rejected, suggesting that the excluded instruments are correlated with the endogenous regressors, and the equation is identified. In addition, the weak identification test is also used to examine the second condition. The Cragg-Donald Wald F statistic is over 10, indicating that our instruments are not weak. In conclusion, the findings align with the primary models, and our chosen instrumental variables demonstrate robust strength.

Table 2-15: Impact of derivatives use on the probability of default: Instrumental variable method

*The table presents the results of effect of derivative use on the default probability under Instrumental Variable approach. The dependent variable is **EDF1YEAR** and **EDF5YEAR**. We report the results of both 2SLS and GMM specifications in panel A and B. **DERIVATIVE USER** is a dummy variable set equal to 1 if a firm is a derivative user and 0 otherwise. Instruments we employed are (1) **HEDGING LEVEL** as the percentage of firms using derivatives in each sector; (2) **DIRECTOR STOCK OPTION** is a dummy with value of 1 if a firm offers stock option for the managers and 0 otherwise. Firm-level factors include **LEVERAGE** is the ratio of total debt to the market value assets. **PROFITABILITY** is measured as EBITDA over total assets. **VOLATILITY** is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate. **FIRM SIZE** is the natural logarithm of total assets. **LIQUIDITY** is the ratio of total current assets minus total stock and work in progress over total current liabilities. **EXCESS RETURN** is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%,5%, or 10% levels, respectively. The regressions include industry and year dummies.*

	PANEL A: 2SLS		**PANEL B: GMM**	
VARIABLES	**EDF1YEAR**	**EDF5YEAR**	**EDF1YEAR**	**EDF5YEAR**
DEGREE OF DERIVATIVE	-0.319*	-0.235*	-0.309*	-0.226*
	(0.191)	(0.138)	(0.188)	(0.136)
LEVERAGE	4.286***	3.394***	4.299***	3.411***
	(0.664)	(0.478)	(0.663)	(0.477)
PROFITABILITY	-0.677	-1.031*	-0.703	-1.048*
	(0.836)	(0.589)	(0.831)	(0.588)
EQUITY VOLATILITY	0.060***	0.040***	0.060***	0.040***
	(0.007)	(0.004)	(0.006)	(0.004)
FIRM SIZE	-0.144*	-0.174***	-0.145*	-0.173***
	(0.079)	(0.055)	(0.079)	(0.055)
LIQUIDITY	-0.027	-0.026	-0.026	-0.026
	(0.067)	(0.046)	(0.067)	(0.046)
EXCESS RETURN	-1.701**	-1.145***	-1.689**	-1.137***
	(0.680)	(0.423)	(0.679)	(0.423)
Constant	-0.749	0.945	-0.721	-0.995
	(0.907)	(0.765)	(0.902)	(0.764)
Observations	3,131	3,131	3,131	3,131
R squared	0.149	0.177	0.162	0.194
F test	8.59	10.92	8.66	11.05
LM statistics	6.832	6.833	6.832	6.832
LM statistics (p-value)	0.033	0.033	0.033	0.033
Cragg-Donald Wald F statistics	15.520	15.520	15.520	15.520
Hansen J statistic	0.082	0.221	0.082	0.221
Hansen J statistic (p-value)	0.774	0.638	0.774	0.638

2.6.2.6.5 Difference-in-difference

In this study, we also employ the difference-in-differences (DID) model to manage self-selection bias that a firm using derivatives may already have a low default probability. The DID model offers a quasi-experimental design that leverages longitudinal data from both treatment and control groups. This approach is particularly valuable for establishing a suitable counterfactual scenario for estimating causal effects. A counterfactual scenario essentially represents the outcome for the treatment group (derivative users) had they not received the "treatment" (not using derivatives). DID accomplishes this by comparing the changes in the outcome variable (default probability) over time between the treatment group and the control group.

The underlying logic of DID relies on the assumption that, in the absence of the treatment (derivative use), any pre-existing differences in the outcome variable between the treatment and control groups would remain constant over time. By analysing the changes in the outcome variable relative to the timing of treatment implementation (derivative use), DID helps to isolate the causal effect of the treatment from other confounding factors. This approach is commonly employed to evaluate the impact of interventions, policy changes, or program implementations by comparing changes in outcomes over time for groups that receive the treatment versus those that do not.

In this model, we match a sample of completely non-derivative users with a sample of firms that are new to derivatives, in other words, firms that at first do not use derivatives and change to use derivatives. The two samples are matched based on the propensity score obtained from the nearest neighbour propensity score matching without replacement method. We, then, compare the difference in EDF between the two groups (non-users and new users) over the difference in the time (three years before and three years after using derivatives), hence, difference-in-difference. Since different firms have different starting point of employing derivatives, it is difficult for us to test a long period before and after using derivatives. As a result, we choose a four-year period to make the most of our matched sample so that we could have the most observations.

The baseline model of DID model is explained as follows:

$$Default_{it} = \beta_0 + \beta_1 Use\_time_{it} + \beta_2 New\_users_{it} + \beta_3 Use\_time_{it} * New\_users_{it} + \beta_4 Leverage_{it} + \beta_5 Liquidity_{it} + \beta_6 Firm\ Size_{it} + \beta_7 Equity\ Volatility_{it} + \beta_8 Profitability_{it} + \beta_9 Excess\ Return_{it} + Industry\ Dummies + Year\ Dummies + Country\ Dummies + \varepsilon_{it} \quad [5]$$

Where USE_TIME is a time-dummy, denoting the time a firm start to use derivative (0 being time before using derivatives and 1 after using derivatives); whereas NEW_USERS is the dummy taking value of 0 for the control (non-user) group and 1 for treatment (new users) group. $\beta 0$ is the average EDF for USE_TIME = 0 and NEW_USERS = 0 (non-users before using derivatives), $\beta 1$ is the change in default risk between the two events for non-users, $\beta 2$ estimates the difference in EDF between the two groups of firms before using derivatives, and $\beta 3$ measures the difference in EDF between the two groups of firms after using derivatives – which is our primary interest.

The results of the DID model are fully displayed in Table 2-16. As we can see for EDF1YEAR, before the use of derivatives, the new users (treated firms) have a significantly higher default risk compared with that of the non-users (a significant 1.474 coefficient of New_users). However, after the commencement of derivative usage, the EDF1YEAR for the treated group considerately drops, as shown by a significant and negative coefficient of the interaction term of Use_time and New_users (-2.149). The negative coefficient of -2.149 on the interaction term implies that the change in default probability for the treatment group (firms that started using derivatives) is lower than the change for the control group after the introduction of derivatives. In other words, the negative coefficient indicates that, on average, the firms adopting derivatives experience a reduction in default risk compared to the non-user firms over the specified time periods before and after derivative usage. Specifically, the coefficient of -2.149 means that after starting to use derivatives, the treatment group of new derivative users experienced a decrease in their EDF (lower default risk) by 2.149 units more than the change experienced by the control group of non-users, all else being equal. Hence, the negative interaction term coefficient suggests that the introduction of derivatives had a beneficial impact in terms of reducing default risk for the firms that adopted derivative usage, relative to those firms that did not use derivatives over the same period. The story is similar for EDF5YEAR with a significant coefficient of -1.549 for the interaction term. We also obtain similar results using the time period of three and five years. Overall, it can be concluded that the result is consistent with the main findings.

Table 2-16: Difference-in-difference model

*The table presents the results of effect of derivative use on the default probability using difference-in-difference model.The dependent variables are **EDF1YEAR, EDF5YEAR**. **NEW USERS** is a dummy variable set equal to 1 if a firm is new to derivative use (firms change from not using derivatives to using derivatives) and 0 otherwise. **USE TIME** is a dummy equal to 1 at the time a firm starts to use derivative and 0 otherwise. **USE TIME*NEW USERS** is the interaction term of the two variables mentioned above. **LEVERAGE** is the ratio of total debt to the market value assets. **PROFITABILITY** is measured as EBITDA over total assets. **VOLATILITY** is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate. **FIRM SIZE** is the natural logarithm of total assets. **LIQUIDITY** is the ratio of total current assets minus total stock and work in progress over total current liabilities. **EXCESS RETURN** is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%,5%, or 10% levels, respectively. The regressions include industry and year dummies.*

	(1) **EDF1YEAR**	(2) **EDF5YEAR**
USE TIME	0.972*	0.612
	(0.566)	(0.409)
NEW USERS	1.474***	1.047***
	(0.684)	(0.499)
USE TIME*NEW USERS	-2.149***	-1.519***
	(0.688)	(0.510)
LEVERAGE	8.751***	6.122***
	(1.981)	(1.243)
PROFITABILITY	-2.395**	-1.643**
	(1.210)	(0.851)
EQUITY VOLATILITY	0.060***	0.042***
	(0.008)	(0.006)
FIRM SIZE	-0.428	-0.332*
	(0.277)	(0.194)
LIQUIDITY	-0.057**	-0.044**
	(0.026)	(0.188)
EXCESS RETURN	-0.582	-0.415
	(1.612)	(1.053)
Constant	-1.686	0.126
	(1.830)	(0.952)
Observation	770	770
Industry FE	Yes	Yes
Country FE	Yes	Yes
Year FE	Yes	Yes
R squared	0.60	0.63

2.7 Conclusion

In this chapter, we investigate the influence of derivative usage on default likelihood in a multiple-country context and subject to various circumstances, with a sample of non-financial firms from 1999 to 2015. This study employs a combination of univariate and multivariate analyses, utilizing a binary variable to capture a firm's decision to utilize derivatives. Our findings reveal a statistically significant negative association between derivative usage and default risk, evident in both short-term and long-term horizons. Particularly, derivative instruments could lower a firm’s probability of default by approximately 14% to 20%. Furthermore, the analysis suggests that derivatives exert a more pronounced effect on short-term default risk compared to long-term default probability, supporting the notion that derivatives function primarily as short-term hedging tools. In addition, our results indicate that IR derivatives possess a stronger influence on mitigating default risk compared to FX or CP derivatives. Besides, the effect on default probability of combing different types of derivatives is not statistically different from using only one derivative type. We also note that firms under significant financial distress tend to engage in hedging activities to a lesser extent. Firms in countries with strong creditor protection experience more pronounced default risk reduction from hedging with derivatives. Moreover, in less risky macroeconomic environments, the impact of derivatives on the probability of default, especially FX derivatives, is less pronounced. Interestingly, it appears that national-level factors, such as creditor rights or economic risk, influence the long-term effect of derivatives. Our results remain valid following a battery of robustness tests.

Appendix to Chapter 2 “The impact of derivative use on default probability among non-financial firms: Evidence from European firms”

This appendix contains additional information on the data used and some analysis. Appendix 2.1 provides some examples of corporate derivative usage information found in annual reports. Appendix 2.2 provides the comparison between the countries in the sample in terms of foreign exchange exposure. Appendix 2.3 provides the comparison between the countries in the sample in terms of interest rate exposure. Appendix 2.4 contains comprehensive explanations and origins for the variables employed in the current chapter's analysis.

Appendix 2.1: Examples of corporate derivative usage in annual reports

Siemens Annual Report 2014

Page 301:

“The Company had interest rate swap contracts to pay variable rates of interest of an average of 0.3 % and 0.3 % as of September 30, 2014 and 2013, respectively and received fixed rates of interest (average rate of 4.0 % and 3.5 %, as of September 30, 2014 and 2013, respectively). The notional amount of indebtedness hedged as of September 30, 2014 and 2013 was € 6,645 million and € 7,100 million, respectively.”

Manz Automation Annual report 2012:

Page 75:

“Manz AG’s currency risks result from the operational activities. Risks from foreign currencies are hedged insofar as they influence the company’s cash flow. In 2011 and 2012, Manz AG was exposed to foreign currency risks due to already fixed and planned transactions in foreign currency. These only affected transactions in US dollars in connection with the sale of products. Derivative financial instruments (primarily forward exchange transactions and, to a lesser extent, currency option and currency swap transactions) helped protect against the associated risks. The conditions for hedge accounting (cash flow hedge) existed for the planned transactions. The risk that delivery dates could change still exists, however, and this would result in losses or gains from extending the derivative financial instruments. On the reporting date, there were neither essential open foreign currency positions nor planned foreign currency transactions. The risk from interest rate fluctuations on variable loans was limited through interest rate swaps."

Adidas Annual Report 2012

Page 198:

"The Group uses derivative financial instruments, such as currency options, forward contracts as well as interest rate swaps and cross-currency interest rate swaps, to hedge its exposure to foreign exchange and interest rate risks. In accordance with its Treasury Policy, the Group does not enter into transactions with derivative financial instruments for trading purposes."

Page 228:

"The adidas Group arranges forward contracts, currency options and currency swaps to protect against foreign exchange risk. The notional amounts of all outstanding currency hedging instruments, which are mainly related to cash flow hedges, are summarised in the following table:

Notional amounts of all outstanding currency hedging instruments (€ in millions)

	December 31, 2012	December 31, 2011
Forward contract	3,943	4,051
Currency options	265	376
Total	**4,208**	**4,427**

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"The Group hedges against currency risks using forward exchange transactions. Interest risks exist only to a minor extent due to relatively insignificant interest-bearing liabilities."

Appendix 2.2: Table of foreign exchange exposure (measured by foreign sales over total sales) between sample countries

Country	Mean foreign sales/total sales
Denmark	0.248
France	0.400
Germany	0.374
Italy	0.268
Netherlands	0.352
Norway	0.427
Spain	0.319
Sweden	0.333
UK	0.450

Appendix 2.3: Table of interest rate exposure (measured by interest coverage) between sample countries

Country	Mean interest coverage
Denmark	16.214
France	15.108
Germany	13.771
Italy	13.271
Netherlands	14.229
Norway	15.233
Spain	11.358
Sweden	19.272
UK	14.872

Appendix 2.4: Definitions of variables and empirical predictions employed in Chapter 2

Variables	Definition	Source	Predicted sign
EDF	Expected default frequency	Moody's Analytics	
DERIVATIVE USER	Dummy variable set to 1 for firms using derivatives to hedge; 0 otherwise	Annual report	+/-
DEGREE OF DERIVATIVES	Notional amounts of derivatives over total assets	Annual report	+/-
Z-SCORE	Altman's Z-score = 1.2*(working capital / total assets) + 1.4*(retained earnings / total assets) + 3.3*(earnings before interest and tax / total assets) + 0.6*(market value of equity / total liabilities) + 1.0*(sales / total assets)	Datastream	+
LEVERAGE	Total debt/ (assets book value – equity book value + equity market value)	Datastream	+
FIRM SIZE	Natural logarithm of total assets	Datastream	-
EXESS RETURN	Annual equity return – annual return of stock index	Yahoo Finance	-
LIQUIDITY	(Total current assets – total stock and work in progress) / total current liabilities	Datastream	-
PROFITABILITY	EBITDA/ total assets	Datastream	-

EQUITY VOLATILITY	Standard deviation of daily stock return in one fiscal year	Datastream	+
HEDGING LEVEL	Percentage of firms that hedge in each sector	Annual report	
DIRECTOR STOCK OPTION	Dummy with value of 1 if a firm offers stock option for the managers and 0 otherwise	Datastream	
GROWTH	Ratio of CAPEX to NPPE	Datastream	
INTEREST COVERAGE	Ratio of EBIT to interest expenses on debt	Datastream	
FC DEBT	Dummy variable set to 1 if the firm use foreign debts and 0 otherwise	Annual report	
FOREIGN TRANSACTION	Dummy variable set to 1 if the firm has operation involving foreign transaction and 0 otherwise	Datastream	
HIGH CREDITOR	Dummy variable set to 1 if a country has a creditor rights index over median and 0 otherwise	Djankov et al. (2007)	
ICRG	Economic risk index from International Country Risk Guide	The PRS Group	
EPU	Economic policy uncertainty index	Baker et al. (2016)	

Chapter 3: The impact of foreign exchange hedging strategies and default probability

3.1 Introduction

Globalization allows firms to access new markets and opportunities, but it also creates new risks from fluctuations in foreign exchange rates, interest rates, and commodity prices. To reduce cash flow volatility and the risk of default due to exchange rate changes, firms can use financial hedging involving derivative contracts such as forwards, swaps, options, and/ or foreign currency debt. In the last twenty years, the number of firms decided to employ foreign exchange derivative contracts and/or take on debt denominated in foreign currencies, rather than their domestic currencies, has been increasing. As reported by the Bank of International Settlement (BIS), by 2021, the total market value of derivatives is over 600 trillion USD[24]. In addition, reported by Mefteh-Wali and Rigobeth (2019), foreign currency debt accounts for 2% of the amount of bonds issued by European non-financial firms in 2002 and had increased by a factor of eight to 16% by 2012, showing the increasing popularity in the use of foreign currency denominated debt. Graham and Harvey (2001) reveal that around a third of surveyed chief financial officers, specifically 31%, perceive foreign currency-denominated debt as an effective natural hedging mechanism against exchange rate volatility. Essentially, firms use foreign exchange (FX) derivatives and foreign currency (FC) debt to hedge against the exposure of foreign exchange risks associated with daily transactions (short-term exposure) or multinational operations (long-term exposure). Even though the original intention of the firms to execute those risk-managing methods is to reduce risk, the final effects on the probability of default still remain unsolved and require further research.

Various studies document the FX exposure-reducing effect of FX derivatives and FC debt (Hagelin and Pramborg, 2004; Nguyen and Faff, 2006; Jong et al., 2006, Bartram et al., 2010). FX derivatives are also found to be able to reduce default probability (Magee, 2013; Marin, 2013). However, previous studies appear to draw premature conclusion that FC debt is an effective hedging tool (Hagelin and Pramborg, 2004; Jong et al., 2006; Bartram et al., 2010). When it comes to the effect on the probability

[24] *OTC derivatives statistics at end-June 2021* (2021) *The Bank for International Settlements.* Available at: https://www.bis.org/publ/otc_hy2111.htm

of default, the story could be different. As the probability of default measures a firm's capability to satisfy its repayment obligations when taking loans, in other words, the chance that the book value of a firm's liabilities is larger compared to the market value of its assets, it can be inferred that the implementation of FC debt has two opposing effects on firm risk of default. The first one is a hedging effect, which happens when firms can reduce cash flow volatility and the likelihood of default due to FX exposure with FC debt. On the other hand, companies with FC debt have higher leverage than ones without FC debt (Allayannis et al., 2003; Clark and Judge, 2009), hence, possess a higher chance of default due to higher interest payments. We refer to this as the leverage effect. Consequently, the effect on default risk of FC debt is still ambiguous. Additionally, most of the firms in our sample choose to combine FX derivatives and FC debt. Hence, it is interesting to see whether combining both strategies is more effective in terms of default risk reduction. Thus, we conduct research on the influence of various currency hedging strategies derived from FX derivatives and FC debt on default probability for non-financial firms among EU countries, including France, Germany, Spain, Italy, Norway, and the UK from 1999 to 2015. To address the possibility that current default probability is influenced by its past values, we employ the System Generalized Method of Moments (SGMM) model, which provides a more comprehensive approach compared to the instrumental variable techniques used in most previous studies on hedging and default risk (Marin, 2013; Boyer and Marin, 2013; Magee, 2013).

Our empirical analysis yields several nuanced findings that significantly contribute to our understanding of corporate risk management. Firstly, the hypothesis is that in the case of FX derivatives, if the company is using derivatives for hedging purposes, the default probability is expected to fall. On the other hand, even though the use of FC debt could act as a natural hedge when firm matches its foreign assets with foreign liabilities, the overall impact on default risk is still questionable, in particular, whether the leverage effect outweighs the hedging effect or vice versa or they neutralize each other. We find that FC debt does not significantly reduce default risk and may even exacerbate it, whereas FX derivatives show the capacity to lower default probability. This suggests that combining both strategies may not offer optimal default risk mitigation, despite its common use among the firms in our sample. Our findings contrast with earlier studies (Hagelin and Pramborg, 2004; Nguyen and Faff, 2006;

Bartram et al., 2010), which suggest that FC debt is an effective hedging tool, even better than FX derivatives. Our results also diverge from Boyer and Marin (2013), who argue that currency risk management involving FX derivatives or FC debt can lower default probability. Their methodology combines FX derivatives and FC debt into a single variable for FX risk management, potentially masking the distinct effects of each strategy. In contrast, our study follows Hagelin and Pramborg (2004) by using separate variables for each hedging approach. We incorporate multiple variables representing different strategies derived from FX derivatives and FC debt, allowing us to assess their individual and combined effects on default probability.

Secondly, there has not been any research investigating the effect of different types of derivatives on firm's default risk. Hence, our next contribution is that we extend the literature by testing the impact of FX hedging on default risk with differentiation between various hedging instruments and strategies. Apart from examining FX derivatives and FC debts, we also look at linear and non-linear FX derivatives. Instruments, of which values are directly related to the price of the underlying assets, such as FX futures or forward contracts and currency swaps, are classified as linear derivatives. On the other hand, if the relationship between the values of the derivatives and the underlying assets is non-linear, then those instruments are non-linear products, such as options. Our paper compares the difference in the effect on default risk between linear and non-linear products instead of discussing the reasons behind the choice of either product. Various previous studies support the use of non-linear derivatives (Froot et al, 1993; Bartram, 2006; Adam, 2009), arguing that non-linear derivative instruments create opportunities for firms to align investment and financing plans better and more precisely, which eventually could increase firm value and reduce default risk. It follows then that non-linear derivative products, such as FX options, are potentially more effective than their linear counterparts because they not only can remove possible downside loss but also allow potential upside gain. Consequently, we expect the negative effect on the probability of default from non-linear derivatives to be greater than linear instruments. Contrary to the expectation, our findings show that linear derivatives are generally more effective in controlling default risk than non-linear ones. However, we also document the circumstances when non-linear derivatives work better than their linear counterparts. We find that non-linear derivatives are more effective in reducing default risk for firms with high growth, while firms with low growth benefit more from using linear derivatives. This is because high-growth firms often have larger investment programs, increasing the likelihood of a mismatch between cash inflows and outflows, leading to non-linear exposures. Hence, non-linear hedging strategies are more suitable for addressing these non-linear exposures (Adam, 2009).

Additionally, we compare the effect of long-term and short-term FX hedging strategies on the likelihood of default. According to Clark and Judge (2009), forwards, options, and futures are more effective in controlling cash flow/ transaction exposure arising from the influence of exchange rate volatility on a company's transactions in foreign-denominated currency due to their typical short-term durations. However, economic exposure, sometimes also known as operating exposure, usually occurs for multinational firms which possess numerous foreign subsidiaries and is long-term by nature. Using near-term derivatives to manage long-term risk not only could increase costs and complexity of monitoring FX risk, but also generate higher basis risk because of the duration mismatch. As a result, to ease the risk management process and mitigate basic risk by reducing duration deviation, long-term FC debt or long-term currency swaps are more appropriate. With that being discussed, we suspect that short-term instruments would be more effective in reducing short-term probability of default; and the impact of long-term hedging would be greater on long-term default risk. In particular, in our test, we focus mainly on FX forwards and FX swaps as the representative of short-term and long-term hedging. Our results document evidence that FX forwards can reduce the short-term likelihood of default better than FX swaps, whereas FX swaps impact more on long-run default risk.

Finally, our research highlights the connection between currency hedging strategies, particularly FC debt, and the efficiency of debt enforcement within a country, an area not previously explored. Bartram et al. (2009) test the hypothesis that firms hedge more in countries with efficient legal systems but found no evidence. Their study mainly focused on FX, IR, and CP derivatives and only included FC debt as a control variable. Following Gatopoulos and Louberge (2013), who show that country-specific factors could impact firms' hedging strategies regarding FC debt, we investigate how these factors influence the effect of FC debt on default probability. Unlike Bartram et al. (2009), which test general legal environments, we specifically examine the debt enforcement efficiency of a country. We are the first to show that in countries with more efficient debt enforcement, the effect of FC debt on default risk is more positive. In such environments, the consequences of default are more severe because lenders are more likely to take legal action to recover debts, potentially leading to bankruptcy. Thus, firms using FC debt in high debt enforcement environments face increased default risk due to the severe consequences of default. Furthermore, we also identify a scenario where FC debt can lower the probability of default. This occurs in firms that operate in countries with less efficient debt enforcement and have a high proportion of foreign sales. This aligns with the notion that firms with substantial foreign assets tend hedge by strategically matching their foreign assets with foreign currency denominated liabilities (Judge and Clark, 2004).

The structural organization of this chapter is as follows: Section 3.2 presents a comprehensive review and synthesis of the pertinent empirical literature. Section 3.3 details the hypotheses formulated to address the research question. Section 3.4 elucidates the data sources and compilation methods employed in the empirical investigation. Section 3.5 presents a descriptive statistical analysis of the data, providing insights into the central tendencies and distributional characteristics of the variables under scrutiny. Section 3.6 reports the empirical findings derived from the quantitative analyses, unveiling the relationships and patterns that emerge from the data. Finally, Section 3.7 synthesizes the key conclusions drawn from the study's results.

3.2 Literature review

3.2.1 FX derivatives and default risk

Only three papers tackle the effect of hedging and default risk, and all of them focus on FX derivatives. Magee (2013) analyzes the relationship between FX derivative usage and financial distress among 401 large US firms from 1996 to 2000. Magee uses "distance to default" as a measure of financial distress and two FX derivative measures: a continuous variable for the level of FX derivative use and a binary variable for hedging presence. The study finds that firms with higher levels of FX derivative usage have a reduced risk of financial distress, as a one standard deviation increase in derivative activity leads to a marked rise in the distance to default. However, Magee does not observe a statistically significant impact of the binary hedging decision on default probability, suggesting the extent of FX derivative use is more important than the mere decision to hedge.

Boyer and Marin (2013) similarly explore the connection between hedging and financial risk in a sample of 531 US manufacturing firms, utilizing various risk proxies, such as asset volatility and distance to default. Their findings indicate that firms hedging FX exposure have a lower risk of financial distress. However, the study groups FX derivatives with other hedging methods like foreign operations and FC debt into one broad FX risk management variable, without distinguishing between different hedging strategies.

In a similar approach that does not separate FX derivatives and FC debt, Marin (2013), based on a matched sample of US firms from 1998 to 2005 that have and have not declared bankruptcy, shows that companies using FX derivatives or FC debt have a significantly lower likelihood of bankruptcy compared to firms that do not hedge.

3.2.2 Foreign-denominated debt and firm risk

The review of the literature above demonstrates that the majority of research on FX hedging and its impact on default risk concentrates on the use of derivative instruments. No study has looked at the impact of hedging with FC debt on default probability. However, numerous empirical studies lend credence to the notion that foreign-denominated debt can serve as a natural hedging mechanism.

Besides using FX derivatives to manage FX risk, firms can also implement natural hedges via the use of FC debt. In accordance with the pecking order theory, non-financial firms prioritize debt over equity when it comes to external financing (Myers and Majluf, 1984). It is a common approach for large firms with overseas operations as they have a choice between issuing debt in domestic currency or foreign-denominated debt, while it is less common for small to medium firms with limited foreign operations. Aabo (2006), based on a questionnaire sent to Danish non-financial firms, indicates that FC debt is a crucial replacement to FX derivatives. Another advantage of FC debt is that it could be cheaper to borrow in FC than taking loans in domestic currency (Keloharju and Niskansen, 2001). The hedging feature of FC debt is already confirmed in papers by Smith and Stulz (1985) or Froot et al (1993). In more detail, their theoretical models suggest that the issuance of debt in the currency that the firm has revenue exposure could create a counterbalancing expense exposure, which could help reduce the total exposure of a currency.

Many papers test the impact of hedging with FC debt on firm risk. Allayannis and Ofek (2001) propose that firms can manage FX risk by issuing FC debt, where cash outflows can be matched with cash inflows from foreign sales. The paper suggests that FC debt can function as a tool for FX risk mitigation and potentially substitute for FX derivatives in hedging FX exposure. Evidence is presented that exporters tend to favour FC debt over derivative instruments. However, while suggesting this potential alternative, the study does not directly scrutinize the effects of FC debt on FX risk itself.

Following Allayannis and Ofek (2001) in an attempt to examine the determinants of FC debt, with a dataset encompassing 44 Finnish corporations that obtained private and public debt in the period of 1985 to 1991, Keloharju and Niskanen (2001) test FC debts' hedging and speculative roles. They uncover that firms exhibiting substantial foreign sales more frequently use FC debt, consistent with matching foreign liabilities to foreign assets for natural hedging. Additionally, evidence reveals Finnish companies opportunistically issue foreign loans when interest rates to fund in a specific currency dip below average relative to alternate choices, capitalizing on temporal mispricing. With 54.9% sample adoption, the analysis confirms dual hedging and speculation motivations for corporate FC debt issuances, indicating both a decrease and increase in firm risk.

Instead of a single-country context, Nandy (2010) explores the factors influencing the use of FC debt, particularly US Dollars (USD), by firms in the United Kingdom and Canada. The study reveals a strong positive correlation between a firm's foreign sales volume and its likelihood of borrowing in USD. This suggests that firms with a significant presence in US markets are more inclined to manage their FX risks by acquiring USD-denominated loans. This aligns with the concept of aligning foreign assets and liabilities, aiming to mitigate the impact of exchange rate fluctuations on financial stability. The research quantifies this relationship, demonstrating that a modest increase in the ratio of a firm's US sales translates into a substantial increase in the chance of obtaining USD-denominated debts. This significant impact highlights the powerful influence of foreign operations on corporate financial decision-making, particularly regarding risk management strategies. Furthermore, Nandy (2010) contends that issuing FC debt presents a cost-effective and less intricate alternative to complex derivative instruments for hedging purposes. By strategically matching foreign income with foreign liabilities, firms can potentially mitigate FX risk without resorting to potentially cumbersome hedging strategies involving derivatives.

Apart from the determinants of FC debt, various studies have started to investigate the effect of FC debt on firm risk. The paper by Hagelin and Pramborg (2004) examines the effectiveness of FX hedging practices in mitigating risk, utilizing a sample of Swedish firms from 1997 to 2001. This study investigates the effectiveness of FX derivatives and FC debt in mitigating FX exposure, using separate dummies for firms using only FX derivatives, or only FC debt, or both. The findings reveal a significant reduction in FX exposure for firms that employ both FX derivatives and FC debt in conjunction. Interestingly, the study also identifies a noteworthy decrease in FX exposure for companies that utilize FX derivatives or FC debt independently. This suggests that both instruments offer distinct risk-reduction benefits in managing FX risk, even when employed in isolation. In other words, firms can achieve a lower level of FX exposure by incorporating either FX derivatives or FC debt into their financial strategy, and a potentially greater reduction in exposure by utilizing both instruments simultaneously.

In a similar attempt with Hagelin and Pramborg (2004) but using separate dummies for FX derivatives and FC debt, Chiang and Lin (2005), with a sample of firms in Taiwan, examine the effectiveness of FX derivatives and FC debt for managing FX exposure. Employing a cross-sectional research design, they analyse the influence of both instruments on a firm's vulnerability to exchange rate fluctuations. Interestingly, the study reveals contrasting impacts of FC debts and FX derivatives on exposure to foreign exchange rates. Specifically, the research identifies a negative association between FX derivatives usage and FX exposure, implying a risk-mitigating effect of these instruments. Conversely, FC debt usage exhibits a positive association with FX exposure. This suggests that FC debt does not function as an effective natural hedging mechanism for Taiwanese firms. The study also find that FC debt and FX derivatives are used as complements.

Instead of using dummies like Hagelin and Pramborg (2004) or Chiang and Lin (2005), Nguyen and Faff (2006) look into the effectiveness as a natural hedging tool of FC debt for Australian firms, analysing its impact on FX exposure with the employment of continuous variables for FC debt. While the research identifies a strong link between the extent of a firm's international operations and its FC debt usage, the overall impact on FX exposure remains inconclusive. The study reveals a clear association between a firm's international presence and its likelihood of issuing FC debt, suggesting a preference for FC debt among firms with wider global reach. However, when examining the overall influence of FC debt upon FX exposure, the study does not record definitive proof of a direct depletion in FX exposure. The authors continue the analysis by looking into specific industry sectors. For firms in the industrial sector, the research identifies a positive correlation between the use of FC debt and reduced FX exposure. This finding aligns with the notion that FC debt serves as a hedging mechanism for these companies, potentially mitigating the impact of exchange rate fluctuations. Conversely, no such risk-reducing effect is observed for firms in the resource sector, which could be explained by that the main motivation for resource sector firms to issue FC debt may lie in securing more favourable borrowing rates, rather than managing FX risks.

Arguing that most of the studies so far focus on the US – one of the least open economies in the world at that time and employing a firm-specific FX exposure calculated from a questionnaire, Jong et al. (2006) investigate FX risk management practices among Dutch firms. Utilizing data from 1994 to 1998, the study reveals that over half of the sampled firms exhibit significant FX exposure. Interestingly, the research does not uncover any statistically significant impacts of derivative-based hedging activities on FX exposure. However, a notable reduction in exposure is observed when firms employ “natural hedges”. These natural hedges include using FC debt or engaging in production activities within foreign countries.

Stepping out of a single-country setting like most papers, Bartram et al. (2010), studying manufacturing firms in 16 countries, provide empirical evidence that corporations utilize a combination of strategies to mitigate FX exposure. Specifically, they observe that firms partially transmit currency fluctuations to their customers while simultaneously employing both operational and financial hedging mechanisms. For a representative firm in their sample (auto manufacturers), the researchers quantify the effectiveness of these strategies. They find that both pass-through pricing strategies and operational hedging techniques independently contribute to a reduction in currency exposure by approximately 10-15%. However, financial hedging emerges as the most potent tool for exposure mitigation. In particular, the use of FC debt proves to be highly effective, diminishing exposure by about 40%. FX derivatives, while still significant, demonstrate a somewhat lesser impact compared to FC debt in reducing currency risk.

Although prior research has established the risk-mitigating properties of FC debt as a hedging instrument, its implications for default probability remain empirically unexplored. The presumption of FC debt's hedging effectiveness necessitates critical examination, particularly given that foreign debt utilization as a hedging mechanism may precipitate increased leverage (Clark and Judge, 2009). Empirical evidence supporting this concern emerges from Allayannis et al. (2003), which reveals that firms employing FC debt maintain debt-to-value ratios that are 10 percentage points higher than their non-user counterparts.

3.2.3 Rationales behind the choice of types of derivatives

This section reviews the literatures on types of derivatives. A fundamental distinction lies in their linearity. Linear derivatives, exemplified by forwards or swaps, demonstrate a value change directly proportional to an underlying variable. In contrast, non-linear derivatives, such as options, exhibit values that do not change linearly concerning the underlying variable. Financial theory posits that the selection of derivative instruments for hedging purposes should be predicated on the alignment between a firm's exposure profile and the payoff characteristics of the instrument. In this context, instruments exhibiting linear payoff profiles, such as forwards, futures, and swaps, are deemed appropriate for hedging linear exposures. Conversely, options, characterized by nonlinear payoff profiles, are theoretically more suitable for mitigating nonlinear exposures (Clark and Judge, 2009).

A limited number of papers delve into the effect of specific types of derivative contracts on firm risk. In addition, no research has examined the impact of different types of FX derivatives on default risk. Allayanis and Ofek (2001), later followed by Magee (2013) use notional amounts of FX forwards and options and treat them as general FX hedging variable. The authors argue that FX swaps are just used to convert either domestic debt into foreign debt or vice versa. However, we would argue that the use of FX swaps for that purpose is also an act of hedging. Additionally, if the hedging usage of swaps is different from that of forwards or options, it is interesting to see how they differ in the impact on default risk. Other papers on FX derivatives use a general category for FX derivatives (Marin, 2013; Boyer and Marin, 2013). Additionally, with a general perspective, not FX or IR or CP derivatives, Bartram et al. (2011) conduct an untabulated section testing if the effect of derivatives on firm risk differs by derivative types, particularly linear, and non-linear derivatives and find limited evidence that derivative types matter.

Other than those, the majority of scholarly works explore why firms opt for particular derivatives and the advantages of certain types over others. Froot et al. (1993) argue that when raising capital from external sources, such as banks or equity markets, is more expensive for companies than relying on internal funding through profits and retained earnings, there is an incentive for those firms to use risk management strategies like hedging. Since external finance charges additional costs and frictions like interest, fees, or dilution of ownership compared to internal funds, managing risks through instruments that limit downsides has extra benefits for entities where outside capital carries premium expenses. Thus, higher costs of external finance rationally motivate corporations to utilize available hedging tools to control exposures. Their study also proposes that non-linear hedging instruments, such as options, offer firms a more precise coordination of investment and financing plans compared to linear instruments.

Apart from options, Geczy et al. (1997) examine the factors influencing the choice of derivative instruments for FX risk management, focusing on forwards and swaps. The study reveals that the nature of the underlying FX exposure significantly impacts not only the decision to use derivatives but also the specific type of instrument chosen. For example, FX exposure arising from frequent international business activities often involves numerous short-term transactions with uncertain payment amounts determined at the transaction time. The research finds that firms facing such exposure are more inclined to utilize forward contracts alone, or potentially combine them with futures or options, rather than currency swaps. This suggests that forward contracts and options offer a cost-effective approach for aligning payoffs with the frequent and unpredictable nature of these transactions. Conversely, the exposure arising from FC debt is typically well-defined at the outset. This characteristic translates to a smaller number of transactions with pre-determined future payments. Consequently, firms can adopt a long-term risk management strategy from the very beginning of the debt contract. Currency swaps, or combinations of swaps, are frequently utilized in these situations. This aligns with the established principle that swaps are particularly effective instruments for managing exposure characterized by known and certain future cash flows. This highlights the importance of tailoring the hedging strategy to the specific FX exposure, with short-term, unpredictable transactions favouring forward contracts/options, and long-term debt exposures benefiting from the stability of currency swaps.

Similar to Geczy et al. (1997), Goswani et al. (2004) empirically investigate the relationship between firms' economic exposure and their utilization of FX swaps. Analysing a comprehensive sample of global, non-financial firms, they find that long-term exchange rate exposure is most effectively addressed through FX swaps. The study employs two distinct measures of economic exposure: a market-based measure and a cash flow-based measure. Their findings provide robust support for the theoretical model, demonstrating a positive correlation between firms' FX swap usage and their economic exposure. Notably, this positive relationship achieves statistical significance exclusively for the cash flow-based measure of economic exposure.

Tackling a different angle, Gay et al. (2003) study the optimal composition of a hedging portfolio based on a firm's risk profile. Their research reveals that companies with minimal inherent business risk, encompassing both quantity and price fluctuations, benefit from hedging strategies primarily composed of linear instruments. However, as business risk increases, prompting concerns about excessive hedging ("overhedging"), the optimal portfolio composition shifts towards incorporating a greater proportion of non-linear derivatives. The study further highlights the significant influence of the connection between a firm's output and market prices on the substitution between linear and non-linear hedging strategies. When this correlation is negative, it incentivizes a stronger substitution of linear instruments with option contracts (non-linear). Conversely, a positive correlation moderates this substitution effect.

Focusing on non-linear derivatives, Bartram (2006) uncovers various reasons why non-financial firms utilize options within their risk management strategies. Options offer significant adaptability as hedging tools, capable of accommodating a diverse range of potential outcomes, with both linear and non-linear exposures. They are particularly well-suited for managing non-linear exposures, where a firm's cash flows are unpredictable and exhibit a non-linear relationship with the risk factor. When managing risks associated with fluctuations in prices and quantities, the optimal composition of the hedging portfolio is contingent upon the interrelationship between these two risk factors. Constructing such portfolios frequently necessitates the fusion of both non-linear derivative instruments and their linear counterparts to achieve an effective risk mitigation strategy. Beyond core risk management considerations, Bartram (2006) highlights the influence of factors such as accounting regulations pertaining to derivatives and market liquidity on the selection of specific derivative instruments. Additionally, the study suggests the potential for agency-related motivations influencing the use of options. Options offer the ability to speculate on both the direction and future volatility of the underlying asset, potentially appealing to certain decision-makers within the firm.

Similarly, Adam (2009), by studying 111 gold mining companies from North America area from 1989 to 1999, explores why firms use option hedging strategies. In more detail, the study finds that the largest and least financially constrained firms tend to use options. Additionally, there is evidence that firms with high growth or large investment projects tend to use a non-linear strategy since the risk exposure is non-linear. It is argued that in the mining sector, capital spending predominantly arises from new mine projects and expanding existing mines. These capital outlays tend to be nonlinear, meaning a firm will only undertake building a new mine if gold prices exceed a certain threshold; otherwise, the development gets deferred or cancelled if prices dip under the threshold. The larger a mining company's investment plans, the higher the potential for mismatch between cash inflows and outflows, making the nonlinearity in expenditures more impactful. Therefore, mining corporations with relatively sizeable investment programs should be more inclined to choose nonlinear hedging approaches than those with comparatively small investment schemes.

On the other hand, Frestad (2009) explains why most firms choose linear hedging strategies. Linear hedging strategies are often the preferred choice for firms due to their effectiveness and simplicity, particularly when dealing with a dominant hedgeable risk factor. These factors typically exhibit a predictable and proportionate influence on profitability, rendering linear hedges sufficiently effective. Additionally, for most companies, the complexity of implementing non-linear strategies outweighs the potential benefits, especially if they lack the expertise to manage them effectively. Even in scenarios where a firm's risk profile is not strictly linear, the marginal benefits of non-linear strategies may not justify their increased complexity.

3.2.4 Country-level factors and FC debt

With the focus on US sample from the majority of previous papers (Marin, 2013; Magee, 2013; Boyer and Marin, 2013), not many papers investigate the potential connection between country-level factors and hedging, especially FC debt. To the best of our knowledge, our paper is the first to examine the influence of debt enforcement efficiency of a country on the impact of FC debt hedging on default risk.

Bartram et al. (2009) conduct an extensive analysis of 7,319 firms from 50 different countries over the years 2000 and 2001 to investigate whether companies are more inclined to engage in hedging activities in countries with more efficient legal systems. The study finds no significant evidence to support the hypothesis that firms in countries with more efficient legal systems hedge more frequently. However, the research primarily focusses on the use of FX, IR, and CP derivatives and the inclusion of FC debt as a control variable is relatively limited. The authors include FC debt in their analysis but do not explore in depth, leaving the link of FC debt and country-level factors somewhat underexplored.

Taking FC debt into account, with a setting of emerging economies, Gatopoulos and Louberge (2013) explore the factors influencing firms' usage of FX derivatives in emerging markets susceptible to currency crises. The study proposes a theoretical model where a firm with international operations determines its ideal level of FC debt and hedging activity. Focusing on five Latin American countries known for their highly volatile exchange rates during post-crisis periods, the study presents a compelling theoretical and empirical analysis, suggesting that country-specific factors, such as a nation's overall exposure to a crisis, public anticipation of exchange rate fluctuations, or long-term interest rate differentials, exert a significant influence on firms' hedging strategies involving the employment of FX derivatives and FC debt.

The model suggests that taking on FC debt can serve a dual purpose, functioning as a hedging tool or a speculative strategy depending on the context. In contrast, the utilization of FX derivative instruments is primarily driven by the objective of mitigating risk exposure. Furthermore, the research highlights the critical role of derivative markets in enabling firms within these emerging economies to manage their vulnerability to exchange rate fluctuations, particularly in the aftermath of a crisis.

To the best of our knowledge, our paper is the first to examine the influence of debt enforcement efficiency of a country on the impact of FC debt on default probability.

3.3 Hypothesis development

If FX derivatives are employed for hedging purposes, one could anticipate a depletion in the likelihood of default (Magee, 2013; Marin, 2013; Boyer and Marin, 2013). However, the implementation of foreign currency (FC) debt has two countervailing effects on a firm's default risk. Firstly, a hedging effect may arise when FC debt mitigates cash flow volatility and default likelihood stemming from FX exposure. Conversely, FC debt increases leverage compared to firms without such debt (Allayannis et al., 2003; Clark and Judge, 2009), consequently elevating default risk. This latter effect is referred as the leverage effect. Since FC debt entails two opposing effects – leverage and hedging – it could be argued that even though firms utilize FC debt for hedging purposes, its effectiveness as a default risk mitigation tool may not be comparable to that of FX derivatives. Consequently, our primary hypothesis postulates the following:

H3-1: FC debt is not as effective as FX derivatives in terms of mitigating default risk.

Shifting our focus to the examination of linear and non-linear derivative strategies, Froot et al. (1993) posit that non-linear derivative instruments present firms with the opportunity to achieve a more precise and optimal alignment between their investment and financing plans, which can ultimately contribute to an enhancement in firm value and a reduction in default risk. Our expectation is predicated on the notion that if a non-linear strategy enables firms not only to mitigate downside risk but also to capitalize on upside potential gains, non-linear derivative instruments should prove more effective than their linear counterparts in mitigating default risk. This reasoning leads us to formulate our second hypothesis:

H3-2: Non-linear FX derivative is more effective in mitigating default risk than linear counterparts.

Regarding long-term and short-term derivatives, since long-term instruments, such as FX swaps, are primarily utilized to hedge long-term exposure, we anticipate that this type of derivative will exert a more pronounced impact on long-term default risk. Conversely, as short-term instruments, such as FX forwards, are primarily employed to hedge short-term exposure, we expect that short-term FX derivatives will influence short-term default probability to a greater extent. Our third hypothesis, therefore, is as follows:

H3-3: FX swaps have a larger effect on long-term default probability, whereas FX forwards impact short-term default probability more significantly.

Concerning the role of debt enforcement in the context of the effects of currency hedging on default risk, we hypothesize that if a country's debt enforcement mechanisms are efficient, creditors will have greater opportunities to exercise their power over borrowers. As a result, firms would be more likely to engage in hedging activities to avoid the unfavourable consequences of defaulting on their debt obligations, and we could witness an amplified effect of hedging on default risk. Alternatively, we predict that in countries with higher levels of debt enforcement, creditors find it easier to exercise their rights, leading to a higher likelihood of legal action being taken against defaulting firms, thereby increasing the propensity for default. Our hypotheses in this regard are as follows:

H3-4: The level of debt enforcement in a country influences the effect of currency hedging on default probability.

Firms strive to manage mismatches between their incoming and outgoing cash flows, especially when external financing is expensive. Large-scale investment programs can exacerbate these mismatches, creating a need for non-linear hedging strategies to effectively mitigate the associated non-linear risks. Research by Froot et al. (1993), Bartram (2006), and Adam (2009) suggest that non-linear hedging approaches are more effective in managing non-linear exposures. Building on this foundation, we hypothesize that firms with significant investment programs, which inherently involve non-linear risk profiles, experience greater benefits from utilizing non-linear FX derivatives for hedging purposes.

H3-5: For firms with large investments, the effect on default probability of non-linear FX derivatives is more pronounced than that of linear FX derivatives.

3.4 Data, methodology, and variable construction

3.4.1 Data

In this second paper, we examine the impact of currency hedging tactics on the risk of default. This is done by scrutinizing hedging methods that incorporate both FC debt and FX derivatives. We delve deeper into the linearity of FX derivatives or specific kinds of FX derivatives. We examine a sample of six countries, including France, Germany, Spain, Italy, Norway, and the UK from 1999 to 2015. The sample period concludes in 2015 to preclude potential biases arising from the UK's withdrawal from the European Union (Brexit) in 2016.

The selection of those European nations is predicated on several compelling factors. Primarily, these economies demonstrate enhanced vulnerability to FX risk due to their greater degree of economic openness, as reflected in the higher ratio of international trade to GDP compared to the US. The European Union's prominence in global trade further compounds its exposure to currency market dynamics. Additionally, Europe's sophisticated derivatives market infrastructure provides an ideal analytical context. The region's advanced financial markets enable corporate entities to optimize their capital structure through both domestic and foreign currency debt issuance, with decisions primarily driven by economic efficiency considerations rather than market access constraints. This institutional framework facilitates more robust empirical analysis of FC debt utilization among non-financial firms.

3.4.2 Methodology

Our primary model to assess the influence of hedging with FX derivative and FC debt on the probability of default is illustrated as follows:

$$\begin{aligned} Default_{it} = {} & \beta_0 + \beta_1 FXderivativeonly_{it} + \beta_2 FCdebtonly_{it} + \\ & \beta_3 FXderivative\ \&\ FCdebt_{it} + \beta_4 Leverage_{it} + \beta_5 Liquidity_{it} + \beta_6 Firm\ Size_{it} + \\ & \beta_7 Equity\ Volatility_{it} + \beta_8 Excess\ Return_{it} + \beta 9 Profitability_{it} + Industry\ Dummies \\ & + Year\ Dummies + Country\ Dummies + \varepsilon_{it} \end{aligned} \quad [6]$$

Where Default variable is EDF one-year or five-year duration. FXderivativeonly, FCdebtonly, and FXderivative & FCdebt are the dummies for different foreign currency hedging strategies, following Hagelin and Pramborg (2004). Then, we take one step further to investigate the effect of linear and non-linear strategies and their combination with foreign debt on default risk. The following model will be used:

$$Default_{it} = \beta_0 + \beta_1 FXLinearonly_{it} + \beta_2 FXNon\text{-}linearonly_{it} + \beta_3 FXLinear\ \&\ Non\text{-}linear\ only_{it} + \beta_4 FXLinear\ \&\ FCDebt_{it} + \beta_5 FXNon\text{-}linear\ \&\ FCDebt_{it} + \beta_6 FXLinear\ \&\ Non\text{-}linear\ \&\ FCDebt_{it} + \beta_7 FCDebtonly_{it} + Control\ Variables + Industry\ Dummies + Year\ Dummies + Country\ Dummies + \varepsilon_{it} \quad [7]$$

Where FXLinearonly, FXNon-linearonly, FXLinear and Non-linear only, FXLinear & FCDebt, FXNon-linear & FCDebt, FXLinear & Non-linear & FCDebt, and FCDebtonly represent different hedging strategies created from FX linear or non-linear derivatives or FC debts. Last but not least, our final base model will cover the impact of various types of derivatives (without considering foreign debt), in particular, forwards, swaps, or options and their combinations on default likelihood. The model is as follows:

$$Default_{it} = \beta_0 + \beta_1 FXForwardsonly_{it} + \beta_2 FXSwapsonly_{it} + \beta_3 FXForwards\ \&\ Swaps_{it} + \beta_4 FXForwards\ \&\ Options_{it} + \beta_5 FXSwaps\ \&\ Options_{it} + \beta_6 FXForwards\ \&\ Swaps\ \&\ Options_{it} + \beta_7 FXOptionsonly_{it} + Control\ Variables + Industry\ Dummies + Year\ Dummies + Country\ Dummies + \varepsilon_{it} \quad [8]$$

Where FXForwardsonly, FXSwapsonly, FXForwards & Swaps, FXForwards & Options, FXSwaps & Options, FXForwards & Swaps & Options and FXOptionsonly are proxies for different hedging strategies from using only forwards, swaps or options or combining them together.

A pooled OLS approach serves as the baseline model, but it does not account for firm-specific heterogeneity or potential reverse causality between derivative usage and default risk. To address the latter, lagged independent variables related to derivative usage are employed (Bellemare et al., 2017), mitigating the possibility that financial distress drives hedging rather than vice versa. To further control for unobserved firm-specific effects that may influence both derivative usage and default likelihood, a fixed effects (FE) model is implemented (Dougherty, 2016). Finally, given that the dependent variable, Expected Default Frequencies (EDF), is bounded between 0 and

1, beta regression is utilized (Ferrari and Cribari-Neto, 2004), as OLS is unsuitable for such fractional response variables.

From equation [6], there are different endogenous variables, which are *FXderivativeonly*, *FCdebtonly*, *FXderivative & FCdebt.* Similarly, from equation [8], *Long-termonly*, *Short-termonly*, *Long-term and short-term* are the endogenous variables. These different variables could affect the likelihood of default and default risk could also have an impact on those variables. This leads to that a different econometric approach is needed to tackle this issue. Following Zirgulis (2014) who also encounters multiple endogenous variables, we leverage dynamic panel data (DPD) analysis to investigate the influence of currency and interest rate hedging on default risk. In more detail, we specifically employ the One-Step System Generalized Method of Moments (SGMM) estimator due to its advantageous precision properties stemming from its reliance on fewer assumptions compared to the two-step GMM alternative.

Linear dynamic panel-data models are used to analyse data with unobserved individual effects (like firm-specific characteristics) across multiple time periods. These models incorporate lags of the dependent variable as explanatory factors but encounter a challenge: the unobserved effects are inherently correlated with these lags, leading to biased estimates if left unaddressed. To tackle this challenge, Arellano and Bond (1991) introduce a consistent GMM estimator. This approach involves transforming the model through either first differencing or orthogonal deviations, essentially removing the fixed effects from the equation. The model employs second and subsequent lags of the endogenous variables as instruments. However, the Arellano-Bond estimator has limitations: (1) it can be unreliable when the influence of past values of the dependent variable (autoregressive parameters) or the relative strength of the unobserved effects are high; (2) it cannot handle models with time-invariant variables; (3) the chosen instruments (higher lags of the dependent variable) become unreliable when the data exhibits high persistence.

Building upon the work of Arellano and Bond (1991), Blundell and Bond (1998) develop the system GMM estimator. This method addresses the weaknesses of the Arellano-Bond approach by incorporating additional moment conditions. It assumes no autocorrelation in the error terms and requires an initial condition of no correlation between the unobserved effects and the first difference of the first observation in the dependent variable. The key advantage of the system GMM is its robustness against biases stemming from weak instruments, as demonstrated by simulations conducted by Blundell and Bond (1998). This robustness has made it a popular choice in various empirical research areas, including this study that chooses it to estimate a dynamic model.

The dynamic model is as follows,

$$Default_{it} = \beta_0 + \rho\ Default_{i,\,t-1} + \beta_1 FXderivativeonly_{it} + \beta_2 FCdebtonly_{it} + \beta_3 FXderivative\ \&\ FCdebt_{it} + \beta_4 Leverage_{it} + \beta_5 Liquidity_{it} + \beta_6 FirmSize_{it}\ \beta_7 EquityVolatility_{it} + \beta_8 ExcessReturn_{it} + \beta 9 Profitability_{it} + Industry\ Dummies + Year\ Dummies + Country\ Dummies + \varepsilon_{it} \quad [9]$$

The System GMM model offers a significant advantage: it does not require external instruments for endogenous variables. Instead, it uses lagged values of the endogenous variables as their own instruments, while contemporaneous exogenous variables serve as instruments for themselves. In this essay, we treat the currency hedging strategies variables (*FXderivativeonly, FCdebtonly, FXderivative & FCdebt*) and all financial variables as endogenous.

3.4.3 Variable description

In the following section, a detailed explication of the dependent variable, capturing corporate default risk, is provided. Furthermore, this section delineates the primary explanatory variables of interest, which serve as the focal independent variables in the empirical analyses. Additionally, the ancillary control variables, employed to account for potential confounding factors and ensure the robustness of the findings, are meticulously described.

Our paper studies the influence of currency hedging strategies on default risk by using big cross-sectional data within the period of 1999 to 2015 for six countries namely the UK, France, Germany, Italy, Spain, and Norway. For every country, we selected the top firms listed on their stock exchange. The number of firms included in the dataset changes annually due to various factors such as mergers, delistings, acquisitions, and the unavailability of financial data. In total, our dataset comprises 7,954 firm-year observations over the sample period.

3.4.3.1 Dependent variable: EDF

This chapter investigates the relationship between currency hedging strategies and default probability by employing Expected Default Frequencies (EDF) as a proxy for default risk. The EDF data, obtained from Moody's Analytics via Dr. Amrit Judge, is derived from distance-to-default model by Merton (1974). This measure has demonstrated reliability across various credit cycles and robustness to model misspecification (Crossen et al., 2011; Berndt et al., 2018).

The utilization of EDFs offers a significant advantage over the traditional distance-to-default model employed in numerous studies, as it provides precise default probabilities rather than merely ranking default risks (Moody's Analytics, 2016). This methodological choice enhances the robustness and precision of our analysis, a particularly salient feature given that our dataset encompasses the 2007-2008 global financial crisis period.

3.4.3.2 Main explanatory variables

The FX derivative use data are hand-picked through the firm’s annual reports. We scan firms’ financial reports and take notes on any accounts associated with a firm’s risk managing policy, especially foreign exchange risk management, to identify if a firm uses derivatives and which specific kinds of instruments are used. We are interested in keywords such as “foreign exchange”, “hedging”, “risk management”, “forwards”, “swaps”, and “options”. When a firm reveals in the annual report that it uses FX derivatives, it is categorized as an FX derivative user, taking a value of 1 in the dummy variable. If the annual report does not contain any reference to the derivative usage, the firm is categorized as a non-derivative user, which has the value of 0 in the dummies. We then take one further step and collect data regarding the types of FX derivatives (forwards, swaps, or options) that companies are using.

It is worth noticing is that if other derivative users, such as IR or CP derivatives, are included in the non-user sample, there would be bias in the examination of the relationship between FX derivative and default risk. As a result, we remove, from the non-user sample, users of IR and CP derivatives to create an unbiased FX derivative dummy.

As for FC debt, our investigation centres specifically on its effectiveness as a hedging tool in reducing default risk. To isolate this effect, we exclusively consider FC debt employed for hedging purposes, as identified through information gleaned from the firm's annual reports. We search for keywords about foreign currency debt or check sections such as "Notes to the Financial Statements", "Management Discussion and Analysis", "Foreign Exchange Exposure" or "Risk" to determine whether a company is using foreign-denominated debt for hedging or not. Firms explicitly indicating the use of FC debt for hedging are classified as "FC debt users." Conversely, firms without such disclosure are categorized as "non-FC debt users." The same approach is applied to other sub-categories of FX derivatives such as types of FX derivatives (forwards, swaps, or options). In addition, we also generate variables for a combination of FX derivative and FC debt. For example, FX DERIVATIVE ONLY takes the value of 1 if firms only use FX derivative and 0 for otherwise; FC DEBT ONLY is 1 if firms only use FC debt and 0 for otherwise; FX DERIVATIVE & FC DEBT is equal to 1 if firms use both hedging methods and 0 otherwise. Other dummies used in our paper include linear derivative, non-linear derivative and their combination with FC debt, or forwards, swaps and options, or their combinations.

3.4.3.3 Control variables

In our model, we incorporate several control variables based on established literature examining firm default determinants (e.g., Smith and Stulz, 1985; Chava and Jarrow, 2004; Brogaard et al., 2017). These variables are as follows:

- *Leverage*

Defined as the ratio of total debt to the sum of market equity value and book value of assets minus book value of equity. Prior research, such as Marin (2013), indicates a strong positive correlation between leverage and bankruptcy probability.

- *Firm size*

Computed as the natural logarithm of total debt plus market equity value (Guay, 1999; Nguyen and Faff, 2010). Magee (2013) posits that larger firms, due to their higher degree of product and geographical diversification, typically exhibit lower firm risk compared to their smaller counterparts.

- *Excess return*

Calculated as the difference between annual equity return and the corresponding annual return of the country-specific stock index (e.g., FTSE 100 for the UK, CAC All

Share for France). A negative relationship between excess return and insolvency probability has been documented in various studies (Shumway, 2001; Magee, 2013; Brogaard et al., 2017).

- *Liquidity*

Proxied by the quick ratio, defined as (current assets - stock and work in progress) divided by current liabilities. Higher liquidity is associated with lower financial distress, as evidenced by several studies (Marin, 2013; Magee, 2013).

- *Profitability*

Measured as the ratio of EBITDA to total assets. Increased profitability is generally linked to decreased bankruptcy risk. Moreover, highly profitable firms often have access to internal funds, reducing reliance on costly external financing and potentially lowering default probability (Bartram et al., 2009).

- *Equity volatility*

Calculated as the standard deviation of daily stock returns within a fiscal year. Campbell et al. (2008) argue that higher equity volatility is associated with an increased likelihood of default.

3.3.3.4 Debt enforcement efficiency index

In this paper, given our focus on the use of FX derivatives, particularly FC debt as hedging instruments, we aim to explore whether the efficiency of debt enforcement in a country could impact the efficacy of FX hedging. Our hypothesis posits that in countries with efficient debt enforcement, creditors have greater leverage to enforce their power over borrowers. Consequently, firms would be more prone to hedge to avert adverse consequences of defaulting on their debt, potentially amplifying the impact of hedging on default risk. Conversely, we anticipate that in nations with robust debt enforcement, creditors can more easily exercise their rights, leading to an increased likelihood of legal action against defaulting firms and, consequently, a higher probability of default. To assess this, we will employ the debt enforcement index introduced by Djankov et al. (2008) to assess how effectively debt contracts are enforced in a given country.

Djankov et al. (2008) present a novel methodology to evaluate the efficiency of debt enforcement mechanisms across a sample of 88 countries. Their approach uses a standardized case study presented to insolvency practitioners in each nation. This case study centers on a hypothetical insolvent firm, specifically a mid-sized hotel named "Mirage," with standardized financial details (employee count, capital structure, ownership) adjusted based on each country's per capita income to ensure comparability.

The case study depicts Mirage obtaining a loan from a local bank, Bizbank, to acquire real estate that serves as collateral for the ten-year loan. Insolvency practitioners in each country then describe the anticipated debt enforcement process, encompassing the specific procedures (foreclosure, liquidation, etc.), associated timeframes, costs, and methods of asset disposition (sale of the entire hotel or piecemeal sale of assets). This data serves as the foundation for calculating an efficiency score for each country's debt enforcement system. Additionally, the study collects information on the legal and economic characteristics of each country's insolvency process to identify factors contributing to efficient asset recovery and overall system effectiveness.

The researchers extract four key variables from the insolvency practitioner survey responses. The first variable, "time," captures the duration from Mirage's default until its ultimate fate is determined, either as a successfully restructured ongoing business or through liquidation via piecemeal asset sales. This timeframe incorporates potential delays due to disputed claims and appeals, as outlined in the case study. In scenarios where Bizbank is not immediately repaid following the resolution of the insolvency proceedings, a separate variable, "time to payment," is measured as the period from default until Bizbank receives full payment. Time is considered a crucial metric for assessing overall debt enforcement efficiency, while time to payment is relevant for calculating Bizbank's ultimate loan recovery rate.

The study also records the "cost" associated with completing the insolvency proceedings, quantified as a proportional percentage of the cumulative value of the bankruptcy estate at the time of filing. The bankruptcy estate itself is defined as the higher value between the estimated worth of Mirage as a going concern and the estimated value from a piecemeal asset sale, both expressed as percentages. Furthermore, the researchers create a binary variable, "GC" (Going Concern), assigned a value of one if Mirage continues to operate as a viable business (considered an efficient outcome) and zero if it is liquidated through piecemeal asset sales.

To evaluate efficiency, the study incorporates assumptions regarding the timing of debt enforcement costs and the value generated by Mirage during the insolvency process. The assumption is made that these costs are incurred at the conclusion of the proceedings, potentially favouring countries with higher interest rates. Additionally, the study assumes that Mirage generates no value during the insolvency process, making bankruptcy proceedings more costly for countries with longer timeframes and higher prevailing interest rates. The efficiency measure is ultimately computed as the present value of the firm's terminal value after factoring in these assumed bankruptcy costs.

$$E = \frac{100 * GC + 70 * (1 - GC) - 100 * c}{(1 + r)^t} \quad [10]$$

The formula integrates the indicator variable GC, taking the value of one if Mirage maintains its status as a going concern and zero otherwise, along with the parameters c (representing the cost), t (denoting the time required to resolve insolvency), and r (symbolizing the nominal lending rate). The data is structured according to income levels and the legal origins of a country's bankruptcy laws, which are categorized into four distinct groups: English, French, German, and Nordic.

3.5 Descriptive statistics

Table 3-1 presents descriptive statistics for the variables employed in our regression analyses. To mitigate the influence of outliers, all variables have been subjected to winsorization at the 1st and 99th percentiles. Examining the probability of default metrics, we observe the following:

For the one-year horizon (EDF1YEAR), the mean is 1.586 and the median is 0.260. In contrast, the five-year horizon (EDF5YEAR) exhibits a mean of 1.564 and a median of 0.631. A comparison of the median values reveals that the long-term probability of default exceeds the short-term default risk.

Our sample encompasses a diverse set of firms, as evidenced by the presented descriptive statistics. The average leverage ratio (22.5%) aligns closely with the findings of Bartram et al. (2011). Notably, the profitability range spans from -170% to

44%, indicating the inclusion of both profitable and loss-making firms. Equity volatility exhibits a mean of 40.9 and a median of 34.31, highlighting the presence of firms with varying levels of stock price fluctuations. Furthermore, the sample firms demonstrate lower returns compared to the overall market, with average and median excess returns of -2.9% and -0.2%, respectively. Liquidity, measured by the quick ratio, also presents a distribution with a mean of 1.61 and a median of 0.95.

The frequency distribution of the hedging variables is shown in Table 3-2. We also divide the frequency distribution in terms of countries, which can be found in Figure 3-1. Panel A presents the data for FX derivatives and FC debt strategies. We can see that a significant portion (62.19%) of firms across the sample use both FX derivatives and FC debt. whereas "FX Derivatives Only" usage is the second most common category (28.96%), followed by "FC Debt Only" (8.85%). This indicates that hedging with derivatives might be a more widely adopted strategy compared to relying solely on FC debt.

If we break this down in terms of countries, as shown in Figure 3-1, we can see that most of the countries in our sample follow this pattern. Specifically, a substantial proportion of firms across most nations prefer employing a synergistic combination of FX derivatives and FC debt as their preferred hedging strategy. However, German and Italian firms seem to prefer to hedge with only FX derivatives. In addition, the percentage of firms using only FC debt in Norway is comparable to the proportion of firms using only FX derivatives (18% with 21% respectively).

We then separate the hedging strategies into smaller categories, which is shown in Panel B of Table 3-2. We now look at hedging strategies with linear, non-linear derivatives and FC debt. As can be seen from panel B of Table 3-2, it seems that linear derivative is the leading strategy that most firms follow. We can see that the distribution of hedging strategies with linear derivative as a component outweighs any other strategies. Nearly half of the firms (45.47%) in our sample use linear derivative and FC debt combination, using only linear strategy accounts for around 24%, and combining all three is approximately 15%. Not many firms prefer to use non-linear FX derivatives. If we look at separate countries, according to Figure 3-1, hedging strategies involving linear derivatives still dominate. Most of the countries have the same pattern: more firms using linear derivatives and FC debt compared with other linear strategies. However, Italy and Germany stand out for their strong preference for FX linear derivatives only (52.71% for Italy and 37.2% for Germany). This suggests a potentially simpler hedging approach compared to other countries.

Panel C of Table 3-2 presents the frequency distribution of hedging strategies using forwards, swaps, and options, not considering the use of FC debt. Since we ignore FC debt, the number of observations for each category increases. As can be seen from Table 3-2, forwards-only strategy dominates with more than 50% of firms using it. Other hedging strategies that involve currency forwards are among the top widely used, with forwards & swaps (16.65%), forwards & options (13.67%), or forwards & swaps & options (10.56%) at the 2nd, 3rd, and 4th place. This pattern still holds for every country in our sample. Interestingly, a significant proportion of firms (36.24%) combine FX forwards and swaps, reflecting a diversified risk management strategy prevalent in the UK.

Table 3-3 presents the Pearson correlation coefficients for the variables employed in this chapter's analysis. The results reveal a statistically significant negative correlation between the use of FX derivatives exclusively and both one-year and five-year Expected Default Frequencies (EDF1YEAR and EDF5YEAR, respectively). Conversely, the exclusive use of FC debt demonstrates a statistically significant positive correlation with both default risk metrics. These correlation patterns suggest a nuanced relationship between different currency hedging strategies and default risk. The negative correlation associated with FX derivatives implies a potential reduction in default risk when firms employ this hedging strategy. On the other hand, the positive correlation observed with FC debt usage indicates a possible increase in default probability. This latter finding may be attributed to the leverage effect of FC debt potentially outweighing its hedging benefits.

Table 3-1: Summary statistics

This table summarizes the standard statistics for the variables used in this paper. The variables included are as follows. ***EDF1YEAR*** *is the Moody's expected default frequencies over one year period.* ***EDF5YEAR*** *is Moody's expected default frequencies in five-year time range.* ***LEVERAGE*** *is the ratio of total debts over market values of assets.* ***PROFITABILITY*** *is measured as the ratio of EBITA over total assets.* ***FIRM SIZE*** *is the natural logarithm of total assets.* ***VOLATILITY*** *is the standard deviation of stock return in a fiscal year.* ***LIQUIDITY*** *is the quick ratio (total assets minus inventory over total liabilities).* ***EXCESS RETURN*** *is annual equity return minus annual return of the stock index representing each country.*

Variable	**N**	**Mean**	**Median**	**Min**	**Max**	**Standard deviation**
EDF1YEAR	7954	1.586	0.260	0.010	32.939	3.949
EDF5YEAR	7954	1.564	0.631	0.010	23.976	2.734
LEVERAGE	7100	0.225	0.185	0.000	0.901	0.196
PROFITABILITY	7345	0.087	0.099	-1.722	0.446	0.151
FIRM SIZE	7020	6.610	6.238	-4.044	17.481	2.768
VOLATILLITY	7127	40.942	34.315	0.000	316.495	25.487
LIQUIDITY	7390	1.617	0.975	0.035	143.900	3.949
EXCESS RETURN	6240	-0.029	-0.002	-0.680	0.269	0.116

Table 3-2: Frequency distribution of currency hedging strategies

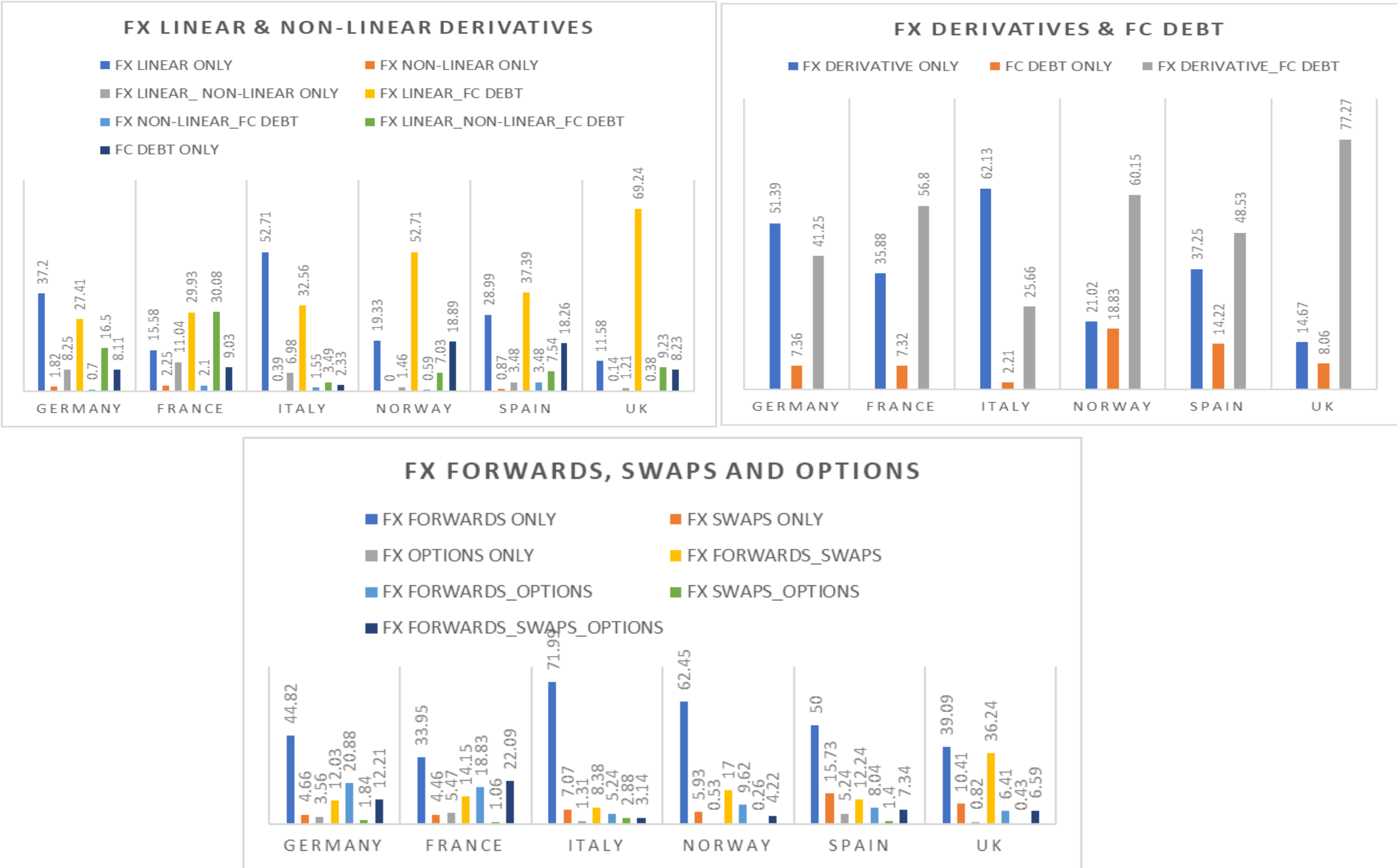
Derivative categories	**Frequency**	**Percentage**
Panel A: FX Derivative and FC debt		
FX DERIVATIVE ONLY	1,411	28.96
FC DEBT ONLY	422	8.85
FX DERIVATIVE & FC DEBT	3,315	62.19
Total	5,148	100
Panel B: FX Linear and non-linear derivative		
FX LINEAR ONLY	1,092	24.15
FX NON-LINEAR ONLY	28	0.90
FX LINEAR & NON-LINEAR ONLY	234	4.73
FX LINEAR & FC DEBT	2,315	45.47
FX NON-LINEAR & FC DEBT	63	1.06
FX LINEAR & NON-LINEAR & FC DEBT	762	14.56
FC DEBT ONLY	422	9.12
Total	4,922	100
Panel C: FX Forwards, Swaps and Options		
FX FORWARDS ONLY	3,251	50.90
FX SWAPS ONLY	372	5.56
FX OPTIONS ONLY	179	2.31
FX FORWARDS & SWAPS	1,191	16.56
FX FORWARDS & OPTIONS	945	13.67
FX SWAPS & OPTIONS	77	0.96
FX FORWARDS & SWAPS & OPTIONS	831	10.04
Total	6,846	100

Table 3-3: Pearson Correlation coefficients

This table presents the correlation coefficients for the main variables used in this analysis. ***EDF1YEAR*** *is the Moody's expected default frequencies over one year period.* ***EDF5YEAR*** *is Moody's expected default frequencies in five-year time range.* ***FX DERIVATIVE ONLY*** *is a dummy variable set equal to 1 if a firm uses FX derivatives only and 0 otherwise.* ***FC DEBT*** *ONLY is a dummy variable set equal to 1 if a firm uses FC Debt only and 0 otherwise.* ***FX DERIVATIVE & FCDEBT*** *is a dummy variable set equal to 1 if a firm uses FC Debt with FX derivatives and 0 otherwise.* ***LEVERAGE*** *is the ratio of total debts over market values of assets.* ***PROFITABILITY*** *is measured as the ratio of EBITA over total assets.* ***FIRM SIZE*** *is the natural logarithm of total market value of assets.* ***VOLATILITY*** *is the standard deviation of stock return in a fiscal year.* ***LIQUIDITY*** *is the quick ratio (total assets minus inventory over total liabilities).* ***EXCESS RETURN*** *is annual equity return minus annual return of the stock index representing each country. ***, **, * statistically different from zero at the 1%, 5%, or 10% level of significance, respectively.*

Variables	FX DERIVATIVES ONLY	FC DEBT ONLY	FX DERIVATIVES & FC DEBT	EDF1YEAR	EDF5YEAR	LEVERAGE	PROFITABILITY	VOLATILITY	SIZE	LIQUIDITY	EXCESS RETURN
FX DERIVATIVES ONLY	1.000										
FC DEBT ONLY	-0.099***	1.000									
FX DERIVATIVES & FC DEBT	-0.414***	-0.201***	1.000								
EDF1YEAR	-0.045***	0.080***	-0.112***	1.000							
EDF5YEAR	-0.062***	0.103***	-0.121***	0.974***	1.000						
LEVERAGE	-0.009	0.020*	0.234***	0.280***	0.289***	1.000					
PROFITABILITY	0.073***	-0.029***	0.139***	-0.256***	-0.281***	-0.076***	1.000				
VOLATILITY	-0.035***	0.037***	-0.105***	0.488***	0.491***	0.159***	-0.326***	1.000			
SIZE	-0.018	-0.001	0.402***	-0.064***	-0.093***	0.224***	0.101***	-0.103***	1.000		
LIQUIDITY	-0.052***	-0.015***	-0.136***	-0.021***	-0.024***	-0.197***	-0.082***	0.080***	-0.126***	1.000	
EXCESS RETURN	0.012	0.030**	-0.018*	-0.024	-0.022	-0.011	-0.001*	-0.038***	0.008	0.004	1.000

Figure 3-1: Frequency distribution of FX hedging strategies sorted by countries.



3.6 Empirical results

In this part, we conduct various tests with respect to our three models (model [6], [7], [8]) to test the effect of different currency hedging strategies on the probability of default. Particularly, the models include ordinary least squares (OLS), one-year lag regressor (LAG), beta regression (BETA), and also System Generalized Methods of Moments (SGMM). The results are presented in Tables 3-4, 3-5, and 3-6, with Table 3-4 dealing with FX derivatives and FC debts; Table 3-5 being about linear and non-linear derivatives; and Table 3-6 covering FX forwards, swaps and options.

3.6.1 Ordinary least square (OLS) results

Column 1 and 5 in Table 3-4 displays the results of OLS for FX derivatives and FC debt model (model [6]) to test hypothesis *H3-1* for EDF1YEAR and EDF5YEAR. We can see from column 1 that the estimate for FX DERIVATIVE ONLY is significantly negative at -0.414, showing that FX derivative could reduce default likelihood. This is converted to a reduction of 25.85% in one-year default probability (-0.414 over the mean EDF1YEAR). Our results demonstrate a stronger effect on default risk compared to the 0.4% reduction observed by Magee (2013) in their US-based research. This disparity could be due to differences in methodology. While Magee (2013) uses a continuous variable to measure FX derivative usage and finds no significant impact with a binary variable, our study specifically employs a dummy variable to represent FX derivative use.

Our analysis yields an intriguing result: the coefficient associated with FC DEBT ONLY for hedging purposes is statistically insignificant. This suggests that employing FC debt in this manner does not demonstrably reduce the probability of default, particularly for short-term default risk. In contrast, the coefficient for FX DERIVATIVE & FC DEBT is significant and negative (-0.406). This value is comparable to the coefficient obtained for using FX derivatives alone. These findings imply that since FC debt on its own may not be an effective hedging tool, combining it with FX derivatives appears to offer risk-mitigating benefits similar to those achieved with FX derivatives alone. As for EDF5YEAR, displayed by column 5, we still find that FX DERIVATIVE ONLY does have a negative effect on default probability (-0.358). The estimate of combining both FX derivatives and FC debts (-0.272) is smaller compared with that of only FX derivatives. Although they are not statistically different, we believe that the factor that can lead to this result is the positive and significant effect of FC debt on default risk. The coefficient of this variable is recorded at 0.578 and significant at the 5% level. This clearly indicates that FC debt may not be a good choice as a hedging tool since the hedging effect is outweighed by the leverage effect. This could be explained by the fact that if firms use more FC debts, their leverage level increases (Clark and Judge, 2009) and, hence, their probability of default also increases accordingly. Our findings align with Chiang and Lin (2005) who document that FX derivative is a good hedging tool while FC debts increase exchange rate exposure. Our results also corroborate the conclusions drawn by Gatopoulos and Louberge (2013), suggesting that the primary motivation behind the use of FX derivatives is hedging. In addition, our findings support the notion that FX derivatives could increase firm value while it is not the case for FC debt (Clark and Judge, 2009). Our results stand in contrast to those of Hagelin and Pramborg (2004), who demonstrate a risk-mitigating effect for both FX derivatives and FC debt. Their study suggests that firms can attain diminished FX exposure through the implementation of either FX derivatives or FC debt within their financial strategies, or a potentially more substantial reduction in exposure through the fusion of both hedging methods.

It is noteworthy that the influence of FC debt on default probability appears to manifest more prominently in the context of long-term default risk. This observation aligns with the rationale that firms typically employ FC debt as a hedging strategy to mitigate long-term exposure. Consequently, it follows that the effect of FC debt should be more pronounced when considering long-term default probability, as this metric captures the firm's risk profile over an extended time horizon, which is consistent with the intended purpose of utilizing FC debt.

With regard to the behaviour of linear and non-linear strategies on default risk (model [7]), the results are summarized in columns 1 and 5 of Table 3-5. In our analysis of the impact of different types of derivative strategies on default risk, we delve deeper into the effectiveness of hedging strategies involving both linear and non-linear derivatives, as well as FC debt. Drawing on insights from Froot et al. (1993) and Gamba and Triantis (2014), which suggest that non-linear strategies, such as options contracts, may offer advantages over linear derivatives like forwards or swaps, we aim to test whether these strategies indeed exhibit differing impacts on default likelihood. The rationale behind this hypothesis (*H3-2*) lies in the potential of non-linear derivatives to mitigate downside losses while retaining the opportunity for upside gains. However, our findings suggest that linear FX derivatives emerge as the primary driver of the negative effect of FX hedging strategies on default risk. In particular, the estimates for LINEAR ONLY, LINEAR & FC DEBT; and LINEAR & NON-LINEAR & FC DEBT are -0.529, -0.376, and -0.447 respectively. The coefficients are not statistically different, indicating that there is no difference in the effect of using only linear derivatives or combining various methods. Once again, we find that FC debt does not seem to reduce default probability. Consequently, we could understand that adding FC debt to the hedging scheme does not reduce default risk more, compared to using only FX derivatives. We also find that, contrary to our expectation, a non-linear strategy does not have a negative influence on default risk. This is consistent with the idea that options are mainly used for trading and speculation (Dash et al., 2007). Bartram (2006) also states that financial options possess the potential to be employed as instruments for establishing speculative positions under the pretence of risk mitigation strategies. This dual nature of options enables their utilization in a manner that seemingly appears to serve hedging purposes while simultaneously facilitating speculative market engagement. Similarly, in an empirical examination of US gold mining firms, Adam (2009) unveils a compelling correlation between the demand for nonlinear derivative instruments and specific market conditions. This observation implies that speculative motives, rather than solely hedging considerations, may be a driving force behind the employment of nonlinear instruments. In fact, one famous case study of this speculative use of options is Allied-Lyons Plc – the British food and liquor company, one of the largest firms in the UK brewing industry, declaring a huge foreign exchange loss of £147 million from trading options[25].

Results for EDF5YEAR are similar to those of EDF1YEAR. The coefficient of LINEAR ONLY is negative and significant at -0.494, meaning the use of only FX linear derivatives could reduce long-term default probability by 31.58% (0.494 over the mean EDF5YEAR of 1.564). Consistent with what we find in EDF1YEAR, FC DEBT ONLY has a positive impact on five-year default probability, with an estimate of 0.579. Thus, the fusion of linear derivative instruments and FC debt also has a negative effect on default risk, but the magnitude is smaller (-0.28 compared with -

[25] Prokesch, S. (1991) *Allied-Lyons reports big loss on currency*, *The New York Times*. Available at: https://www.nytimes.com/1991/03/20/business/company-news-allied-lyons-reports-big-loss-on-currency.html.

0.49 of only linear derivatives). Additionally, we also find that the use of FX options does not reduce EDF5YEAR, indicating the ineffectiveness of non-linear derivatives as a hedging tool.

In this section, we aim to delve deeper into the examination of specific FX derivatives excluding FC debt, namely forwards, swaps, and options, to assess their respective impacts on the likelihood of default (*H3-3*). The outcomes of the OLS regression analysis (model [8]) are presented in column 1 and 5 of Table 3-6. Given that swap contracts typically serve as long-term hedging tools, while forwards are commonly deployed for short-term exposure, we anticipate that FX swap contracts will exert a greater influence on five-year default probability, whereas forwards will have a more pronounced effect on one-year EDF. Our analysis reveals that the coefficient of FX forwards only is both negative and significant at -0.543, indicating a notable impact on short-term default probability. Conversely, the significance of the coefficient for the FX swaps-only variable is not observed. This finding suggests that FX forward contracts, which are primarily used for hedging short-term exposure, can effectively influence short-term default probability. According to Geczy et al. (1997), the short-term nature of forwards, futures, and options renders them appropriate instruments for hedging cash flow volatility stemming from routine and unpredictable transactions, such as import and export activities. Conversely, long-term exposure stemming from foreign subsidiaries, such as net worth exposure, necessitates a distinct approach due to its extended duration. Managing currency risk associated with foreign subsidiaries using short-term derivatives would entail significant basis risk and operational costs. In contrast, long-term currency swaps offer a more effective means of mitigating basis risk by aligning the maturity of the hedge with that of the exposure. Consequently, we observe that swap contracts do not effectively reduce EDF1YEAR, given their long-term hedging nature. Moreover, the combination of forwards and swaps, forwards and options, or all three derivatives collectively also exhibits a negative impact on default risk. However, this impact is likely predominantly driven by FX forwards, considering their focus on short-term EDF mitigation.

With regard to the five-year EDF, we anticipate a negative influence on long-term default risk from FX swaps and the effect should be more pronounced than that of forwards. As expected, the estimate of FX swaps is -0.571, which is larger than the coefficient of FX forwards only (-0.412) despite the fact that it is not statistically different from that of FX forwards. As we find that FX swaps do not impact short-term default probability, this significant negative coefficient can confirm that FX swaps are long-term hedging instruments. Other variables regarding the combinations of different instruments have negative and significant coefficients as anticipated. The magnitude of those negative impacts on EDF5YEAR seems to be larger than that of using only one type of derivative since now we have swap contracts to join force with forwards to hedge risk.

Table 3-4: Multivariate regressions of FX derivatives and/or FC debt on default probability

*This table presents the results of the impact of currency hedging strategies on the probability of default. In panel A the dependent variable is the probability of default for a one-year horizon (**EDF1YEAR**) and in panel B the dependent variable is the probability of default for a five-year horizon (**EDF5YEAR**). **FX DERIVATIVE ONLY** is a dummy variable set equal to 1 if a firm uses FX derivatives only and 0 otherwise. **FC DEBT ONLY** is a dummy variable set equal to 1 if a firm uses FC Debt only and 0 otherwise. **FX DERIVATIVE & FCDEBT** is a dummy variable set equal to 1 if a firm uses FC Debt with FX derivatives and 0 otherwise. **LEVERAGE** is the ratio of total debt to the market value assets. **PROFITABILITY** is measured as EBITDA over total assets. **VOLATILITY** is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate. **FIRM SIZE** is the natural logarithm of the market value of assets. **LIQUIDITY** is the ratio of total current assets minus total stock and work in progress over total current liabilities. **EXCESS RETURN** is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%, 5%, or 10% levels, respectively. The regressions include industry and year dummies.*

	PANEL A: EDF1YEAR				PANEL B: EDF5YEAR			
	OLS	Lag	Beta	SGMM	OLS	Lag	Beta	SGMM
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L.EDF				0.520***				0.528***
				(0.160)				(0.140)
FX DERIVATIVE ONLY	-0.414*	-0.475*	-0.075*	-2.318*	-0.358**	-0.383**	-0.110***	-2.013**
	(0.218)	(0.259)	(0.042)	(1.399)	(0.145)	(0.170)	(0.037)	(0.852)
FC DEBT ONLY	0.582	0.486	0.259***	0.951	0.578**	0.482	0.250***	-0.933
	(0.400)	(0.475)	(0.057)	(3.028)	(0.293)	(0.339)	(0.048)	(1.755)
FX DERIVATIVE & FC DEBT	-0.406*	-0.594**	-0.049	-1.465	-0.272*	-0.413**	-0.061*	-1.316*
	(0.225)	(0.281)	(0.041)	(1.164)	(0.155)	(0.190)	(0.035)	(0.714)
LEVERAGE	5.776***	6.264***	1.972***	3.748	4.330***	4.586***	1.753***	2.290
	(0.726)	(0.772)	(0.071)	(2.752)	(0.497)	(0.518)	(0.060)	(1.663)
PROFITABILITY	-1.303	-3.025**	-0.325***	2.724	-1.290**	-2.427***	-0.362***	0.883
	(0.946)	(1.175)	(0.068)	(4.162)	(0.639)	(0.718)	(0.057)	(2.407)
VOLATILITY	0.062***	0.052***	0.010***	0.054**	0.041***	0.036***	0.008***	0.029**
	(0.006)	(0.005)	(0.000)	(0.022)	(0.004)	(0.003)	(0.000)	(0.014)
FIRM SIZE	-0.179***	-0.101*	-0.098***	-0.277	-0.180***	-0.117***	-0.104***	-0.224
	(0.048)	(0.057)	(0.008)	(0.245)	(0.033)	(0.039)	(0.007)	(0.164)
LIQUIDITY	-0.060**	-0.072***	-0.032***	-0.071	-0.045**	-0.053***	-0.038***	-0.049
	(0.027)	(0.025)	(0.007)	(0.065)	(0.019)	(0.018)	(0.007)	(0.044)
EXCESS RETURN	-0.306	-0.259	-0.078	-2.113	-0.218	-0.337	-0.102	-0.462
	(0.526)	(0.555)	-0.075*	(3.377)	(0.366)	(0.388)	(0.087)	(2.049)
Constant	-0.235	0.753	-4.549***	-1.280	0.760**	1.219***	-4.197***	0.484
	(0.494)	(0.612)	(0.123)	(1.957)	(0.353)	(0.413)	(0.104)	(1.277)
Observations	4,925	4,413	4,925	3,481	4,925	4,413	4,925	3,481
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

R-squared	0.371	0.344			0.402	0.386		
Log pseudolikelihood			18630				17293	
Hansen test of over-identification (p-value)				0.859				0.816
AR(1) test (p-value)				0.021				0.012
AR(2) test (p-value)				0.178				0.137

3.6.2 One-year lagged and beta regression

We then continue the analysis by performing one-year lagged and beta regression. By lagging all regressors by one year, the problem of reverse causality is mitigated. At the same time, because EDF is proportional, we employ beta model. The results for those two specifications are fully displayed in Table 3-4, 3-5, and 3-6 columns 2, 3 for EDF1YEAR and 6, 7 for EDF5YEAR. In particular, as shown in Table 3-4, the lagged regression results showcase negative coefficients for FX derivative only in both short-term and long-term default probability (-0.475 and -0.383 for EDF1YEAR and EDF5YEAR respectively). This is also consistent with the results from beta regression (-0.075 and -0.110 for EDF1YEAR and EDF5YEAR respectively). FC debt, on the other hand, does not have significant coefficients for both EDF1YEAR and EDF5YEAR in the lagged model. Interestingly, from beta regression results, we witness positive coefficients for FC debt in both short and long-term default risk. These findings demonstrate the effectiveness of FX derivatives in terms of mitigating default risk, compared with FC debts.

Table 3-5 sheds light on the efficacy of linear and non-linear hedging strategies in reducing default risk. The lagged model results (columns 2 and 6) demonstrate that LINEAR ONLY strategy yields statistically significant negative coefficients for both short-term (EDF1YEAR, coefficient -0.529) and long-term (EDF5YEAR, coefficient -0.486) default probabilities. In contrast, NON-LINEAR ONLY does not exhibit any significant coefficients, suggesting its ineffectiveness in lowering default risk. The beta regression results mirror those of the lagged model, with significant negative coefficients for LINEAR ONLY (-0.128 for EDF1YEAR and -0.172 for EDF5YEAR) and insignificant coefficients for NON-LINEAR ONLY. Notably, both the lagged and beta regressions reveal significant coefficients for LINEAR & FC DEBT, further supporting the superiority of linear instruments in mitigating default risk.

Delving deeper into the effectiveness of specific linear instruments (FX forwards and FX swaps) within Table 3-6, we observe that the "FORWARDS ONLY" strategy displays significant coefficients for short-term default risk (EDF1YEAR, -0.529 in lagged model and -0.128 in beta model). Conversely, the "SWAPS ONLY" strategy lacks any significant results. This suggests that FX forwards are more impactful in managing short-term default risk compared to FX swaps. For long-term default risk (columns 6 and 7), the beta model results are inconclusive, with identical coefficients for both FORWARDS ONLY and SWAPS ONLY. However, the lagged model offers some evidence that FX swaps influence long-term default risk more than forwards (-0.533 for SWAPS ONLY compared to -0.345 for FORWARDS ONLY).

Overall, the results obtained from lagged and beta specification models corroborate the OLS findings, revealing several key insights: FC debt does not exhibit a hedging effect on default risk. Conversely, FX derivatives demonstrate efficacy in mitigating default probability for both short-term and long-term EDF. Linear hedging strategies emerge as the predominant risk management approach. Consequently, either linear derivatives in isolation or any combination incorporating linear instruments prove effective in diminishing default risk. Swap contracts impact long-term default risk, aligning with their application in hedging long-term exposures. Forwards, meanwhile, exert a more pronounced influence on short-term default probabilities.

Table 3-5: Multivariate regressions of linear with non-linear FX derivatives and/or FC debt on default probability

*This table presents the results of the impact of linear and non-linear FX derivatives on default risk. In panel A the dependent variable is the default risk for a one-year horizon (**EDF1YEAR**) and in panel B the dependent variable is the probability of default for a five-year horizon (**EDF5YEAR**). **LINEAR ONLY, NON-LINEAR ONLY, LINEAR & NON-LINEAR ONLY, LINEAR & FC DEBT, NON-LINEAR & FC DEBT, LINEAR & NON-LINEAR & FC DEBT, FC DEBT ONLY** are dummy variables set equal to 1 if a firm uses the hedging strategy and 0 otherwise. **LEVERAGE** is the ratio of total debt to the market value assets. **PROFITABILITY** is measured as EBITDA over total assets. **VOLATILITY** is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate. **FIRM SIZE** is the natural logarithm of the market value of assets. **LIQUIDITY** is the ratio of total current assets minus total stock and work in progress over total current liabilities. **EXCESS RETURN** is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%, 5%, or 10% levels, respectively. The regressions include industry, country and year dummies.*

	PANEL A: EDF1YEAR				PANEL B: EDF5YEAR			
	OLS	Lag	Beta	SGMM	OLS	Lag	Beta	SGMM
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L.EDF				0.482***				0.584***
				(0.128)				(0.091)
LINEAR ONLY	-0.529***	-0.529**	-0.128***	-1.996**	-0.494***	-0.486***	-0.172***	-1.810***
	(0.201)	(0.256)	(0.048)	(0.967)	(0.134)	(0.168)	(0.043)	(0.638)
NON-LINEAR ONLY	-0.679	-0.744	-0.210	2.584	-0.548	-0.539	-0.275	1.691
	(0.468)	(0.458)	(0.192)	(6.791)	(0.354)	(0.370)	(0.174)	(4.496)
LINEAR & NON-LINEAR ONLY	0.158	-0.237	-0.069	-0.048	0.138	-0.111	-0.079	0.083
	(0.390)	(0.297)	(0.097)	(1.901)	(0.259)	(0.198)	(0.088)	(1.208)
LINEAR & FC DEBT	-0.376*	-0.508*	-0.067	-2.298**	-0.280**	-0.378**	-0.079**	-2.066***
	(0.196)	(0.260)	(0.042)	(1.085)	(0.137)	(0.177)	(0.037)	(0.713)
NON-LINEAR & FC DEBT	0.581	0.169	0.152	-2.387	0.531	0.188	0.184*	-1.511
	(1.163)	(1.054)	(0.118)	(3.290)	(0.903)	(0.783)	(0.103)	(1.938)
LINEAR & NON-LINEAR & FCDEBT	-0.447*	-0.687**	-0.156***	-0.409	-0.339*	-0.519**	-0.199***	-0.261
	(0.253)	(0.311)	(0.055)	(1.713)	(0.174)	(0.209)	(0.049)	(1.102)
FC DEBT ONLY	0.608	0.537	0.245***	0.345	0.579**	0.500	0.234***	-1.068
	(0.388)	(0.462)	(0.056)	(2.388)	(0.286)	(0.332)	(0.048)	(1.557)
				(control variables included)				
Observations	4,922	4,411	4,922	3,478	4,922	4,411	4,922	3,478
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

R-squared	0.371	0.344			0.404	0.386		
Log pseudolikelihood			18627				17298	
Hansen test of over-identification (p-value)				0.989				0.987
AR(1) test (p-value)				0.012				0.002
AR(2) test (p-value)				0.146				0.146

Table 3-6: Multivariate regressions on FX forwards, swaps, options and default probability

*This table presents the results of the impact of types of currency derivatives on the probability of default. In panel A the dependent variable is the probability of default for a one-year horizon (**EDF1YEAR**) and in panel B the dependent variable is the probability of default for a five-year horizon (**EDF5YEAR**). **FORWARDS ONLY, SWAPS ONLY, FORWARDS & SWAPS, FORWARDS & OPTIONS, SWAPS & OPTIONS, SWAPS & OPTIONS, FORWARDS & SWAPS & OPTIONS, OPTIONS ONLY** are dummy variables set equal to 1 if a firm uses the derivative strategy and 0 otherwise. **LEVERAGE** is the ratio of total debt to the market value assets. **PROFITABILITY** is measured as EBITDA over total assets. **VOLATILITY** is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate. **FIRM SIZE** is the natural logarithm of the market value of assets. **LIQUIDITY** is the ratio of total current assets minus total stock and work in progress over total current liabilities. **EXCESS RETURN** is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%, 5%, or 10% levels, respectively. The regressions include industry, country and year dummies.*

	PANEL A: EDF1YEAR				PANEL B: EDF5YEAR			
	OLS	Lag	Beta	SGMM	OLS	Lag	Beta	SGMM
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L.EDF				0.492***				0.557***
				(0.041)				(0.034)
FORWARDS ONLY	-0.477***	-0.491**	-0.063**	-0.456***	-0.412***	-0.345**	-0.134***	-0.459***
	(0.186)	(0.224)	(0.030)	(0.270)	(0.120)	(0.139)	(0.024)	(0.120)
SWAPS ONLY	-0.678	-0.762	-0.096	-0.510	-0.571**	-0.533*	-0.134**	-0.799***
	(0.409)	(0.468)	(0.064)	(0.398)	(0.257)	(0.279)	(0.052)	(0.197)
FORWARDS & SWAPS	-0.830***	-0.834***	-0.207***	-0.535*	-0.798***	-0.732***	-0.336***	-0.695***
	(0.216)	(0.276)	(0.046)	(0.295)	(0.140)	(0.165)	(0.037)	(0.159)
FORWARDS & OPTIONS	-0.662***	-0.710***	-0.157***	-0.462*	-0.615***	-0.609***	-0.247***	-0.425***
	(0.215)	(0.241)	(0.045)	(0.267)	(0.144)	(0.156)	(0.037)	(0.158)
SWAPS & OPTIONS	-0.181	-0.146	0.184	-0.537	-0.146	-0.053	0.067	-0.226
	(0.214)	(0.297)	(0.131)	(0.526)	(0.187)	(0.276)	(0.113)	(0.305)
FORWARDS & SWAPS & OPTIONS	-0.698***	-0.948***	-0.186***	-0.482	-0.636***	-0.740***	-0.262***	-0.558***
	(0.272)	(0.300)	(0.052)	(0.348)	(0.177)	(0.198)	(0.043)	(0.183)
OPTIONS ONLY	-0.225	-0.266	-0.093	-0.508	-0.271	-0.285	-0.113	-0.439
	(0.769)	(0.847)	(0.085)	(0.617)	(0.459)	(0.507)	(0.073)	(0.348)
				(control variables included)				
Observations	6,096	5,440	6,096	4,882	6,096	5,393	6,096	4,882
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.365	0.331			0.385	0.366		
Log pseudolikelihood			25556				24872	
Hansen test of over-identification (p-value)				0.358				0.806
AR(1) test (p-value)				0.000				0.000
AR(2) test (p-value)				0.204				0.389

3.6.3 Robustness check

The subsequent section explores the application of the dynamic panel System Generalized Method of Moments (SGMM) model as a robustness check to counter multiple endogeneity issue in our models. This approach is largely motivated by prior research, such as Zirgulis (2014), who confronts multiple endogenous variables in his investigation into the dynamics of international tax competition for foreign capital inflows and suggests that the most optimal model for this situation is SGMM. In addition, Magee (2013) also employs SGMM in examining currency hedging and firm value to address concerns about the strict exogeneity assumption required by ordinary least squares or fixed effect models. Magee (2013) posits that current hedging levels are influenced by past firm values. Similarly, Chen and King (2014) utilize dynamic SGMM specifications in their analysis of hedging and cost of debt relationships. Our study adopts a similar approach, acknowledging that while hedging can affect default probability, both current and historical default probabilities may influence present hedging decisions. Consequently, we employ the dynamic SGMM model to address these issues of dynamic endogeneity and simultaneity.

To implement this model, we incorporate a one-year lagged value of the Expected Default Frequency (EDF) in our primary regression. This methodology offers a notable advantage: it eliminates the need for new instruments for endogenous variables. Instead, lagged values of the endogenous variables serve as instruments for themselves, while contemporaneous exogenous variables act as instruments for the exogenous variables. In our model, we treat hedging strategy variables and other financial variables as endogenous.

The SGMM framework incorporates two crucial post-estimation diagnostic tests. The initial test evaluates the presence of autocorrelation in the second lag of endogenous variables. Detection of such autocorrelation would suggest potential inadequacy of lagged endogenous variables as instruments for their contemporary counterparts. The subsequent test, known as the Hansen test of over-identification restrictions, assesses the validity of the employed instruments. The desirable outcome is a failure to reject the null hypothesis, which would corroborate the instruments' validity. Comprehensive results are delineated in columns 4 and 8 of Tables 3-4, 3-5, and 3-6, addressing both EDF1YEAR and EDF5YEAR metrics. Across all specifications, the findings consistently affirm a statistically significant relationship between prior default probabilities and current default likelihood.

Concerning FX derivatives and FC debt (*H3-1*), as shown in Table 3-4 columns 4 and 8, FX DERIVATIVE ONLY yields significant coefficients of -2.318 and -2.013 for EDF1YEAR and EDF5YEAR respectively, while FC DEBT ONLY is not significant. The results corroborate the notion that the FC debt hedging strategy, on its own, does not appear to generate a reduction in default probability. This suggests that any potential hedging benefits from FC debt are likely negated or outweighed by its leverage effect. Particularly from column 8 of Table 3-4, the significant coefficient of -1.316 for FX DERIVATIVE & FC DEBT indicates that the negative effect on default likelihood of FX derivative is reduced if combined with FC debt. Hence, combining both methods is not as effective as using solely FX derivatives to hedge. As for the two post-estimation tests, the AR(2) p-values of 0.178 (EDF1YEAR) and 0.137 (EDF5YEAR) suggest that it is appropriate to use the second lag of the endogenous variables as instruments. In addition, the failure to reject the null hypothesis of the Hansen test (p-value of 0.859 in EDF1YEAR and 0.816 in EDF5YEAR) confirms the validity of the instrument.

As for linear and non-linear strategies (*H3-2*), columns 4 and 8 of Table 3-5 present coefficients for LINEAR ONLY that are statistically significant and negative for both short-term (EDF1YEAR, -1.996) and long-term (EDF5YEAR, -1.810) default probabilities. Conversely, the coefficients for NON-LINEAR ONLY are insignificant. These findings conclusively demonstrate that linear FX derivative strategies are more successful in mitigating default risk across both short and long-term horizons compared to their non-linear counterparts. In addition, significant results for LINEAR & FC DEBT indicate that using linear derivatives or a combination involving linear derivatives could reduce default risk for both short and long-term better than non-linear counterparts. The post-estimation diagnostics yield favourable results for both EDF1YEAR and EDF5YEAR models. The AR(2) test produces p-values of 0.146 for both metrics, indicating the absence of second-order serial correlation and thus validating the use of second-order lags of endogenous variables as instruments. Furthermore, the Hansen test fails to reject the null hypothesis, with p-values of 0.989 and 0.987 for EDF1YEAR and EDF5YEAR respectively, which substantiate the overall validity of the instrumental variables employed in the SGMM model.

Regarding FX forwards and swaps (*H3-3*), according to Table 3-6 column 4, we observe a significant negative coefficient (-0.453) for the FORWARDS ONLY strategy, while SWAPS ONLY lacks significance. This aligns with the findings from OLS, Lag, and Beta models, reinforcing the notion that FX forwards are more impactful in managing short-term default risk compared to FX swaps. Column 8 of Table 3-6 showcases a statistically significant difference between the coefficients of SWAPS ONLY (-0.79) and FORWARDS ONLY (-0.45). This suggests that FX swap contracts hold a greater influence in mitigating long-term default risk when compared to FX forwards. The post-estimation tests support the chosen modelling approach. The p-values of the Arellano-Bond (AR(2)) tests for second-order autocorrelation in the differenced residuals are 0.204 (one-year lagged dependent variable) and 0.389 (five-year lagged dependent variable). These non-significant p-values indicate the absence of second-order autocorrelation, suggesting that the second lags of the endogenous variables are appropriate instruments. Furthermore, the Hansen tests for overidentifying restrictions yield p-values of 0.358 (one-year lagged) and 0.806 (five-year lagged), respectively. These high p-values (> 0.05) imply that we cannot reject the null hypothesis of valid instruments. Collectively, these tests provide evidence for the internal validity of the system GMM model and the chosen instruments.

In addition to the SGMM model, we expand our robustness check by running regression focusing on middle-sized firms only, following Aabo et al. (2013). In the context of exchange rate exposure management, medium-sized firms present a particularly intriguing subject for analysis. These firms typically possess sufficient scale and sophistication to be susceptible to and responsive toward exchange rate volatility. Simultaneously, they generally lack the extensive international network of foreign subsidiaries that characterizes large multinational corporations, which often renders the latter almost impervious to fluctuations in exchange rates. This unique positioning makes medium-sized firms especially vulnerable to currency risks while also potentially more proactive in their management strategies. We run regressions for a sample of middle-sized firms for models [6], [7] and [8]. The findings are fully displayed in Table 3-7, in which columns 1 and 4 are the results for FX derivatives and FC debts specification, columns 2 and 5 are the results for linear and non-linear specification, and columns 3 and 6 are the results for forwards and swaps specification.

Table 3-7: Effect of currency hedging on default risk with sample of middle-sized firms

*This table presents the results of the impact of currency hedging on the probability of default for middle-sized firms. In panel A the dependent variable is the probability of default for a one-year horizon (**EDF1YEAR**) and in panel B the dependent variable is the probability of default for a five-year horizon (**EDF5YEAR**). **FX DERIVATIVE ONLY** is a dummy variable set equal to 1 if a firm uses FX derivatives only and 0 otherwise. **FC DEBT ONLY** is a dummy variable set equal to 1 if a firm uses FC Debt only and 0 otherwise. **FX DERIVATIVE & FCDEBT** is a dummy variable set equal to 1 if a firm uses FC Debt with FX derivatives and 0 otherwise. **LINEAR ONLY, NON-LINEAR ONLY, LINEAR & NON-LINEAR ONLY, LINEAR & FC DEBT, NON-LINEAR & FC DEBT, LINEAR & NON-LINEAR & FC DEBT, FC DEBT ONLY** are dummy variables set equal to 1 if a firm uses the hedging strategy and 0 otherwise. **FORWARDS ONLY, SWAPS ONLY, FORWARDS & SWAPS, FORWARDS & OPTIONS, SWAPS & OPTIONS, SWAPS & OPTIONS, FORWARDS & SWAPS & OPTIONS, OPTIONS ONLY** are dummy variables set equal to 1 if a firm uses the derivative strategy and 0 otherwise. **LEVERAGE** is the ratio of total debt to the market value assets. **PROFITABILITY** is measured as EBITDA over total assets. **VOLATILITY** is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate. **FIRM SIZE** is the natural logarithm of the market value of assets. **LIQUIDITY** is the ratio of total current assets minus total stock and work in progress over total current liabilities. **EXCESS RETURN** is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%, 5%, or 10% levels respectively. The regressions include industry, country and year dummies.*

	PANEL A: EDF1YEAR			PANEL B: EDF5YEAR		
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
FX DERIVATIVES ONLY	-0.414*			-0.358**		
	(0.218)			(0.145)		
FX DERIVATIVES & FC DEBT	-0.406*			-0.272*		
	(0.225)			(0.155)		
FC DEBT ONLY	0.582	0.608		0.578*	0.579**	
	(0.400)	(0.388)		(0.293)	(0.286)	
LINEAR ONLY		-0.529***			-0.494***	
		(0.201)			(0.134)	
NON-LINEAR ONLY		-0.679			-0.548	
		(0.468)			(0.122)	
LINEAR & NON-LINEAR ONLY		0.158			0.138	
		(0.390)			(0.259)	
LINEAR & FC DEBT		-0.376*			-0.280**	
		(0.196)			(0.137)	
NON-LINEAR & FC DEBT		0.581			0.531	
		(1.163)			(0.903)	
LINEAR & NON-LINEAR & FCDEBT		-0.447*			-0.339*	
		(0.253)			(0.174)	
FORWARDS ONLY			-0.385**			-0.285**
			(0.176)			(0.118)
SWAPS ONLY			-0.576			-0.485*
			(0.416)			(0.261)
FORWARDS & SWAPS			-0.653***			-0.546***
			(0.200)			(0.139)
FORWARDS & OPTIONS			-0.569***			-0.432***
			(0.206)			(0.143)
SWAPS & OPTIONS			-0.081			0.069
			(0.205)			(0.167)
FORWARDS & SWAPS & OPTIONS			-0.579**			-0.427***
			(0.262)			(0.184)
OPTIONS ONLY			0.158			-0.148
			(0.766)			(0.490)
			(control variables included)			
Observations	4,925	4,922	6,096	4,925	4,922	6,096
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.371	0.371	0.364	0.402	0.404	0.393

From the results in Table 3-7, columns 1 and 4, we observe that FX derivatives exhibit a statistically significant negative impact on default probability. This is reflected in the coefficients of -0.414 for (EDF1YEAR and -0.358 for EDF5YEAR. These negative coefficients indicate that firms using FX derivatives experience a reduction in default risk. In contrast, FC debt does not appear to be an effective hedging tool. The coefficient for FC DEBT ONLY in EDF1YEAR is statistically insignificant, implying no clear association with default risk. However, the model for EDF5YEAR shows a significant and positive coefficient (0.578). This suggests that FC debt might not be beneficial for mitigating long-term default risk and could even be associated with an increased risk of default in the long run.

Columns 2 and 5 of Table 3-7 demonstrate that linear FX derivatives exhibit greater efficacy in mitigating default risk compared to their non-linear counterparts. This is evidenced by statistically significant coefficients ($p < 0.01$) of -0.529 and -0.494 for FX LINEAR ONLY in the one-year and five-year Expected Default Frequency (EDF) models, respectively. The significance of various combinations involving linear derivatives further corroborates their primary role in default risk reduction.

Examining the specific effects of FX forwards versus FX swaps, column 3 (EDF1YEAR) of Table 3-7 shows a significant coefficient of -0.385 for FORWARDS ONLY, while SWAPS ONLY yields no significant result. This suggests that FX forwards are more effective in diminishing short-term default probability, aligning with their typical application in hedging short-term exposures. On the other hand, column 6 (EDF5YEAR) indicates that SWAPS ONLY has a significant coefficient of -0.485, surpassing that of FORWARDS ONLY (-0.285). This finding implies that FX swaps are more effective in mitigating long-term default probability, consistent with their predominant use in hedging long-term exposures.

Overall, the results from the dynamic SGMM method and sample of middle-sized firms are consistent and similar to what we find in other model specifications (OLS, Lag, Beta). We document that FC debt is not an optimal hedging instrument as the leverage effect can neutralize (short-term default risk) or even dominate (long-term default risk) the hedging effect. In order words, firms employing FC debt as a hedging strategy face an elevated probability of default, attributable to increased interest payment obligations. Consequently, the exclusive use of FX derivatives may prove more efficacious in risk mitigation than a combined strategy of derivatives and FC debt. We also document that linear strategies (forwards or swaps) are more effective in terms of risk reduction than non-linear counterparts (option contracts). Additionally, we present evidence suggesting that FX forward contracts have a more pronounced impact on mitigating near-term default risk. Conversely, FX swap contracts appear to exert a more substantial influence on reducing long-term default probability.

3.6.4 The role of debt enforcement

Differences in economic, financial, and political features among countries offer opportunities to empirically test current or novel implications for risk management theory. The research conducted by Gatopoulos and Louberge (2013) presents compelling theoretical and empirical evidence that highlights the significant influence of country-specific factors, such as a nation's overall susceptibility to currency crises, on firms' strategies regarding FC debt and hedging activities. Particularly, in this analysis, we are interested in examining the legal environment. The reason is that within the financial hedging literature, various studies investigate the connection between the legal environment and decision to hedge or the extent of hedging. However, the findings are mixed and inconclusive. Bartram et al. (2009) test the hypothesis that firms tend to hedge more in countries with more efficient legal systems but find no evidence. Bartram et al. (2009) use the legality index proposed by Berkowitz et al. (2003) to measure how efficient a legal environment is. Because our paper covers the use of FX derivative and especially FC debt as hedging instruments, we are keen on examining if debt enforcement efficiency in a country could possibly impact the effectiveness of FX hedging. We hypothesize that if debt enforcement in a country is efficient, the creditors will have more opportunity to exercise their power over borrowers. As a result, firms would be more likely to hedge to avoid unfavourable consequences of defaulting on their debt and we could witness an increase in the magnitude of the effect of hedging on default likelihood. Alternatively, we predict that in countries with higher levels of debt enforcement, creditors find it easier to exercise their rights, as a result, the creditors are more likely to take legal action against defaulting firms, leading to higher default likelihood. In this test, we will use the debt enforcement index introduced by Djankov et al. (2008) to measure how efficient debt contracts are enforced in a country. We interact the score with each of the hedging dummies, including FX DERIVATIVE ONLY, FX DEBT ONLY, FX DERIVATIVE

& FC debt. Thus, if firms adopt derivatives or FC debt for hedging incentives, we expect a negative coefficient of the interaction term, indicating that the effect of hedging will be more pronounced as the debt enforcement index rises. The results are fully displayed in Table 3-8.

As can be seen from the table, the coefficients of the interaction terms are significantly positive. In particular, the estimate of the interaction term between FC DEBT ONLY and the debt enforcement index is 0.050; and that of the interaction term between FX DERIVATIVE & FC DEBT and the debt enforcement index is 0.020. On the other hand, the interaction term between the debt enforcement index and FX DERIVATIVE ONLY is not significant. The results suggest that as debt enforcement is more efficient, the coefficients of FC DEBT ONLY or FX DERIVATIVE & FC DEBT are reduced.

This follows then that the effect of FC debt on default risk is more positive as debt enforcement in a country becomes more efficient. When debt enforcement is more efficient, the consequences of default are more severe for firms. Lenders are more likely to take legal actions to recover the debt. These actions may include the seizure of corporate assets, potentially precipitating genuine bankruptcy scenarios for the defaulting firms. Therefore, firms that use FC debt in high enforcement environments are at higher risk of default due to more severe consequences of default. Based on our findings, a crucial implication emerges for firms operating within environments characterized by strict debt enforcement. These firms should exercise particular caution when contemplating the usage of FC debt for hedging purposes. Our study suggests that the effect of FC debt on the likelihood of default becomes more positive in such settings. Additionally, it seems that debt enforcement efficiency does not seem to influence FX derivatives, only FC debt. The results for EDF5YEAR are similar to what we find for EDF1YEAR. We also document similar findings when using the legality index by Berkowitz, Pistor and Richard (2003), as a robustness-checking method[26].

[26] Appendix 3-2

Table 3-8: Impact of debt enforcement on the effect of currency hedging on default risk

*This table presents the results of the impact of debt enforcement on the effect of currency hedging on default risk. The dependent variables are **EDF1YEAR, EDF5YEAR**. **FX DERIVATIVE ONLY** is a dummy variable set equal to 1 if a firm uses FX derivatives only and 0 otherwise. **FC DEBT ONLY** is a dummy variable set equal to 1 if a firm uses FC Debt only and 0 otherwise. **FX DERIVATIVE & FCDEBT** is a dummy variable set equal to 1 if a firm uses FC Debt with FX derivatives and 0 otherwise. **DEBT ENFORCEMENT** is debt enforcement efficiency index. **LEVERAGE** is the ratio of total debt to the market value assets. **PROFITABILITY** is measured as EBITDA over total assets. **VOLATILITY** is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate. **FIRM SIZE** is the natural logarithm of total assets. **LIQUIDITY** is the ratio of total current assets minus total stock and work in progress over total current liabilities. **EXCESS RETURN** is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%, 5%, or 10% levels, respectively. The regressions include industry and year dummies*

Variables	EDF1YEAR	EDF5YEAR
FX DERIVATIVE ONLY	-1.021	-0.182
	(0.756)	(0.507)
FC DEBT ONLY	-3.589***	-2.830***
	(1.219)	(0.927)
FX DERIVATIVE & FC DEBT	-2.448***	-1.293**
	(0.778)	(0.545)
FX DERIVATIVE ONLY*DEBT ENFORCEMENT	0.004	-0.006
	(0.010)	(0.007)
FC DEBT ONLY*DEBT ENFORCEMENT	0.050***	0.040***
	(0.018)	(0.013)
FX DERIVATIVE & FC DEBT*DEBT ENFORCEMENT	0.020**	0.008
	(0.010)	(0.007)
DEBT ENFORCEMENT	-0.018**	-0.452***
	(0.009)	(0.127)
LEVERAGE	5.357***	3.977***
	(0.698)	(0.477)
PROFITABILITY	-1.968**	-1.770***
	(0.920)	(0.623)
VOLATILITY	0.066***	0.044***
	(0.006)	(0.004)
FIRM SIZE	-0.001	-0.038
	(0.043)	(0.031)
LIQUIDITY	-0.050*	-0.035**
	(0.026)	(0.018)
EXCESS RETURN	-0.376	-0.268
	(0.536)	(0.376)
Constant	-0.264	0.071
	(0.708)	(0.481)
Observations	4,925	4,925
Industry FE	Yes	Yes
Year FE	Yes	Yes
R-squared	0.364	0.391

3.6.5 Low level of debt enforcement with high level of foreign sales

Our results, thus far, suggest that hedging with FC debt does not necessarily reduce default probability; it could even increase the long-term risk of default. This effect is more positive when firms operate in a country with more efficient debt enforcement mechanisms. However, it could also be inferred that the less efficient the debt enforcement, the less positive the impact of FC debt on default risk. Additionally, in accordance with Judge and Clark (2004), firms tend to use FC debt rather than FX derivatives to hedge their foreign currency exposure from assets located overseas. In other words, firms with foreign currency exposure from foreign operations might structure their balance sheets so that foreign assets are matched with foreign debt. Building on these findings, we aim to test whether using FC debt as a hedging tool could potentially reduce default probability for firms with high levels of foreign assets, especially in countries with low debt enforcement efficiency. To test this hypothesis, we run the model specification [6] for a sample of firms with higher than median foreign sales over total sales and operating in lower than median debt enforcement efficiency index. We follow Judge and Clark (2004) in using foreign sales to measure firm's underlying FX exposure. A higher level of foreign sales could indicate a higher level of foreign assets.

The results are displayed in Table 3-9, with column (1) for EDF1YEAR and column (2) for EDF5YEAR. As can be seen from the table, FC DEDT ONLY has significant, at 1% level, negative coefficients for both short-term and long-term default probabilities (-1.401 for EDF1YEAR and -1.004 for EDF5YEAR). Consistent with our expectations, these results demonstrate that hedging with FC debt reduces the likelihood of default for firms with high levels of foreign sales and in a country where the efficiency of debt enforcement is low. This corroborates with Judge and Clark (2004) in the notion that firms with high levels of foreign assets tend to hedge by matching foreign assets with foreign debts. It follows that in general, according to our findings, the use of FC debt as a hedging tool is not effective as it could increase the probability of default. However, hedging with FC debt is beneficial in terms of default risk mitigation, especially for firms with high levels of foreign sales and operating in a less efficient debt enforcement environment.

Table 3-9: Effect of currency hedging strategies on default risk for firms with high foreign sales and in less efficient debt enforcement environment

*This table presents the results of the effect of currency hedging strategies on default risk for firms with high foreign sales and in less efficient debt enforcement environment. High level of foreign sales is identified by higher than median foreign sales to total sales. Low level of debt enforcement efficiency is identified by lower than median debt enforcement efficiency index. The dependent variables are **EDF1YEAR, EDF5YEAR**. **FX DERIVATIVE ONLY** is a dummy variable set equal to 1 if a firm uses FX derivatives only and 0 otherwise. **FC DEBT ONLY** is a dummy variable set equal to 1 if a firm uses FC Debt only and 0 otherwise. **FX DERIVATIVE & FCDEBT** is a dummy variable set equal to 1 if a firm uses FC Debt with FX derivatives and 0 otherwise. **LEVERAGE** is the ratio of total debt to the market value assets. **PROFITABILITY** is measured as EBITDA over total assets. **VOLATILITY** is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate. **FIRM SIZE** is the natural logarithm of total assets. **LIQUIDITY** is the ratio of total current assets minus total stock and work in progress over total current liabilities. **EXCESS RETURN** is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%, 5%, or 10% levels, respectively. The regressions include industry, country and year dummies .*

Variables	**EDF1YEAR**	**EDF5YEAR**
	(1)	(2)
FX DERIVATIVE ONLY	-0.318	-0.175
	(0.380)	(0.248)
FC DEBT ONLY	-1.401***	-1.004***
	(0.311)	(0.206)
FX DERIVATIVE & FC DEBT	-0.153	0.003
	(0.487)	(0.337)
LEVERAGE	4.824***	3.930***
	(1.432)	(0.872)
PROFITABILITY	-2.636*	-1.954**
	(1.410)	(0.926)
VOLATILITY	0.057***	0.038***
	(0.012)	(0.008)
FIRM SIZE	-0.435***	-0.344***
	(0.109)	(0.074)
LIQUIDITY	-0.128***	-0.086***
	(0.043)	(0.029)
EXCESS RETURN	-0.128	0.065
	(0.600)	(0.384)
Constant	-2.329**	2.161***
	(0.982)	(0.636)
Observations	1,535	1,535
Industry FE	Yes	Yes
Countries FE	Yes	Yes
Year FE	Yes	Yes
R-squared	0.361	0.413

3.6.6 High growth versus low growth firms

In the preceding sections of this chapter, we have presented empirical evidence indicating that the use of non-linear FX hedging strategies, specifically FX options, does not appear to significantly reduce the probability of default when compared to alternative hedging methods such as swaps or forwards. This finding contrasts with the prevailing perspective advocated by several existing studies, including Froot et al. (1993), Adam (2009), or Gamba and Triantis (2014), which suggest that non-linear hedging strategies represent an optimal approach for some firms. The theoretical rationale behind this assertion lies in the notion that firms seek to align their cash inflows and outflows, particularly when external capital is costly. In instances where firms undertake substantial investment programs, there is a greater likelihood of a mismatch between cash inflows and outflows, thereby necessitating a non-linear hedging approach to effectively mitigate this non-linearity in expenditures. Bartram (2006) also supports the notion that option contracts emerge as particularly effective hedging instruments in scenarios where firms encounter nonlinear exposures. Consequently, we seek to explore whether our sample data can provide further insights into this matter, particularly in discerning whether FX option derivatives may serve as effective hedging tools under specific circumstances.

To capture firm growth or investment programs, we employ the ratio of capital expenditure to total assets as our measure. Subsequently, we conduct regression analyses using subsamples comprising firms with low growth and high growth, corresponding to the bottom and top 20% of capital expenditure over total assets, respectively. Guided by our hypothesis positing that firms experiencing rapid growth are more inclined to use non-linear hedging strategies, while those with slower growth tend to favour linear derivatives, we anticipate observing a stronger impact of non-linear derivatives on default probability among high-growth firms, with linear strategies exerting a more pronounced effect on default risk among low-growth firms.

Table 3-10 displays the full results for this section in both EDF1YEAR and EDF5YEAR. According to column 1, which is the results for the bottom 20% of CAPEX to total assets, the coefficient of linear derivative only is significant at -0.691, while that of non-linear only is not significant. Additionally, LINEAR & FC DEBT variable also has a negative and significant estimate of -0.70. Those results indicate that for firms with low growth or small investment programs, the use of linear derivatives to hedge is more effective in terms of default risk reduction, whereas a non-linear strategy does not seem to work. From column 2, which displays the results for the top 20% of CAPEX to total assets, we can see that both LINEAR ONLY and NON-LINEAR ONLY are significantly negative. Interestingly, the coefficient for NON-LINEAR ONLY is significant at 1% and larger than that of linear only (-1.33 compared with -0.79). Consistent with our expectation, the results demonstrate that non-linear strategy can reduce default risk more for firms with high growth, and linear strategies seem to benefit firms with low growth more. The results for EDF5YEAR (columns 4 and 5) are similar to those of EDF1YEAR, which supports the notion that low-growth firms prefer linear strategy, while non-linear derivatives are optimal for firms with high growth.

Table 3-10: Impact of currency hedging on the probability of default between high and low growth firms

*This table presents the results of the impact of currency hedging on the probability of default between high and low growth firms. In panel A the dependent variable is the probability of default for a one-year horizon (**EDF1YEAR**) and in panel B the dependent variable is the probability of default for a five-year horizon (**EDF5YEAR**). **LINEAR ONLY, NON-LINEAR ONLY, LINEAR & NON-LINEAR ONLY, LINEAR & FC DEBT, NON-LINEAR & FC DEBT, LINEAR & NON-LINEAR & FC DEBT, FC DEBT ONLY** are dummy variables set equal to 1 if a firm uses the hedging strategy and 0 otherwise. **CAPEX TO SALES** is the ratio of capital expenditure to total sales. **LEVERAGE** is the ratio of total debt to the market value assets. **PROFITABILITY** is measured as EBITDA over total assets. **VOLATILITY** is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate. **FIRM SIZE** is the natural logarithm of the market value of assets. **LIQUIDITY** is the ratio of total current assets minus total stock and work in progress over total current liabilities. **EXCESS RETURN** is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%, 5%, or 10% levels, respectively. The regressions include industry, country and year dummies.*

Variables	**EDF1YEAR**		**EDF5YEAR**	
CAPEX TO SALES	Bottom 20%	Top 20%	Bottom 20%	Top 20%
	(1)	(2)	(3)	(4)
LINEAR ONLY	-0.691*	-0.795**	-0.628**	-0.686***
	(0.374)	(0.384)	(0.276)	(0.262)
NON-LINEAR ONLY	-0.514	-1.331***	-0.526	-1.092***
	(1.046)	(0.357)	(0.765)	(0.244)
LINEAR & NON-LINEAR ONLY	-0.094	0.802	0.050	0.465
	(0.505)	(0.511)	(0.337)	(0.349)
LINEAR & FC DEBT	-0.701**	-0.509	-0.562**	-0.442*
	(0.343)	(0.336)	(0.266)	(0.254)
NON-LINEAR & FC DEBT	-1.202	2.720	-0.238	1.868
	(0.877)	(2.008)	(0.651)	(1.407)
LINEAR & NON-LINEAR & FC DEBT	0.466	-0.272	0.389	-0.356
	(0.768)	(0.422)	(0.575)	(0.302)
FC DEBT ONLY	0.077	0.756	0.351	0.479
	(0.576)	(0.763)	(0.444)	(0.531)
		(control variables included)		
Observations	603	740	603	740
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
R-squared	0.426	0.413	0.435	0.457

3.7 Conclusion

Drawing on a comprehensive panel dataset encompassing six countries (Germany, France, Italy, Norway, Spain, and the UK) over the period from 1999 to 2015, this study examines the impact of various currency hedging strategies, specifically those utilizing foreign exchange (FX) derivatives and/or foreign currency (FC) debt, on the likelihood of default among non-financial firms. Our analysis yields several key conclusions:

First of all, FX derivatives are shown to significantly reduce the probability of default, while FC debt, by contrast, does not demonstrate a mitigating effect on default risk and may even contribute to an elevated likelihood of long-term default. Secondly, linear FX derivatives are found to be more effective than non-linear strategies in reducing default probability. This finding is consistent with the perspective that non-linear derivatives, such as options, are often employed for speculative purposes rather than purely for hedging (Bartram, 2006; Dash et al., 2007). Thirdly, the effectiveness of non-linear and linear FX derivatives varies depending on firm characteristics. Firms exhibiting high growth, as proxied by capital expenditures (CAPEX) relative to sales, experience greater reductions in default risk when hedging with non-linear derivatives, whereas firms with lower growth tend to benefit more from the use of linear FX derivatives. Fourthly, within the linear derivative category, FX swaps are observed to have a greater impact on reducing long-term default probability, while FX forwards exert a stronger influence on mitigating short-term default risk. Fifthly, the influence of FC debt on default probability appears to be contingent upon the level of debt enforcement efficiency in a country. Our findings indicate that the more efficient the debt enforcement system, or the more easily lenders can pursue legal recourse in the event of default, the more FC debt positively influences default risk. Last but not least, interestingly, hedging with FC debt is found to reduce the probability of default, particularly for firms that operate in countries characterized by low levels of debt enforcement efficiency and that maintain a high proportion of foreign sales.

Appendix to Chapter 3 "The impact of derivative use on default probability among non-financial firms: Evidence from European firms"

This supplementary section presents ancillary data and analytical findings. Specifically, Appendix 3.1 illustrates exemplars of corporate currency risk management strategies, encompassing foreign exchange derivatives and foreign currency debt, as disclosed in annual financial statements. Appendix 3.2 delineates the statistical outcomes from regression analyses investigating the interplay between economic risk and the influence of derivative instruments on default probability, using legality index. Appendix 3.3 furnishes an exhaustive catalogue of variables utilized throughout the chapter, accompanied by their precise definitions and bibliographic sources.

Appendix 3.1: Examples of foreign exchange hedging strategies in annual reports

Abbot Group Annual report 2013

Page 46:

"Certain Abbott foreign subsidiaries enter into foreign currency forward exchange contracts to manage exposures to changes in foreign exchange rates for anticipated intercompany purchases by those subsidiaries whose functional currencies are not the US dollar."

"Abbott has designated foreign-denominated short-term debt as a hedge of the net investment in a foreign subsidiary of approximately $505 million, $615 million and $680 million as of December 31, 2013, 2012 and 2011, respectively. Accordingly, changes in the fair value of this debt due to changes in exchange rates are recorded in Accumulated other comprehensive income (loss), net of tax."

Pearson Annual Report 2012

Page 141:

"Although the Group is based in the UK, it has its most significant investment in overseas operations. The most significant currency for the Group is the US dollar. The Group's policy on routine transactional conversions between currencies (for example, the collection of receivables, and the settlement of payables or interest) remains that these should be transacted at the relevant spot exchange rate. The majority of the

Group's operations are domestic within their country of operation. No unremitted profits are hedged with foreign exchange contracts, as the company judges it inappropriate to hedge non-cash flow translational exposure with cash flow instruments. However, the Group does seek to create a natural hedge of this exposure through its policy of aligning approximately the currency composition of its core net borrowings (after the impact of cross-currency rate derivatives) with its forecast operating profit before depreciation and amortisation"

"The Group uses both currency denominated debt and derivative instruments to implement the above policy. Its intention is that gains/losses on the derivatives and debt offset the losses/gains on the foreign currency assets and income. Each quarter the value of hedging instruments is monitored against the assets in the relevant currency and, where practical, a decision is made whether to treat the debt or derivative as a net investment hedge (permitting foreign exchange movements on it to be taken to reserves) for the purposes of IAS 39."

Informa Annual Report 2010

Page 91

"Historically and for the foreseeable future the Group has been and is expected to continue to be in a net borrowing position. The Group's policy is to fulfil its borrowing requirements by borrowing in the currencies in which it operates, principally GBP, USD and EUR; thereby providing a natural hedge against projected future surplus USD and EUR cash inflows as well as spreading the Group's interest rate profile across a number of currencies."

Rolls Royce Annual Report 2008

Page 64:

"The Group regards its interests in overseas subsidiary companies as long-term investments. The Group aims to match its translational exposures by matching the currencies of assets and liabilities. Where appropriate, foreign currency financial liabilities may be designated as hedges of the net investment."

Britvic Annual Report 2012

Page 80:

“Foreign currency risk is primarily in respect of exposure to fluctuations to the sterling-euro, sterling-US dollar and euro-US dollar rates of exchange. The group has operations in euro-denominated countries and finances these partly through the use of foreign currency borrowings and cross currency swaps which hedge the translation risk of net investments in foreign operations.”

Appendix 3.2: Table of regression results for impact of debt enforcement on hedging (legality index)

*This table presents the results of the impact of legality on the effect of currency hedging on the probability of default. The dependent variables are **EDF1YEAR, EDF5YEAR**. **FX DERIVATIVES ONLY** is a dummy variable set equal to 1 if a firm uses FX derivatives only and 0 otherwise. **FC DEBT ONLY** is a dummy variable set equal to 1 if a firm uses FC Debt only and 0 otherwise. **FX DERIVATIVES & FCDEBT** is a dummy variable set equal to 1 if a firm uses FC Debt with FX derivatives and 0 otherwise. **LEGALITY** is legality index by Berkowitz, Pistor and Richard (2003), higher value indicates higher level of legal effectiveness. **LEVERAGE** is the ratio of total debt to the market value assets. **PROFITABILITY** is measured as EBITDA over total assets. **VOLATILITY** is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate. **FIRM SIZE** is the natural logarithm of total assets. **LIQUIDITY** is the ratio of total current assets minus total stock and work in progress over total current liabilities. **EXCESS RETURN** is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%, 5%, or 10% levels, respectively. The regressions include industry and year dummies.*

Variables	EDF1YEAR	EDF5YEAR
FX DERIVATIVES ONLY	-1.735	-0.312
	(2.521)	(1.728)
FC DEBT ONLY	-16.805***	-11.821***
	(6.027)	(4.333)
FX DERIVATIVES & FC DEBT	-5.592*	-3.002
	(2.880)	(2.020)
FX DERIVATIVES ONLY*LEGALITY	0.052	-0.045
	(0.128)	(0.087)
FC DEBT ONLY*LEGALITY	0.854***	.610***
	(0.311)	(0.013)
FX DERIVATIVES & FC DEBT*LEGALITY	0.232	0.116
	(0.144)	(0.101)
LEGALITY	-0.061	0.107
	(0.316)	(0.079)
LEVERAGE	5.447***	4.122***
	(0.696)	(0.475)
PROFITABILITY	-1.849**	-1.705***
	(0.938)	(0.629)
VOLATILITY	0.064***	0.042***
	(0.006)	(0.004)
FIRM SIZE	-0.051	-0.072
	(0.039)	(0.027)
LIQUIDITY	-0.048*	-0.037**
	(0.025)	(0.018)
EXCESS RETURN	-0.382	-0.264
	(0.527)	(0.369)
Constant	-1.476	-2.121
	(2.235)	(1.534)
Observations	4,925	4,925
Industry FE	Yes	Yes
Year FE	Yes	Yes
R-squared	0.366	0.397

Appendix 3.3: Definition of variables and empirical prediction employed in Chapter 3

Variables	Definition	Source	Predicted sign
EDF	Expected default frequency	Moody's Analytics	
FX DERIVATIVE ONLY	Dummy variable set to 1 for firms using long-term IR derivatives only; 0 otherwise	Annual report	+/-
FC DEBT ONLY	Dummy variable set to 1 for firms using short-term IR derivatives only; 0 otherwise	Annual report	+/-
FX DERIVATIVES & FC DEBT	Dummy variable set to 1 for firms using both long and short-term IR derivatives; 0 otherwise	Annual report	+/-
LEVERAGE	Total debt/ (assets book value – equity book value + equity market value)	Datastream	+
FIRM SIZE	Natural logarithm of (total debt + market value of equity)	Datastream	-
EXESS RETURN	Annual equity return – annual return of stock index	Yahoo Finance	-
LIQUIDITY	(Total current assets – total stock and work in progress) / total current liabilities	Datastream	-
PROFITABILITY	EBITDA/ total assets	Datastream	-
EQUITY VOLATILITY	Standard deviation of daily stock return in one fiscal year	Datastream	+
CAPEX TO SALES	CAPEX divided by total sales	Datastream	
DEBT ENFORCEMENT	Debt enforcement efficiency index	Djankov et al. (2008)	

Chapter 4: The impact of long-term and short-term interest rate derivatives and default risk

4.1 Introduction

In today's dynamic economic environment, businesses across various sectors are increasingly exposed to interest rate risk. This risk poses a significant threat to their financial performance and, ultimately, their ability to survive and thrive in a competitive market. As interest rates fluctuate, firms that have not implemented prudent hedging strategies to mitigate their interest rate exposure face the risk of substantial financial losses, which could potentially cripple their operations and undermine their long-term viability. To combat this formidable challenge, firms have at their disposal a powerful arsenal of interest rate (IR) derivatives, such as interest rate forwards, swaps, and options. These financial instruments serve as crucial hedging tools, enabling businesses to effectively manage and mitigate their interest rate exposure. By employing these derivatives judiciously, firms can safeguard themselves against the impacts of interest rate volatility, ensuring a more stable and predictable financial environment.

Among all types of derivatives, IR derivative is considered the most popular financial product. In fact, the interest rate derivative market is the largest derivative market in the world. According to ESMA’s annual statistical report in 2021[27], interest rate derivatives account for 79% of the total notional amount of the market, with more than $400 trillion. However, the effectiveness of IR derivatives in reducing default risk is subject to debate. Moreover, the question of whether or not those instruments could mitigate default risk is important in light of tightening monetary policy in response to rising inflation from the Bank of England or European Central Bank.

To cope with an inflation rate of a high 11.1% in October 2022, which was far above MPC’s target of 2%, from November 2021, the Bank of England implemented a series of 14 consecutive interest rate increases, ultimately reaching 5.25%, a level not seen since February 2008. Following this period of rate increases, the Bank has maintained

[27] *EU derivatives markets* (2021) ESMA. Available at: https://www.esma.europa.eu/sites/default/files/library/esma50-165 -2001_emir_asr_derivatives_2021.pdf

the interest rate at its current level for seven consecutive policy meetings, with the most recent decision to hold rates occurring in June 2024[28].

The European Central Bank (ECB) has continued to raise interest rates to combat persistent inflation, despite concerns about a potential economic slowdown in the Eurozone. This latest increase in September 2023 marks the tenth consecutive rate hike, bringing the deposit rate to 4% its highest level since the euro's inception[29]. In addition, according to Fitch Ratings, there is an increase in default rates in the European high-yield and institutional leveraged loan markets in the years 2024 and 2025[30]. This is mainly because of the weaker macroeconomic growth and rising interest rates.

The amount of research on interest rate derivatives and default risk is very scarce. The majority of prior studies on hedging and default risk put more focus on FX derivatives. (Marin, 2013; Magee, 2013; Boyer and Marin, 2013). In addition, previous studies concentrate on IR swaps (Faulkender, 2005; Chernenko and Faulkender, 2011; Jermann and Yue, 2018; Hecht, 2019) and neglect the potential different effects from other types of IR derivatives. Particularly, the choice between long and short-term IR instruments may be a critical factor in determining the success of interest rate hedging. While long-term instruments, such as IR swaps, are often used to hedge against long-term exposures, short-term instruments, such as IR options and forwards, may be more appropriate for shorter-term exposures. Consequently, there may be variations in effects of long and short-term IR derivatives on default risk. In fact, IR swaps maintain their position as the dominant traded instruments, comprising nearly two-thirds of global turnover, as reported in a 2019 Bank for International Settlements analysis[31]. However, recent years have seen some upward movement in the use of other types of IR derivatives, especially IR forwards, which account for 16% of the notional amount of the EU’s IR derivative market in 2020, as reported by ESMA in 2021. Additionally,

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[28] *Bank rate maintained at 5.25% - May 2024* (2024) *Bank of England*. Available at: https://www.bankofengland.co.uk/monetary-policy-summary-and-minutes/2024/may-2024

[29] European Central Bank (2024) *Official interest rates*, *European Central Bank*. Available at: https://www.ecb.europa.eu/stats/policy_and_exchange_rates/key_ecb_interest_rates/html/index.en.html.

[30] *European and US LevFin Default Rates Will Continue to Rise in 2024* (2024) *Fitch Ratings: Credit Ratings & Analysis for Financial Markets*. Available at: https://www.fitchratings.com/research/corporate-finance/european-us-levfin-default-rates-will-continue-to-rise-in-2024-08-01-2024.

[31] Ehlers, T. and Hardy, B. (2019) *The evolution of OTC interest rate derivatives markets*, *The Bank for International Settlements*. Available at: https://www.bis.org/publ/qtrpdf/r_qt1912i.htm.

according to the triennial survey conducted by the BIS in 2019, in the UK, the average daily turnover of IR options increase from $80 billion in 2013 to $443 billion in 2019[32]. As a result, the purpose of this study is not only to shed light on whether the use of IR derivatives could mitigate default risk but also if the effect on default risk varies with types of IR derivatives (long-term and short-term instruments). To the best of our knowledge, we are the first to study the impact of long-term and short-term IR derivatives on different time horizon of default risk. We do so by studying panel data of European non-financial firms from France, Germany, Italy, Spain, Sweden, Denmark, Norway, the Netherlands, and the United Kingdom from 1999-2015.

Our results highlight the importance of using IR derivatives as a risk management tool to reduce default risk. Particularly, we find that IR swap contracts are more effective than their short-term counterparts (forwards and options) in managing both short and long-term default probability. This could be explained by the fact that long-term derivatives are designed to hedge a firm’s total IR exposure (both short-term and long-term). However, our study unveils an interesting interaction effect between a firm's liability structure and the risk-reduction benefits derived from derivatives. We find evidence suggesting that firms operating in countries that encourage the use of short-term liabilities benefit more when employing short-term IR derivatives. For instance, German and Spanish firms with a higher dependence on short-term liabilities, with evidence from our dataset[33], witness a more substantial decrease in default probability compared to those utilizing long-term contracts. Furthermore, our analysis reveals a preference within the category of short-term derivatives. The results indicate that IR option derivatives appear to be more effective in mitigating default risk than interest rate forwards, aligning with Froot et al. (1993), who argue that options, a type of non-linear hedging instrument, provide firms with greater flexibility in aligning their investment and financing decisions compared to linear instruments like forwards and swaps, and Gamba and Triantis (2014), who also suggest that options are more effective in mitigating risk for some firms than forwards and swaps. Our results are contrary to Bartram et al. (2011), who find that the nonlinear payoff structure of derivatives minimally affects firm risk reduction through derivative usage. Additionally, we document evidence that middle-sized firms experience a more

[32] *Foreign Exchange and OTC derivatives markets turnover survey – 2019* (2019) *Bank of England*. Available at: https://www.bankofengland.co.uk/statistics/bis-survey/2019.
[33] Appendix 6.2

pronounced reduction in default probability by hedging with IR swaps, compared to small and large firms. Overall, our findings are novel and able to deliver significant contributions to the corporate hedging literature.

The subsequent sections of this chapter will unfold in the following manner. Section 4.2 provides a systematic examination of relevant empirical literature. Section 4.3 details the hypotheses formulated to address the research question. Section 4.4 then delves into the data employed for the analysis. Following this, Section 4.5 presents a descriptive overview of the data characteristics. The empirical results of the study are subsequently presented in Section 4.6, and the chapter culminates with concluding remarks in Section 4.7.

4.2 Literature review

4.2.1 IR derivatives and default risk

Recent research on the relationship between derivative usage and default probability has predominantly focused on FX derivatives, with limited attention given to IR derivatives. For example, Marin (2013) provides evidence that firms engaging in risk management through FX derivatives experience a significantly lower likelihood of bankruptcy compared to those without adequate risk control measures. Similarly, Boyer and Marin (2013) document a reduction in financial distress risk among US manufacturing firms that use FX derivatives. Magee (2013), examining a sample of US firms from 1996 to 2000, finds that firms using foreign currency derivatives also face a lower probability of financial distress.

Although these studies demonstrate the risk-reducing benefits of FX derivatives, they fail to examine the potential impact of IR derivatives on default risk. It could be argued that interest rate derivatives may yield similar benefits, as some firms using FX derivatives may also hedge with interest rate derivatives. However, interest rate risk is often considered more complex than foreign exchange or commodity risk, as noted by Faulkender (2005), which might explain the lack of attention to interest rate derivatives in these studies. A few theoretical studies attempt to explain the relationship between IR derivatives and default probability. Kuprianov (1994) explains that firms use IR swaps to manage uncertainties arising from volatile financial markets, thereby potentially reducing default risk. However, Jermann and Yue (2018) provide a more nuanced view. Their model of IR swap usage reveals that while firms may use swaps to mitigate default costs, this does not lead to a significant overall reduction in default rates. Instead, firms experience slightly lower default rates during economic recessions and moderately higher default rates during expansions. This highlights the need for further research into how interest rate derivatives affect default risk across different economic conditions. As a result, we conduct this study to fill this gap in empirical literature.

4.2.2 The dominance of IR swaps in literature

It is worth noticing that most of the papers on IR derivatives and firm risk focus on the use of IR swaps and treat it as the representative of IR derivatives as it is the most widely used type of IR derivatives[34].

Faulkender (2005), studying 133 chemical companies, challenges the traditional assumption that firms use IR derivatives for hedging purposes. The research reveals a surprising outcome: firms are primarily driven by speculation or market timing, not risk management, when it comes to their IR risk profile. Faulkender finds no evidence that companies use derivatives to hedge their IR exposure. There is no association between a company's IR exposure and the type of debt instrument they issued (fixed vs. floating rate). The study suggests firms primarily use IR derivatives for speculative purposes, potentially aiming to reduce their short-term cost of capital. One approach entails converting fixed-rate debt into floating-rate debt when the interest rate spread is substantial. This strategy may lower short-term debt servicing costs and enhance quarterly earnings. Additionally, firms might factor in their own forecasts of future IR trends when managing their IR exposure. As a result, their decisions may become highly responsive to yield spreads, particularly if their predictions consistently align with the general trends in the yield curve.

Furthermore, Chernenko and Faulkender (2011) extend the research on timing behaviour initially observed by Faulkender (2005), conducting a more in-depth analysis of firms' motivations for utilizing IR swaps. Their investigation reveals two potential drivers that suggest speculative intent: the manipulation of analyst earnings forecasts and the augmentation of managerial compensation. This aligns with the concept of firms engaging in derivatives for speculative purposes. Additionally, their

[34] Ehlers, T. and Hardy, B. (2019) *The evolution of OTC interest rate derivatives markets, The Bank for International Settlements*. Available at: https://www.bis.org/publ/qtrpdf/r_qt1912i.htm.

findings support the economies of scale hypothesis explored by Froot et al. (1993). The study reveals that larger investment firms primarily utilize IR swaps for hedging purposes, aligning their IR liabilities with cash flows. This suggests a potential correlation between firm size and the likelihood of engaging in speculative activities with IR derivatives. Furthermore, Chernenko and Faulkender (2011) reinforce the argument for speculative motives by demonstrating a positive association between performance-based managerial compensation and speculative IR derivative usage. They postulate that if a firm's IR exposure remains stable, the usage of IR derivatives should not significantly fluctuate over time. However, they find evidence of significant fluctuations in IR derivative usage, which signifies speculative motives.

Some other studies also document both hedging and speculating effects of IR derivatives. Hecht (2019), studying 315 German firms from 2010 to 2015 using IR swaps, reveals that approximately 63 percent of IR exposure is managed through strategies that decrease risk, while the remaining 37 percent is managed through strategies that either increase or maintain risk levels. This finding suggests a potential shift towards a more risk-tolerant posture among firms in the long term. Notably, this research provides the first empirical data of this nature, capturing both hedging and speculative elements within corporate IR risk management practices. One potential explanation for the observed speculative behaviour centers on firms attempting to exploit historically low interest rates. This strategy might involve securing long-term fixed-rate positions and subsequently converting them into short-term floating-rate positions to potentially capitalize on future interest rate movements.

In addition, Liu et al. (2020) inspect the linkage between the usage of IR derivatives and exposure to interest rate risk among US life insurers from 2000 to 2016. The study discovers a positive association between the two variables - usage of IR derivatives and the degree of inherent IR risk exposure. In particular, life insurers facing greater fundamental IR risk are more prone to employ IR derivatives than those less exposed to such risk. Moreover, life insurers actively using IR derivatives possess elevated observable IR risk. Nevertheless, during the post-crisis period, there is evidence of an inverse correlation between the use of IR derivatives and IR exposure, indicating a decrease in risk.

Thus far, no study has yet examined IR forwards and options. With the increase in the use of forwards and options, we are the first to compare IR swaps with IR forwards and options in terms of effectiveness in mitigating default risk. The reason for distinguishing between those instruments is due to their time horizon. IR swap contract is normally used for long-term exposure, whereas IR forwards and options are for short-term exposure. For instance, companies usually use IR options for forwards to hedge against fluctuation of interest rate for their short-term loans (less than 12 months), whereas IR swaps are preferred to manage long-term bonds (one to ten years). Consequently, it is expected that the effect of different types of IR derivatives on default probability will vary.

4.3 Hypothesis development

IR swap contracts are normally used for hedging long-term IR exposure, whereas IR forwards and options are for managing short-term exposure. For instance, companies usually use IR options for forwards to hedge against the fluctuation of interest rates for their short-term loans (less than 12 months), whereas IR swaps are preferred to manage long-term loans and bonds (more than 1 year). With this in mind, we could witness that the effect of IR swaps will be more pronounced on long-term default probability, while IR forwards or options will have a more significant impact on short-term default risk. Hence, we develop our first hypothesis as follows:

H4-1: Long-term IR derivatives (IR swaps) have a greater impact on long-term default risk, whereas short-term IR derivatives (IR options or forwards) exhibit a more pronounced effect on short-term default risk.

After comparing the effects on default likelihood between long-term IR derivatives (IR swaps) and short-term IR derivatives (IR forwards or options), we are keen on exploring the difference in risk-reducing effects between the two short-term instruments (IR forwards and options). Froot et al. (1993) advocate for the use of non-linear derivative instruments, such as option contracts. They argue that these tools enable firms to align investment and financing plans, ultimately leading to increased firm value and reduced default risk. This argument hinges on the idea that non-linear derivatives outperform their linear counterparts by offering protection against potential losses while also allowing for potential gains. As a result, we hypothesize that:

H4-2: IR options outperform IR forwards in terms of default risk reduction

Country-level factors could play an important role in determining the adoption of derivatives of non-financial companies. Since short-term derivatives are designed to manage short-term exposure, one plausible factor that may affect the effectiveness of short-term hedging strategies is the financial system of a country, particularly whether it is bank-based, which promotes the use of short-term hedging, or market-based, which encourages long-term hedging. Baum et al. (2006) highlight the reliance of German firms on short-term debt, with a high average ratio of short-term liabilities. This behaviour aligns with Germany's bank-based financial system (Calomiris, 1993). Such systems typically feature large banking sectors and close bank-firm relationships, facilitating debt financing. Firms often rely on a single "house bank" for financing, potentially leading to lower short-term borrowing costs. Consequently, these firms might utilize short-term interest rate derivatives (forwards, options) more extensively to hedge exposures arising from these liabilities. In contrast, market-based economies rely less on bank financing and have more developed bond markets. This potentially grants firms in such systems greater access to long-term debt financing such as bonds. Therefore, firms in market-based economies might have greater reliance on market-based debt resulting in the use of long-term interest rate derivatives such as swaps.

Our hypothesis is as follows:

H4-3: In bank-based economies, the effect of short-term IR derivatives on default probability will be more pronounced compared to long-term derivatives; whereas in market-based economies, the impact of long-term IR derivatives on default risk will be stronger compared to short-term derivatives.

We then further our research by exploring the potential interaction between firm size and the effect of IR swaps on firm default risk. While prior research has extensively examined the factors influencing derivative use, the question of whether firm size affects the impact of IR swaps on risk has received less attention. Several studies (Allayannis and Ofek, 2001; Judge, 2006; Chernenko and Faulkender, 2011; Bartram et al., 2011) indicate a positive correlation between firm size and derivative activity, including IR swaps. Large firms appear to be more likely to engage in hedging via derivatives, potentially due to their ability to absorb the initial costs associated with setting up a derivatives program. Their scale and financial strength allow them to readily bear these fixed costs, while the potential benefits of hedging outweigh the initial investment.

Conversely, the association between a firm's size and direct costs incurred due to bankruptcy suggests that smaller firms experience a higher proportional burden from bankruptcy (Clark and Juge, 2007). This heightened risk incentivizes smaller firms to adopt hedging strategies to mitigate the potential consequences of bankruptcy (Smith and Stulz, 1985). Beyond direct costs, smaller firms often encounter challenges in securing external financing due to their limited size and track record. Information asymmetry can make it difficult for them to convince lenders or investors of their creditworthiness, leading to higher external financing costs and potentially promoting the use of hedging as an alternative. Covitz and Sharpe (2005) offer a new angle, suggesting that smaller firms may have a distinct approach to managing interest rate risk. Their findings indicate that smaller firms might rely more heavily on IR derivatives compared to larger firms. While larger firms might favour long-term, fixed-rate debt to mitigate interest rate fluctuations, smaller entities might predominantly use derivatives to hedge the volatility associated with their reliance on floating-rate debt (for example, bank-sourced debt). Thus, our hypothesis is as follows:

H4-4: Firm size influences the effect of IR swaps on default probability.

4.4 Data, methodology, and variable construction

4.4.1 Data

This chapter investigates the influence of both long-term and short-term IR derivatives on the likelihood of default. Our sample involves nine countries including the UK, France, Germany, Denmark, Italy, Norway, the Netherlands, Spain, and Sweden from 1999 to 2015.

Compared with the US, which is the focus in previous research, those countries are chosen to be the setting of this study for several reasons. The European derivative market is highly significant, valued at €735 trillion in total notional amount at the end of 2018, with OTC contracts accounting for 90% of this, according to the European Securities and Market Authority (ESMA). Key players in this market include Germany, Italy, France, Spain, and the Netherlands, while the UK dominates global OTC interest rate derivatives, handling 50% of global turnover by 2019. Following

Brexit, derivative activity has increased in Germany and France, further strengthening their positions in foreign exchange and interest rate derivatives. Many European countries face high interest rate risk due to their reliance on bank loans, which provide around 80% of capital for non-financial firms. As bank funding is often linked to floating interest rates, firms in Europe are more exposed to interest rate fluctuations, incentivizing them to use derivatives for risk management. This highlights the importance of derivatives in these markets compared to the US.

The decision to end the sample period in 2015 is influenced by two major economic factors: Brexit uncertainties and the rise of negative interest rates in Europe. The lead-up to the UK's 2016 EU referendum generated economic uncertainty, impacting firms' risk management strategies, particularly those with UK-EU cross-border operations. Simultaneously, the European Central Bank's introduction of negative interest rates in 2014, which spread to several countries by 2015, changed the dynamics of interest rate hedging. Negative interest rates increased hedging costs due to the negative returns on cash deposits required for margin purposes, reducing the demand for IR derivatives. Consequently, we decided to stop the sample period at 2015 to prevent such noise from influencing our results.

4.4.2 Methodology

The regression model to assess the influence of long-term and short-term interest rate hedging strategies on the probability of default is illustrated as follows:

$$\begin{aligned} Default_{it} = {} & \beta_0 + \beta_1 Long\text{-}termonly_{it} + \beta_2 Short\text{-}termonly_{it} \\ & + \beta_3 Long\text{-}term\ \&\ short\text{-}term_{it} + \beta_4 Leverage_{it} + \beta_5 Liquidity_{it} + \beta_6 Firm\ Size_{it} \\ & + \beta_7 Equity\ Volatility_{it} + \beta_8 Excess\ Return_{it} + \beta_9 Profitability_{it} + Industry \\ & Dummies + Year\ Dummies + Country\ Dummies + \varepsilon_{it} \end{aligned} \quad [11]$$

Where Default variable is EDF one-year or five-year duration. Long-termonly, short-termonly, Long-term & short-term are the metrics for possible IR hedging strategies derived from long-term and short-term IR derivatives.

In our examination of the effects between the two short-term IR derivatives (forwards and options), the following model is employed:

$$Default_{it} = \beta_0 + \beta_1 IR\ Swaps\ Only_{it} + \beta_2 IR\ Forwards\ \&\ Swaps_{it} + \beta_3 IR\ Forwards\ Only_{it} + \beta_4 IR\ Options\ Only_{it} + \beta_5 IR\ Forwards\ \&\ Options_{it} + \beta_6 IR\ Swaps\ \&\ Options_{it} + \beta_7 IR\ Forwards\ \&\ Swaps\ \&\ Options_{it} + Control\ variables + Industry\ Dummies + Year\ Dummies + Country\ Dummies + \varepsilon_{it} \quad [12]$$

Where IR Swaps Only, IR Forwards & Swaps, IR Forwards Only, IR Options Only, IR Forwards & Options, IR Swaps & Options, IR Forwards & Swaps & Options are proxies for different IR hedging strategies involving three types of IR derivatives.

In our attempt to test the impact of IR swaps on default risk with respect to firm size, we divide the IR swap users into several quantiles of firm size. The model is as follows:

$$Default_{it} = \beta_0 + \beta_1 SwapsuserQ1_{it} + \beta_2 SwapsuerQ2_{it} + \beta_3 SwapuserQ3_{it} + \beta_4 SwapsuserQ4_{it} + \beta_5 Leverage_{it} + \beta_6 Liquidity_{it} + \beta_7 FirmSize_{it} + \beta_8 EquityVolatility_{it} + \beta_9 ExcessReturn_{it} + \beta_{10} Profitability_{it} + Industry\ Dummies + Year\ Dummies + Country\ Dummies + \varepsilon_{it} \quad [13]$$

Where SwapsuserQ1, SwapsusersQ2, SwapsuersQ3, SwapsusersQ4 are proxies for IR swaps users for firms belonging to the first, second, third, and fourth quantiles of firm size respectively.

The methodological approach initiates with a pooled Ordinary Least Squares (OLS) estimation serving as the foundational model, while recognizing its inherent limitations regarding firm-specific heterogeneity and endogeneity between derivative usage and default risk. To address potential reverse causality—specifically, the possibility that hedging decisions are driven by financial distress—the analysis incorporates lagged independent variables related to derivative usage, following Bellemare et al. (2017). A fixed effects (FE) specification is implemented to account for unobserved firm-specific attributes that may simultaneously affect derivative adoption and default likelihood (Dougherty, 2016). Furthermore, given the bounded nature of the dependent variable, Expected Default Frequencies (EDF), within the [0,1] interval, the study employs beta regression methodology (Ferrari and Cribari-Neto, 2004), as traditional OLS estimation is unsuitable for fractional response variables.

In this study, model [11] indicates that LONG-TERM ONLY, SHORT-TERM ONLY, LONG-TERM AND SHORT-TERM are the endogenous variables. Zirgulis (2014), in his study regarding how countries compete by adjusting their taxes on capital to attract foreign investments, also encounters the situation of multiple endogenous variables and proposes the most optimal solution is the System Generalized Method of Moments (SGMM) model. In more detail, we specifically employ the One-Step System Generalized Method of Moments (SGMM) estimator due to its advantageous precision properties stemming from its reliance on fewer assumptions compared to the two-step GMM alternative.

The SGMM model is as follows,

$$Default_{it} = \beta_0 + \rho\ Default_{i,\,t-1} + \beta_1 Long\text{-}termonly_{it} + \beta_2 Short\text{-}termonly_{it} + \beta_3 Long\ \&\ short\text{-}term_{it} + \beta_4 Leverage_{it} + \beta_5 Liquidity_{it} + \beta_6 FirmSize_{it} + \beta_7 EquityVolatility_{it} + \beta_8 ExcessReturn_{it} + \beta 9 Profitability_{it} + Industry\ Dummies + Year\ Dummies + Country\ Dummies + \varepsilon_{it} \quad [14]$$

A key methodological strength of the System Generalized Method of Moments (System GMM) framework lies in its capacity for internal instrumentation, eliminating the need for external instrumental variables. The model leverages lagged values of endogenous variables as instruments, and utilizing contemporaneous exogenous variables as self-instruments. In our empirical specification, the IR hedging strategies variables (*Long-termonly, Short-termonly, Long & short-term*) and all financial variables are treated as endogenous.

4.4.3 Variable description

This section delineates the dependent variable, capturing the probability of corporate default, as well as the primary independent variables of interest and the ancillary control variables employed in the empirical analysis undertaken within this chapter.

Our paper studies the influence of long-term and short-term IR derivatives on default risk by using cross-sectional data within the period of 1999 to 2015 for nine countries including the UK, France, Germany, Denmark, Italy, Norway, the Netherlands, Spain and Sweden. Our sample consists of non-financial firms listed on the stock exchanges of the countries included in our study. The number of firms in our dataset varies from year to year due to mergers, delistings, acquisitions, or the absence of financial data. Over the entire sample period, our dataset includes a total of 12,465 firm-year observations.

4.4.3.1 Dependent variable: EDF

We analyse the relationship between long-term and short-term IR derivatives and the probability of default by using Moody's Expected Default Frequencies (EDF) as a proxy for default risk, which is grounded in Merton's (1974) distance-to-default model. This approach has proven reliable across various credit cycles and remains resilient against model misspecification (Crossen et al., 2011; Berndt et al., 2018). By using EDFs, we obtain precise default probabilities, offering an advantage over the distance-to-default model employed in many other studies, which only ranks default risks (Moody’s Analytics, 2016). This selection improves the accuracy and robustness of our analysis, particularly given that our data spans the 2007-2008 global financial crisis. Further details on this variable can be found in Chapter 3.

4.4.3.2 Main explanatory variable

This section outlines the data collection process for identifying derivative usage among firms. By carefully reviewing annual reports, we are able to determine which firms employed various types of IR derivatives, including swaps, forwards, and options. This information is then used to create dummy variables indicating the specific hedging strategies employed by each firm, such as using only IR swaps, using only IR forwards, or combining different types of instruments. These dummy variables are subsequently grouped into broader categories based on the time horizon of the derivatives used, such as long-term only, short-term only, or a combination of both. To avoid bias, we only compared firms that used IR derivatives to firms that abstain from derivative usage. This ensures that our results accurately reflect the impact of IR derivatives on default risk.

4.4.3.3 Control variables

In this section, we outline the control variables used in our model, following the approaches of various studies on firm default determinants, including Smith and Stulz (1985), Chava and Jarrow (2004), and Brogaard et al. (2017).

- *Leverage*

This is calculated as the ratio of total debt to the book value of assets, minus the book value of equity, plus the market value of equity. Prior research, such as Marin (2013), indicates a strong correlation between leverage and the likelihood of bankruptcy.

➢ *Firm size*

Firm size is measured by taking the natural logarithm of total debt plus the market value of the firm’s equity. According to Magee (2013), larger firms tend to face lower risk due to greater product and market diversification compared to smaller companies.

➢ *Excess return*

Excess return is calculated by subtracting the annual return of the country's stock index from the firm's annual equity return. Specifically, we use the S&P 500 for the US, FTSE 100 for the UK, OMX Copenhagen All-share for Denmark, CAC All-share for France, DAX 40 for Germany, FTSE Italia All-share for Italy, AEX All-share for the Netherlands, IBEX 35 for Spain, OMX Stockholm All-share for Sweden, and Oslo Børs All-share for Norway. Numerous studies, including Shumway (2001), Magee (2013), and Brogaard et al. (2017), have found a negative relationship between excess return and the probability of insolvency.

➢ *Liquidity*

We use the quick ratio as a proxy for liquidity, which is calculated as current assets minus inventories and work-in-progress, divided by current liabilities. High liquidity indicates a strong cash position, reducing the firm’s financial distress or risk compared to firms with lower liquidity. The inverse relationship between liquidity and default risk is supported by studies such as Marin (2013) and Magee (2013).

➢ *Profitability*

Profitability is measured as EBITDA divided by total assets. As profitability increases, the risk of bankruptcy decreases. Profitable firms tend to be less financially constrained and can rely on internal funding, which lowers the probability of default by reducing the need for costly external financing (Bartram et al., 2009).

➢ *Equity volatility*

This is calculated as the standard deviation of daily stock returns over a fiscal year. Higher equity volatility, as noted by Campbell et al. (2008), is associated with a greater likelihood of default.

4.5 Descriptive statistics

Table 4-1 displays summary statistics for variables used in our regressions. All of the variables are winsorized at the top and bottom 1 percentile to eliminate extreme values. Starting with the probability of default one-year (EDF1YEAR) and five-year time horizon (EDF5YEAR), the mean and median of EDF1YEAR are 1.805 and 0.295, and those of EDF5YEAR are 1.735 and 0.661 respectively. By comparing the median, we can see that the long-term probability of default is higher than the short-term default risk.

The firms in our sample demonstrate an average leverage ratio of roughly 22%, consistent with prior research conducted by Bartram et al. (2011). The sample encompasses a wide spectrum of profitability, with firms reporting ratios ranging from -172% to 44%. This broad range incorporates both financially successful and struggling entities, thus enhancing the sample's representativeness and diversity. With regard to equity volatility, a key indicator of financial risk exposure, the sample firms exhibit a mean value of 42.4 and a median of 35.3. Furthermore, the excess return metric, which measures the firms' performance relative to the broader market, reveals that the sample firms generate lower returns on average, with a mean of -2.8% and a median of -0.2%. The liquidity position of the firms, as measured by the quick ratio, exhibits a mean of 1.54 and a median of 0.96, indicating varying levels of liquidity across the sample.

Next, the frequency distribution of our hedging strategy variables is displayed in Table 4-2. We also divide the frequency distribution in terms of countries, which is shown in Figure 4-1. From panel A of Table 4-2, we can see that around 57% of our sample is IR derivative users, whereas the proportion of firms that do not hedge at all is approximately 28%, half of IR users. Only around 15% is firms using only other types of derivatives, which will be excluded from the non-user sample to reduce bias. If we look at IR derivative frequency in separate countries, from Figure 4-1, the pattern remains relatively consistent for most of the countries, except for Sweden, Denmark, Norway and Spain. In those countries, the proportion of IR users and non-hedgers is fairly similar, whereas there are more non-hedgers than IR hedgers in Denmark. Italy is the nation which has the largest proportion of IR users (approximately 70%), while non-users account for only 19%. As shown on panel B of Table 4-2, IR swaps are the dominant hedging instruments with over 90% of firms preferring to use them (8,092 as a proportion of 8,875 IR derivative users). Among the short-term derivatives, IR options are more popular than IR forwards. This pattern also happens across most of the countries in the sample, except for Sweden, the Netherlands, and the UK, as displayed in Figure 4-1. Interestingly, it can be seen that German and Spanish firms exhibit the highest proportions of IR option users relative to overall IR derivative users, with Germany at 42.06% and Spain at 37.96%. This phenomenon may be attributed to the bank-centric financial systems prevalent in both countries. Such systems typically encourage the utilization of short-term debt instruments, which in turn may influence firms to favour short-term IR derivatives as their preferred hedging mechanism. This observation suggests a potential link between a country's financial structure and corporate risk management strategies, which we will investigate later in the chapter.

Panel C of Table 4-2 presents our primary variables of interest, revealing compelling patterns in interest rate hedging strategies across our sample. The data indicates a pronounced preference for IR swaps as the sole hedging instrument, with over 60% of firms in our sample adopting this approach. This finding aligns with the well-documented dominance of IR swaps in financial markets. The second most prevalent strategy involves a combination of long-term and short-term instruments, which also incorporate IR swaps. This further underscores the ubiquity of swap contracts in corporate risk management practices. Notably, only a small fraction of firms—approximately 4%—exclusively employ short-term hedging strategies. This pattern of hedging preferences is consistently observed across all countries in our sample, suggesting a widespread consensus on the efficacy of IR swaps for managing interest rate risk.

The Pearson correlation coefficients, presented in Table 4-3, elucidate the associations between the probability of default, IR hedging strategies, and the independent variables incorporated in the analysis. The results reveal a negative correlation between the long-term only strategy or the combined long and short-term strategy for IR hedging and the probability of default. Conversely, the utilization of short-term IR derivatives exhibits a positive correlation with default risk; however, this relationship is statistically insignificant from zero. Consequently, the impact of short-term IR derivatives on default likelihood remains ambiguous. Furthermore, the analysis uncovers a positive association between leverage and equity volatility with default risk, aligning with theoretical expectations. On the contrary, firm size, profitability, liquidity, and excess return exhibit negative correlations with the likelihood of default, corroborating the predicted relationships.

Table 4-1: Summary statistics

This table summarizes the standard statistics for the variables used in this paper. The variables included are as follows. ***EDF1YEAR*** *is the Moody's expected default frequencies over one year period.* ***EDF5YEAR*** *is Moody's expected default frequencies in five-year time range.* ***LEVERAGE*** *is the ratio of total debts over market values of assets.* ***PROFITABILITY*** *is measured as the ratio of EBITA over total assets.* ***FIRM SIZE*** *is the natural logarithm of total market value of assets.* ***VOLATILITY*** *is the standard deviation of stock return in a fiscal year.* ***LIQUIDITY*** *is the quick ratio (total assets minus inventory over total liabilities).* ***EXCESS RETURN*** *is annual equity return minus annual return of the stock index representing each country.*

Variable	N	Mean	Median	Min	Max	Standard deviation
EDF1YEAR	12465	1.805	0.295	0.010	32.939	4.152
EDF5YEAR	12465	1.735	0.661	0.010	23.976	2.955
LEVERAGE	10885	0.217	0.179	0.000	0.901	0.191
PROFITABILITY	11212	0.084	0.103	-1.722	0.446	0.170
FIRM SIZE	10720	6.633	6.312	-4.044	17.481	2.862
VOLATILLITY	10756	42.391	35.272	0.000	316.495	26.423
LIQUIDITY	11285	1.532	0.968	0.035	58.441	2.894
EXCESS RETURN	9813	-0.028	-0.002	-0.680	0.269	0.116

Table 4-2: Frequency distribution of IR derivative use

Derivative categories	Frequency	Percentage
Panel A: IR Derivative user and non-user		
IR DERIVATIVE USER	8,875	57.37
FX AND CP DERIVATIVE ONLY USER	2,281	14.75
NON-USER	4,312	27.88
Total	15,468	100
Panel B: IR Forwards, Swaps and Options		
IR SWAPS	8,092	91.8
IR FORWARDS	1,300	14.65
IR OPTIONS	2,123	23.92
Panel C: IR Long-term and short-term strategies		
LONG-TERM ONLY	5,356	60.51
SHORT-TERM ONLY	409	4.62
LONG & SHORT-TERM	2,722	30.67
UNABLE TO DETERMINE	388	4.2
Total	8,875	100

Figure 4-1: Frequency distribution of IR hedging strategies sorted by countries.

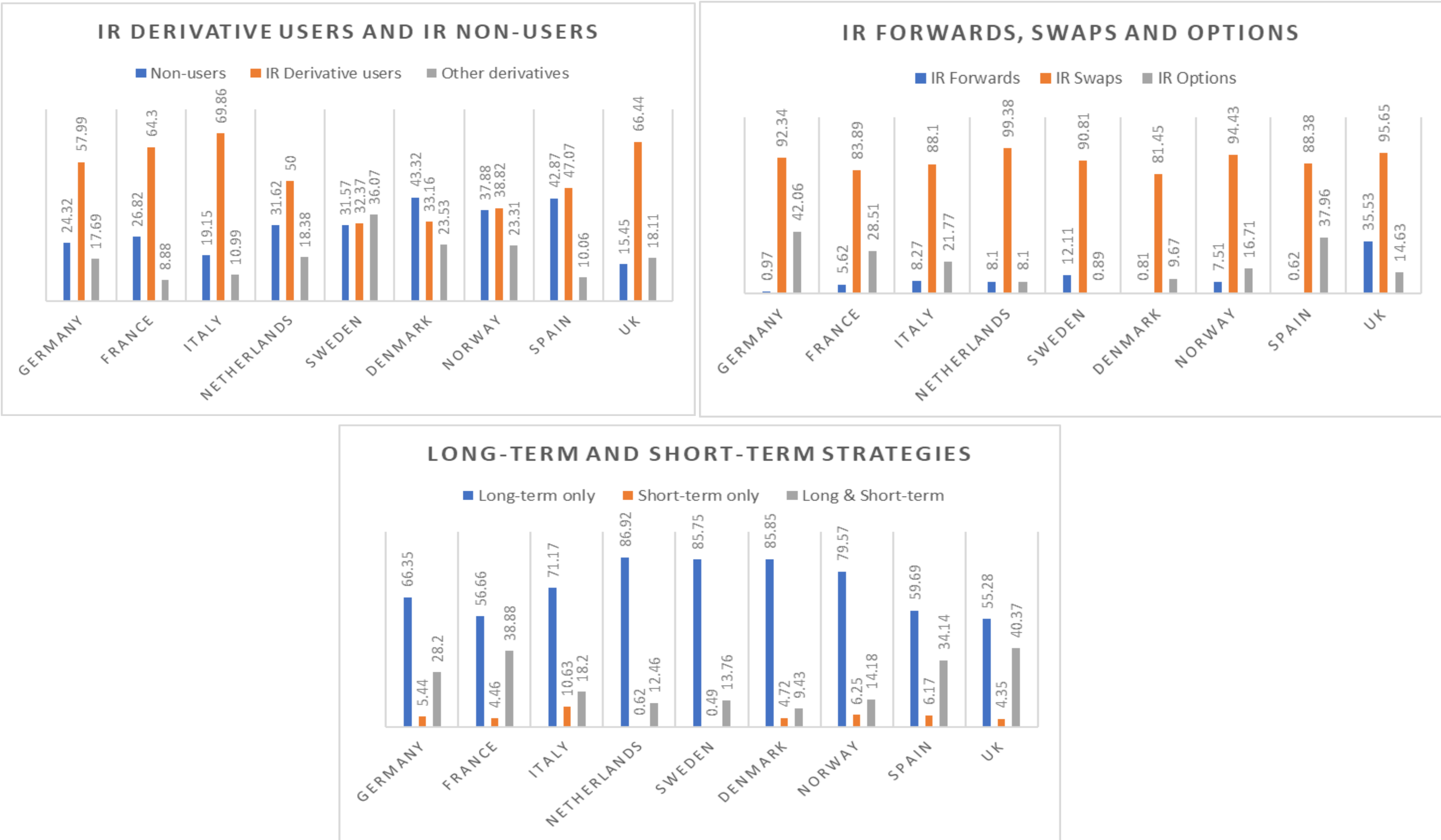

Table 4-3: Pearson Correlation coefficients

*This table presents the correlation coefficients for the main variables used in this analysis. **EDF1YEAR** is the Moody's expected default frequencies over one year period. **EDF5YEAR** is Moody's expected default frequencies in five-year time range. **IR DERIVATIVE USER** is the dummy taking value of 1 if the firm uses IR derivatives and 0 if not hedging. **LONG-TERM ONLY** is the dummy taking value of 1 if the firm uses long-term derivatives only and 0 otherwise. **SHORT-TERM ONLY** is the dummy taking value of 1 if the firm uses short-term derivatives only and 0 otherwise. **LONG & SHORT-TERM** is the dummy taking value of 1 if the firm uses long-term derivatives together with short-term derivatives and 0 otherwise. **LEVERAGE** is the ratio of total debts over market values of assets. **PROFITABILITY** is measured as the ratio of EBITA over total assets. **FIRM SIZE** is the natural logarithm of total market value of assets. **VOLATILITY** is the standard deviation of stock return in a fiscal year. **LIQUIDITY** is the quick ratio (total assets minus inventory over total liabilities). **EXCESS RETURN** is annual equity return minus annual return of the stock index representing each country. ***, **, * statistically different from zero at the 1%, 5%, or 10% level of significance, respectively.*

	IR DERIVATIVE USER	LONG TERM ONLY	SHORT TERM ONLY	LONG & SHORT TERM	EDF1YEAR	EDF5YEAR	LEVERAGE	PROFITABILITY	VOLATILITY	SIZE	LIQUIDITY	EXCESS RETURN
IR DERIVATIVE USER	1.000											
LONG TERM ONLY	0.578***	1.000										
SHORT TERM ONLY	0.107***	-0.159***	1.000									
LONG & SHORT TERM	0.351***	-0.492***	-0.097***	1.000								
EDF1YEAR	-0.128***	-0.077***	0.005	-0.048***	1.000							
EDF5YEAR	-0.146***	-0.088***	0.007	-0.056***	0.976***	1.000						
LEVERAGE	0.291***	0.117***	0.008	0.174***	0.219***	0.221***	1.000					
PROFITABILITY	0.187***	0.098***	0.025***	0.077***	-0.236***	-0.258***	-0.043***	1.000				
VOLATILITY	-0.117***	-0.080***	0.024***	-0.041***	0.481***	0.483***	0.103***	-0.337***	1.000			
SIZE	0.324***	0.204***	-0.003	0.116***	-0.144***	-0.175***	0.219***	0.165***	-0.190***	1.000		
LIQUIDITY	-0.172***	-0.074***	-0.019	-0.091***	-0.013***	-0.015***	-0.164***	-0.075***	0.056***	-0.094***	1.000	
EXCESS RETURN	-0.001**	-0.007*	-0.038***	0.022	0.019	0.021	0.019	-0.012	-0.007**	-0.004***	0.004	1.000

4.6 Empirical results

4.6.1 Univariate

Table 4-4 displays the results of univariate regressions for both EDF1YEAR and EDF5YEAR. As can be seen from the table, the coefficients of long-term derivatives only and long-term combined with short-term are negative and significant at -0.87 and -0.781 respectively for EDF1YEAR. The results for EDF5YEAR are similar, with -0.756 for Long-term only and -0.732 for Long & Short-term respectively. These demonstrate that long-term IR derivatives (IR swaps) negatively impact default risk in the short and long run, while short-term instruments do not seem to affect default likelihood. This, in some way, is the evidence of why IR swaps dominate the IR derivative market.

Table 4-4: Univariate regression on long-term & short-term IR derivatives and default probability

*This table presents the univariate results of the impact of different IR derivative strategies on the probability of default measured by **EDF1YEAR, EDF5YEAR**. **LONG-TERM ONLY** is the dummy taking value of 1 if the firm uses long-term derivatives only and 0 otherwise. **SHORT-TERM ONLY** is the dummy taking value of 1 if the firm uses short-term derivatives only and 0 otherwise. **LONG & SHORT-TERM** is the dummy taking value of 1 if the firm uses long-term derivatives together with short-term derivatives and 0 otherwise. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%, 5%, or 10% levels, respectively. The regressions include industry and year dummies.*

Variables	EDF1YEAR	EDF5YEAR
LONG-TERM ONLY	-0.870***	-0.756***
	(0.152)	(0.110)
SHORT-TERM ONLY	-0.244	-0.312
	(0.426)	(0.282)
LONG & SHORT TERM	-0.781***	-0.732***
	(0.185)	(0.135)
Constant	1.115***	1.289***
	(0.392)	(0.302)
Observations	12,465	12,465
Industry fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Country fixed effects	Yes	Yes
R-squared	0.1443	0.3817

4.6.2 Multivariate

In this part, we conduct various tests to examine the impact of long-term and shorter-term IR hedging strategies on the probability of default. Particularly, the models include ordinary least squares (OLS), one-year lag regressor (LAG), beta regression (BETA), and also the System Generalized Method of Moments (SGMM). All of the results are presented in Table 4-5.

4.6.2.1 Pooled ordinary least square (OLS) results

Columns 1 and 5 in Table 4-5 present the results of OLS specification for EDF1YEAR and EDF5YEAR. From column 1 for EDF1YEAR, we can see that all of the strategies have negative and significant coefficients, with -0.588 for long-term only, -0.524 for short-term only, and -0.672 for long & short-term combination. As for EDF5YEAR, the results are similar, with all of the variables of interest having significantly negative coefficients at -0.474 for LONG-TERM ONLY, -0.361 for SHORT-TERM ONLY and -0.523 for both short and long-term. These results indicate that both long-term and short-term IR derivatives could reduce the probability of default in both the short and long run. Even though the variation is not substantial, we can witness that the effect of IR swaps on long-term EDF is relatively stronger than that of short-term derivatives. In particular, LONG-TERM ONLY strategy reduces around 27% of EDF5YEAR (-0.474 as a proportion of the mean of EDF5YEAR of 1.735) while SHORT-TERM ONLY could lower approximately 20% of EDF5YEAR (-0.361 over mean EDF5YEAR of 1.735). Moreover, from column 1 of Table 4-5, IR swaps could also mitigate short-term default likelihood as effectively as IR forwards or options, which are designed for hedging short-term exposure. The coefficient for LONG-TERM ONLY is -0.588, whereas it is -0.534 for SHORT-TERM ONLY. These findings align with the notion that IR swaps are designated to hedge a firm's total IR exposure, not only long-term IR exposure from long-term liabilities. IR swaps offer a unique hedging advantage due to the concept of notional principal amount that is never exchanged (Bicksler and Chen, 1986). This predetermined reference amount, distinct from any actual cash exchange, allows the swap to be customized to a firm's total loan exposure. In accordance with McNulty (2012), IR swaps offer unparalleled flexibility in terms of maturity and notional amount, allowing for a high degree of customization to meet specific hedging requirements. Swaps can be tailored to accommodate any desired maturity period and any negotiated notional value. This flexibility allows for a more precise alignment of the swap instrument with the borrower's hedging needs. This contrasts with forwards and options, which typically target specific loans or future cash flows. Consequently, IR swaps with a well-defined notional principal amount provide a more comprehensive and strategic approach to mitigating the risk of interest rate fluctuations on a company's entire debt portfolio.

4.6.2.2 One-year lagged and beta regression results

To avoid the possibility of reverse causality, we use a one-year lagged value of regressors specification in our analysis. As shown in column 2 of Table 4-5, LONG-TERM ONLY has significant and negative coefficients: -0.614. Interestingly, the estimate for SHORT-TERM ONLY is not significant with this model. This has further indicated that IR forwards or options may not be as effective as IR swaps in terms of default risk reduction. Similarly, the results for EDF5YEAR, as shown in column 6 of Table 4-5, confirm that long-term IR derivative is better at managing default probability than short-term derivatives with -0.500 coefficient for the long-term only method. One thing worth noticing is that the estimates of LONG & SHORT TERM are both significant for EDF1YEAR and EDF5YEAR. Those results could be mainly driven by IR swaps, since short-term only is not significant, which again indicates the effectiveness of default risk reduction of IR swap contracts in both the short and long run. Our study’s results confirm the default risk reduction effect of IR swap instruments, which is in accordance with Kuprianov (1994). We also conduct beta regression to counter the bias or inconsistency potentially created by the fact that EDF is a proportion (ranging from 0 to 1). As can be seen from columns 3 and 7 of Table 4-5, the results from beta regression are consistent with lagged and OLS model, where we witness significant results for long-term IR derivatives, and insignificance for short-term ones. Interestingly, the coefficients for LONG-TERM ONLY and combination strategy are the same for EDF1YEAR and EDF5YEAR. In more detail, using IR swaps only has coefficients of -0.197 for the one-year and five-year likelihood of default, whereas combining both long-term and short-term IR derivatives yields coefficients of -0.227 in both EDF1YEAR and EDF5YEAR. The findings reinforce the perspective that IR swaps can be advantageous in mitigating default risk across both long and short-term horizons. This is attributable to the ability of swaps to hedge a firm's total IR exposure.

Table 4-5: Effect of long-term & short-term IR derivative strategies and default probability

*This table presents the results of the impact of IR long and short-term hedging strategies on the probability of default. In panel A the dependent variable is the probability of default for a one-year horizon (**EDF1YEAR**) and in panel B the dependent variable is the probability of default for a five-year horizon (**EDF5YEAR**). **LONG-TERM ONLY** is the dummy taking value of 1 if the firm uses long-term derivatives only and 0 otherwise. **SHORT-TERM ONLY** is the dummy taking value of 1 if the firm uses short-term derivatives only and 0 otherwise. **LONG & SHORT-TERM** is the dummy taking value of 1 if the firm uses long-term derivatives together with short-term derivatives and 0 otherwise. **LEVERAGE** is the ratio of total debt to the market value assets. **PROFITABILITY** is measured as EBITDA over total assets. **VOLATILITY** is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate. **FIRM SIZE** is the natural logarithm of the market value of assets. **LIQUIDITY** is the ratio of total current assets minus total stock and work in progress over total current liabilities. **EXCESS RETURN** is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%, 5%, or 10% levels, respectively. The regressions include industry, country and year dummies.*

	PANEL A: EDF1YEAR				PANEL B: EDF5YEAR			
	OLS	Lag	Beta	SGMM	OLS	Lag	Beta	SGMM
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L.EDF				0.627***				0.661***
				(0.064)				(0.067)
LONG-TERM ONLY	-0.588***	-0.614***	-0.197***	-0.791*	-0.474***	-0.500***	-0.197***	-0.663**
	(0.187)	(0.219)	(0.028)	(0.436)	(0.127)	(0.147)	(0.025)	(0.308)
SHORT-TERM ONLY	-0.524**	-0.336	-0.089	-1.720	-0.361**	-0.282	-0.088	-0.993
	(0.243)	(0.316)	(0.062)	(1.064)	(0.164)	(0.209)	(0.054)	(0.645)
LONG & SHORT-TERM	-0.674***	-0.735***	-0.227***	-1.106*	-0.523***	-0.563***	-0.227***	-0.852**
	(0.216)	(0.252)	(0.034)	(0.576)	(0.151)	(0.174)	(0.030)	(0.396)
LEVERAGE	5.281***	5.472***	1.775***	2.917***	3.997***	4.134***	1.612***	1.916**
	(0.525)	(0.603)	(0.060)	(1.129)	(0.357)	(0.409)	(0.051)	(0.781)
PROFITABILITY	-0.621	-2.572***	-0.178***	0.248	-0.693	-1.991***	-0.183***	-1.132
	(0.676)	(0.811)	(0.058)	(1.310)	(0.472)	(0.517)	(0.049)	(1.008)
VOLATILITY	0.061***	0.047***	0.010***	0.037***	0.040***	0.033***	0.008***	0.016**
	(0.005)	(0.004)	(0.000)	(0.010)	(0.003)	(0.003)	(0.000)	(0.007)

FIRM SIZE	-0.185***	-0.137***	-0.083***	-0.017	-0.177***	-0.136***	-0.092***	-0.030
	(0.038)	(0.043)	(0.006)	(0.080)	(0.027)	(0.030)	(0.005)	(0.057)
LIQUIDITY	-0.050**	-0.067***	-0.024***	-0.041	-0.040***	-0.051***	-0.029***	-0.010
	(0.021)	(0.018)	(0.005)	(0.030)	(0.015)	(0.014)	(0.005)	(0.019)
EXCESS RETURN	0.383	0.656**	0.105	2.808*	0.276	0.361	0.083	1.381
	(0.316)	(0.319)	(0.088)	(1.444)	(0.218)	(0.230)	(0.078)	-0.056
Constant	-0.886**	-0.908**	-4.908***	-1.462*	0.197	0.047	-4.521***	(0.591)
	(0.392)	(0.382)	(0.124)	(0.853)	(0.290)	(0.277)	(0.107)	(1.277)
Observations	7,318	6,506	7,318	5,370	7,318	6,506	7,318	5,370
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.352	0.313			0.382	0.350		
Log pseudolikelihood			26979				25144	
Hansen test of over-identification (p-value)				0.148				0.313
AR(1) test (p-value)				0.000				0.000
AR(2) test (p-value)				0.161				0.101

4.6.2.3 Robustness check

The following section will discuss the use of the dynamic panel System Generalized Method of Moments (SGMM) model as a robustness test to tackle the issue of multiple endogenous variables in our models. This method is primarily inspired by previous studies, including Zirgulis (2014), who addresses multiple endogenous variables in his exploration of international tax competition for foreign capital inflows. He proposes that the most suitable model for handling such complexities is the SGMM method. Additionally, Magee (2013) also employs the SGMM method, assuming that the current level of hedging is influenced by the past level of firm value. In our research, we approach it in a similar way in the sense that hedging can affect default probability, but default probability and even the past value of default probability can impact current hedging. Consequently, the SGMM model will be used to address this dynamic endogeneity and simultaneity. In order to implement the dynamic SGMM model, we include the one-year lag value of EDF in the main regression. This approach has one clear benefit that we do not require new instruments for the endogenous variables. The lags of the endogenous variables will be utilized as instruments for the endogenous variables themselves, while the instrumental variables for the exogenous variables are the contemporaneous exogenous variables. We assume that the hedging strategy dummies and the control variables are endogenous.

The SGMM model includes two post-estimation tests. The first test checks for autocorrelation of the lag two of the endogenous variables. If autocorrelation is detected, it suggests that the lagged endogenous variables may not be appropriate instruments for the contemporary values. The second test is the Hansen test of over-identification restrictions, which tests the validity of the instruments. We expect not to reject the null hypothesis of the Hansen test, indicating that the instruments are valid. The full results are presented in columns 4 and 8 of Table 4-5 for EDF1YEAR and EDF5YEAR respectively. The results confirm the significant relationship between the previous default likelihood and the current probability of default. Additionally, both of the results for EDF1YEAR and EDF5YEAR are similar to lagged and beta models. In particular, the estimates for LONG-TERM ONLY are -0.791 and -0.663 for EDF1YEAR and EDF5YEAR respectively, whereas it is not significant for SHORT-TERM ONLY. The combination strategy has significant coefficients of -1.106 and -0.852 for EDF1YEAR and EDF5YEAR respectively. The Arellano-Bond (AR(2)) tests for second-order serial correlation yield statistically insignificant results (p-values of 0.161 for EDF1YEAR and 0.101 for EDF5YEAR). This implies that the second lags of the endogenous variables function as valid instruments in the SGMM estimation. Additionally, the Hansen tests of overidentifying restrictions produce high p-values (0.148 for EDF1YEAR and 0.313 for EDF5YEAR). As we cannot reject the null hypothesis of the Hansen test in either case, we can strengthen our confidence in the validity of the instruments employed within the SGMM framework. Two post-estimation tests are satisfied, which proves that our results are robust, and the instruments are valid. Overall, we find that long-term IR derivatives (IR swaps) are more effective in mitigating default risk compared to their short-term counterparts. In particular, IR swaps could influence the likelihood of default in both the short and long run, which supports the notion that long-term derivatives are designed to hedge a firm's total exposure.

4.6.2.4 Interest rate forwards or options

In this section, we delve into a comparative analysis of the effects of IR forwards and IR options on default probability, unveiling intriguing insights into the relative efficacy of these short-term IR derivatives. While our previous findings have indicated that short-term IR derivatives only prove effective in specific circumstances, it remains a captivating endeavour to examine which of these two instruments – IR forwards or IR options – wields a more potent impact in reducing default risk. Froot et al. (1993) present a compelling argument in favour of non-linear derivative instruments, such as option contracts. They contend that these instruments empower firms to more precisely align their investment and financing plans, thereby facilitating an increase in firm value and a reduction in default risk. This assertion is predicated on the notion that non-linear derivative products, exemplified by IR options, are more effective than their linear counterparts, such as IR forwards, by their ability to not only mitigate potential losses but also allow for the realization of potential gains.

We test this hypothesis (*H4-2*) by including seven specific hedging strategies generated from the three types of IR derivatives. They are IR swaps only, IR forwards & swaps, IR forwards only, IR options only, IR forwards & options, IR swaps & options, IR forwards & swaps & options. To examine the difference between IR forwards and options, we will pay more attention to the variables IR options only and

IR forwards only since their coefficients are exactly the effect of each type of instrument on EDF.

Table 4-6: Impact of different types of IR derivatives on the probability of default

This table presents the results of the impact of IR derivative types on the probability of default. The dependent variables are ***EDF1YEAR, EDF5YEAR. IR SWAPS ONLY, IR FORWARDS & SWAPS, IR FORWARDS ONLY, IR OPTIONS ONLY, IR FORWARDS & OPTIONS, IR SWAPS & OPTIONS, IR FORWARDS & SWAPS & OPTIONS*** *are dummy variables set equal to 1 if a firm uses a corresponding strategy and 0 otherwise.* ***LEVERAGE*** *is the ratio of total debt to the market value assets.* ***PROFITABILITY*** *is measured as EBITDA over total assets.* ***VOLATILITY*** *is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate.* ***FIRM SIZE*** *is the natural logarithm of total assets.* ***LIQUIDITY*** *is the ratio of total current assets minus total stock and work in progress over total current liabilities.* ***EXCESS RETURN*** *is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%, 5%, or 10% levels, respectively. The regressions include industry and year dummies.*

Variables	**EDF1YEAR**	**EDF5YEAR**
	(1)	(2)
IR SWAPS ONLY	-0.575***	-0.469***
	(0.187)	(0.127)
IR FORWARDS & SWAPS	-0.497**	-0.490***
	(0.225)	(0.166)
IR FORWARDS ONLY	-0.131	-0.204
	(0.468)	(0.309)
IR OPTIONS ONLY	-0.697***	-0.449**
	(0.247)	(0.179)
IR FORWARD & OPTIONS	-0.707	-0.329
	(0.825)	(0.538)
IR SWAPS & OPTIONS	-0.693***	-0.498***
	(0.243)	(0.168)
IR FORWARDS & SWAPS & OPTIONS	-0.936***	-0.755***
	(0.249)	(0.172)
LEVERAGE	5.343***	4.018***
	(0.528)	(0.358)
PROFITABILITY	-0.645	-0.706
	(0.675)	(0.471)
VOLATILITY	0.061***	0.040***
	(0.005)	(0.003)
FIRM SIZE	-0.187***	-0.177***
	(0.038)	(0.027)
LIQUIDITY	-0.050**	-0.040***
	(0.021)	(0.015)
EXCESS RETURN	0.383	0.273
	(0.313)	(0.217)
Constant	-0.749*	0.250
	(0.398)	(0.294)
Observations	7,325	7,325
Industry FE	Yes	Yes
Year FE	Yes	Yes
Country FE	Yes	Yes
R-squared	0.353	0.382

Table 4-6 presents the results for this section in both EDF1YEAR and EDF5YEAR. Looking at the estimates of IR options only and IR forwards only, we can see that only IR option is significant at -0.697 for EDF1YEAR and 0.449 for EDF5YEAR, while IR forward is not significant. This clearly indicates that IR forwards do not seem to be able to impact default probability, while IR option contracts reduce the likelihood of default. Our results are consistent with the argument that non-linear derivatives are better at reducing risk than linear strategies, consistent with Froot et al., 1993; Gamba and Triantis, 2014. Interestingly, the coefficient for IR FORWARDS & OPTIONS is not significant, which suggests that it is better for firms to use IR options alone or with IR swaps.

4.6.2.5. Bank-based versus market-based financial systems

As we continue to explore the effectiveness of interest rate hedging strategies on default risk, we recognize that the institutional context in which firms operate may play an important role. While our initial results suggest that long-term interest rate derivatives are more effective in managing default risk than short-term derivatives, we acknowledge that short-term derivatives are designed for short-term interest rate exposure. In light of this, we believe that it is important to investigate under what circumstances short-term hedging strategies are most effective. One plausible factor that may affect the effectiveness of short-term hedging strategies is the financial system of a country, particularly whether it is bank-based or market-based.

The study conducted by Baum et al. (2006) reveals that German firms exhibit a pronounced reliance on short-term debt financing, with the average ratio of short-term liabilities to total liabilities exceeding 70% within their sample of firms. The explanation for this behaviour of German firms is that Germany is a bank-based economy, which is one of the two possible financial systems along with market-based Anglo-American systems (Calomiris, 1993). In a bank-based economy, firms are much more debt-financed thanks to large banking sectors and close relationship between banks and firms. In simpler terms, firms in a bank-based economy typically depend on one primary bank to fulfil their financing needs. This “house bank” often pledges to assist firms in overcoming financial difficulties. Consequently, the cost of procuring short-term financing in the German economy may be comparatively lower in relation to other economies, thereby incentivizing German firms to engage in extensive utilization of short-term liabilities as a source of funding. On the other hand, market-based countries rely less on financing from banks and have a more developed equity market. Countries in our sample which are known for bank-based economies are Germany, Italy, and Spain. However, as argued by Cobham et al. (1999), Italy is neither bank-based nor market-based. Thus, we exclude Italy from the bank-based countries in our sample, leaving us with only Germany and Spain. As firms in bank-based countries tend to use more short-term debts as a mean of financing, it is more likely that those firms will use short-term interest rate derivatives such as forwards or swaps to hedge the exposure generated from the short-term liabilities. As a result, we hypothesize that the effect of short-term IR derivatives on the probability of default will be more pronounced than their long-term counterpart in bank-based economies. At the same time, firms in market-based countries may have more access to long-term financing sources such as bond markets, compared to firms in bank-based countries that rely more on short-term bank loans. Hence, firms in market-based economies may be better equipped to manage their long-term interest risk via the use of long-term interest rate derivatives. Consequently, our hypothesis is that the impact on default risk of long-term IR derivatives will be stronger in market-based nations (*H4-3*).

We therefore plan to split our sample into bank-based and market-based economies to examine the impact of institutional differences on the effectiveness of IR hedging strategies in managing default risk. Germany is a bank-based economy, in which companies rely more heavily on short-term debts due to large banking sector and close bank-client relationship (Baum et al., 2006). Spain also has a bank-based financial system, so we assume the behaviour of Spanish firms would be similar to German firms. We hypothesize that the effect of short-term IR derivatives on default probability will be more significant in bank-based countries. The results are fully displayed in Table 4-7. For EDF1YEAR, in the bank-based economies, we can see that only the short-term derivative strategy has a significant coefficient (-0.888), while the long-term derivative only or the combination strategy is not significant, which is in accordance with our expectation. This demonstrates that firms in bank-based countries such as Germany or Spain, which depend more extensively on short-term loans and are more exposed to short-term IR risk, benefit from hedging with short-term IR derivatives. In fact, within our sample, Germany and Spain have higher short-term debt percentages compared with other countries[35]. On the other hand, in market-

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based countries, we can see that short-term strategy does not seem to work due to the insignificant coefficient. Instead, LONG-TERM ONLY has a significant estimate of -0.602, and the significant coefficient of the combination of short and long-term is -0.643. This illustrates that companies in market-based nations, which focus more on long-term financing, experience a reduction in the probability of default given that they incorporate IR swaps in their hedging scheme. The results for EDF5YEAR are consistent with those of EDF1YEAR.

Table 4-7: Effect of long-term & short-term IR derivatives on default risk (Bank-based versus market-based countries)

*This table presents the results of the impact of derivatives use on the probability of default. In panel A the dependent variable is the probability of default for a one-year horizon (**EDF1YEAR**) and in panel B the dependent variable is the probability of default for a five-year horizon (**EDF5YEAR**). **LONG-TERM ONLY** is the dummy taking value of 1 if the firm uses long-term derivatives only and 0 otherwise. **SHORT-TERM ONLY** is the dummy taking value of 1 if the firm uses short-term derivatives only and 0 otherwise. **LONG & SHORT-TERM** is the dummy taking value of 1 if the firm uses long-term derivatives together with short-term derivatives and 0 otherwise. **LEVERAGE** is the ratio of total debt to the market value assets. **PROFITABILITY** is measured as EBITDA over total assets. **VOLATILITY** is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate. **FIRM SIZE** is the natural logarithm of the market value of assets. **LIQUIDITY** is the ratio of total current assets minus total stock and work in progress over total current liabilities. **EXCESS RETURN** is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%, 5%, or 10% levels, respectively. The regressions include industry, country and year dummies.*

VARIABLES	**PANEL A: EDF1YEAR**		**PANEL B: EDF5YEAR**	
	Bank-based	Market-based	Bank-based	Market-based
LONG-TERM ONLY	-0.307	-0.602***	-0.185	-0.527***
	(0.375)	(0.212)	(0.246)	(0.145)
SHORT-TERM ONLY	-0.888**	-0.383	-0.580*	-0.302
	(0.444)	(0.306)	(0.306)	(0.207)
LONG & SHORT-TERM	-0.580	-0.643**	-0.325	-0.557***
	(0.446)	(0.249)	(0.314)	(0.172)
LEVERAGE	3.798***	5.630***	3.331***	4.166***
	(1.138)	(0.590)	(0.755)	(0.402)
PROFITABILITY	-1.534	-0.500	-1.023	-0.647
	(1.289)	(0.786)	(0.863)	(0.548)
VOLATILITY	0.056***	0.063***	0.039***	0.041***
	(0.010)	(0.006)	(0.007)	(0.004)
FIRM SIZE	-0.279***	-0.161***	-0.237***	-0.163***
	(0.073)	(0.045)	(0.049)	(0.032)
LIQUIDITY	-0.051	-0.051**	-0.038	-0.041**
	(0.038)	(0.026)	(0.026)	(0.018)
EXCESS RETURN	-0.023	0.524	-0.134	0.409*
	(0.814)	(0.334)	(0.537)	(0.235)
Constant	1.584**	-1.163***	1.587***	0.073
	(0.784)	(0.441)	(0.529)	(0.328)
Observations	1,795	5,517	1,795	5,517
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
R-squared	0.279	0.400	0.332	0.419

4.6.2.6 Effect of firm size on swap user

The role of firm size in shaping the relationship between IR swap usage and firm default risk presents a compelling dimension of our analysis. Despite the extensive research into the determinants of derivative utilization, limited attention has been given to whether the impact of IR swap usage on risk of default varies according to the size of the firm.

As to fill this gap, and test hypothesis *H4-4*, we employ a method that segments our sample into four categories based on IR swap usage. IR SWAP USER Q1 includes the smallest 25% of firms exclusively using IR swaps, while IR SWAP USER Q4 encompasses the largest 25% of firms indicating IR swap usage. The results, displayed in Table 4-8, are indeed intriguing, revealing that firms in Q2 and Q3 engaging in IR swap activities experience a notable reduction in default probability for both EDF1YEAR and EDF5YEAR (-0.655 and -1.026, respectively). Strikingly, firms in Q1 and Q4 yield statistically insignificant results.

It appears that medium-size enterprises experience a more pronounced default risk reduction with the use of IR swaps, as evidenced by the substantial coefficients observed for the second and third quartiles (Q2 and Q3). On the other hand, the use of IR swaps by small firms, as shown by the insignificance for the first quartile (Q1), does not reduce default probability. This is likely due to the capacity to manage the initial costs associated with derivative utilization of larger firms, which is in line with previous studies conducted by Allayannis and Ofek (2001), Judge (2006), Chernenko and Faulkender (2011). This observation also supports the notion that small firms may be deficient in the requisite collateral assets to satisfy the stipulations inherent to derivative contracts, thereby diminishing their access to derivative hedging (Rampini et al. 2014). Furthermore, among the largest firms (Q4), the insignificant result may suggest that the availability of fixed-rate borrowing options appears to obviate the necessity for hedging. This finding aligns with the conclusions drawn by Covitz and Sharpe (2005).

Table 4-8: Impact of IR swaps on the probability of default and firm size

The table presents the results of effect of IR swaps usage on the default probability based on different firm size.The dependent variable is ***EDF1YEAR*** *and* ***EDF5YEAR****.* ***IR SWAP USER Q1, IR SWAP USER Q2, IR SWAP USER Q3, IR SWAP USER Q4*** *are dummy variables set equal to 1 if a firm is swaps user belonging to the 1st, 2nd, 3rd, 4th quartile of firm size and 0 otherwise.* ***LEVERAGE*** *is the ratio of total debt to the market value assets.* ***PROFITABILITY*** *is measured as EBITDA over total assets.* ***VOLATILITY*** *is expressed as the square root of the number of trading days in a year multiplied by the standard deviation of the natural log of the daily price growth rate.* ***FIRM SIZE*** *is the natural logarithm of total assets.* ***LIQUIDITY*** *is theratio of total current assets minus total stock and work in progress over total current liabilities.* ***EXCESS RETURN*** *is annual equity return minus annual return of the stock index representing each country. The standard errors, reported in parentheses, are adjusted for heteroskedasticity (White (1980)) and clustering at the firm level. ***, **, * denote significance at the 1%,5%, or 10% levels, respectively. The regressions include industry, country and year dummies.*

VARIABLES	EDF1YEAR	EDF5YEAR
IR SWAP USER Q1	-0.424	-0.437
	(0.496)	(0.339)
IR SWAP USER Q2	-0.655**	-0.543***
	(0.297)	(0.194)
IR SWAP USER Q3	-1.026***	-0.920***
	(0.309)	(0.215)
IR SWAP USER Q4	-0.204	-0.249
	(1.214)	(0.802)
LEVERAGE	6.628***	5.062***
	(0.872)	(0.593)
PROFITABILITY	-0.772	-0.742
	(0.863)	(0.594)
VOLATILITY	0.064***	0.043***
	(0.007)	(0.005)
FIRM SIZE	-0.148*	-0.167***
	(0.088)	(0.060)
LIQUIDITY	-0.066	-0.049***
	(0.025)	(0.018)
EXCESS RETURN	0.462	0.329
	(0.525)	(0.350)
Constant	-1.137	0.035
	(0.703)	(0.510)
Observations	3,191	3,191
Industry FE	Yes	Yes
Year FE	Yes	Yes
Country FE	Yes	Yes
R-squared	0.339	0.372

4.7 Conclusion

This chapter conducts a comparative analysis of the effectiveness of long-term (swaps) and short-term (forwards and options) IR derivatives in mitigating default likelihood for non-financial firms across a diverse European landscape. Encompassing data from Germany, France, Spain, Italy, Denmark, Sweden, the Netherlands, Norway, and the UK for the period 1999-2015, our investigation sheds light on the significance of IR derivatives as a risk management tool for reducing default probability. The analysis reveals a nuanced relationship between the maturity of IR derivatives and their impact on default risk. Our expectation is that short-term IR derivatives might exert a more substantial influence on the short-term probability of default, while long-term instruments might be more effective in mitigating long-term default probabilities compared to their short-term counterparts. However, contrary to the expectation, our findings suggest the superiority of IR swap contracts in managing both short-term and long-term default risk when compared to short-term instruments like IR forwards and options. This observed effectiveness of swaps could be attributed to their design, which allows for hedging a firm's total exposure to interest rate fluctuations, encompassing both short-term and long-term exposure.

Moreover, our research also uncovers evidence that the effect of IR derivatives on default probability can be influenced by a nation's financial system. Firms operating in countries that encourage the use of short-term liabilities appear to benefit more significantly from utilizing short-term IR derivatives to reduce default probability. Specifically, firms in Germany and Spain, which exhibit a higher reliance on short-term financing[36], experience a larger decrease in default likelihood when employing short-term derivatives compared to long-term contracts like swaps. Furthermore, a deeper dive into the short-term IR derivative category reveals that option derivatives seem to be more potent than forwards in reducing default probability for firms.

Company size also emerges as a potential factor influencing the utilization of IR derivatives for hedging purposes. Our findings suggest that medium-sized firms exhibit a more significant reduction in default probability. Conversely, the impact of IR derivatives appears to be less pronounced for both the smallest and largest firms. This observation could be explained by several factors. Smaller firms might face

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limitations in accessing derivative markets due to a lack of resources and expertise. Large firms, on the other hand, may have greater access to alternative risk management strategies, such as fixed-rate borrowing options, which could diminish the relative appeal of IR derivatives.

Appendix to Chapter 4: Long-term or short-term interest rate derivatives and default risk

This appendix contains additional information on the data used and some analysis. Appendix 4.1 provides some examples of corporate IR derivative usage information found in annual reports. Appendix 4.2 provides the comparison between the countries in the sample in terms of short-term debt percentage. A detailed explanation of the variables employed throughout this chapter, along with their corresponding definitions and source references, could be found in Appendix 4.3.

Appendix 4.1: Examples of corporate IR derivative usage in annual reports

Pennon Group Annual Report 2009

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"The Group's exposure to interest rate movements is managed by the use of interest rate derivatives. The Board's policy is that in any one year at least 50% of net debt is fixed. Interest rate swaps are used to manage the mix of fixed and floating rates. The Group has fixed approximately 60% of existing net debt up to 31 March 2010. At 31 March 2009 the Group had interest rate swaps to convert floating rate liabilities to fixed rate, and hedge financial liabilities, with a notional value of £760 million and a weighted average maturity of 2.4 years (2008 £634 million, with 2.1 years). The weighted average interest rate of the swaps for their nominal amount was 4.5% (2008 4.8%). The notional principal amounts of the interest rate swaps are used to determine settlement under those swaps and are not therefore an exposure for the Group."

Abacus Property Group Annual Report 2012

Page 59:

"The main purpose of the financial instruments used by the Group is to raise finance for the Group's operations. The Group has various other financial assets and liabilities such as trade receivables and trade payables, which arise directly from its operations. The Group also enters into derivative transactions principally interest rate swaps. The purpose is to manage the interest rate exposure arising from the Group's operations and its sources of finance."

Mercedes Annual Report 2000

Page 98:

"The Group enters into interest and interest rate cross-currency swaps, interest rate forward and futures contracts and interest rate options in order to reduce funding costs, to diversify sources of funding, or to alter interest rate exposures arising from mismatches between assets and liabilities."

Appendix 4.2: Short-term debt proportion over total debts across sample countries

Country	**Mean short-term debt percentage**
Denmark	17.86%
France	13.56%
Germany	24.34%
Italy	15.11%
Netherlands	14.16%
Norway	9.09%
Spain	21.50%
Sweden	10.96%
UK	11.58%

Appendix 4.3: Definition of variables and empirical prediction employed in Chapter 4

Variables	Definition	Source	Predicted sign
EDF	Expected default frequency	Moody's Analytics	
LONG-TERM ONLY	Dummy variable set to 1 for firms using long-term IR derivatives only; 0 otherwise	Annual report	+/-
SHORT-TERM ONLY	Dummy variable set to 1 for firms using short-term IR derivatives only; 0 otherwise	Annual report	+/-
LONG & SHORT-TERM	Dummy variable set to 1 for firms using both long and short-term IR derivatives; 0 otherwise	Annual report	+/-
LEVERAGE	Total debt/ (assets book value – equity book value + equity market value)	Datastream	+
FIRM SIZE	Natural logarithm of (total debt + market value of equity)	Datastream	-
EXESS RETURN	Annual equity return – annual return of stock index	Yahoo Finance	-
LIQUIDITY	(Total current assets – total stock and work in progress) / total current liabilities	Datastream	-
PROFITABILITY	EBITDA/ total assets	Datastream	-
EQUITY VOLATILITY	Standard deviation of daily stock return in one fiscal year	Datastream	+

Chapter 5: Conclusion

5.1 Summary of findings

This thesis presents three separate papers regarding hedging and default risk, giving an in-depth understanding of corporate hedging and default probability.

In Chapter 2, our research delves into the impact of derivative usage on the likelihood of defaults within non-financial firms, employing a cross-country perspective. Utilizing a distinctive dataset comprising derivative usage information from non-financial firms across nine European countries, spanning the period 1999 to 2015, including the UK, France, Germany, Denmark, Italy, Norway, the Netherlands, Spain, and Sweden, we ascertain that engaging in derivative hedging corresponds to a diminished probability of default. Notably, our investigation reveals that default risk reduction is more pronounced when employing IR derivatives compared to FX and CP derivatives. Furthermore, our study suggests a greater negative impact of derivative usage on short-term default risk compared to the long-term likelihood of default. The adverse correlation between derivatives and default probability remains robust even after employing various models to address potential endogeneity concerns arising from derivative usage and default probability. Additionally, our findings shed light on that firms experiencing severe financial distress might hedge less. Regarding the influence of creditor rights on the relationship between derivative use and default risk, our results show that derivative usage reduces default risk more in countries where creditor protection is robust. Furthermore, our study presents evidence suggesting that the effectiveness of derivatives diminishes in economies characterized by lower economic risk. Interestingly, the results suggest the effect of national-level factors on the long-term efficacy of derivatives.

In Chapter 3, we pioneer an examination into the impact of diverse currency hedging strategies—specifically, FX derivatives and FC debt—employed by non-financial firms on default probability. The sample encompasses firms in six countries—France, Germany, Italy, Norway, Spain, and the UK—over the period 1999 to 2015. Our findings suggest that, in comparison to currency derivatives, FC debt generally does not reduce the probability of default. Additionally, we observe that linear derivatives, such as FX forwards or swaps, exhibit a greater capacity to reduce the probability of default compared to non-linear strategies like FX options. However, we note that the non-linear strategy proves to be more optimal, in terms of default risk reduction, for firms with high growth, while low-growth firms tend to benefit more from FX linear strategies. Furthermore, our results highlight that currency forwards are more effective in mitigating short-term default likelihood, whereas currency swaps have a more pronounced impact on long-term default risk. Notably, we uncover evidence suggesting that the effect of FC debt on default probability is more positive in countries with stringent debt enforcement. Fascinatingly, our analysis reveals a specific circumstance in which FC debt may potentially mitigate default risk. This phenomenon is observed in entities with a significant proportion of foreign sales, and operating within countries characterized by suboptimal debt enforcement mechanisms.

In Chapter 4, we conduct a comparative analysis of the efficacy of long-term (swaps) and short-term IR derivatives (forwards and options) in mitigating default risk for non-financial firms across several European countries. Our findings underscore the crucial role of IR derivatives as a risk management tool for reducing default risk. Intriguingly, IR swap contracts are more effective than their short-term counterparts (forwards and options) in managing both short and long-term default probability, possibly due to their design to hedge a firm's total exposure. Moreover, our results reveal that firms in countries emphasizing the use of short-term liabilities, such as Germany and Spain, can experience a more substantial risk of default reduction through the use of short-term derivatives. Specifically, German and Spanish firms heavily reliant on short-term liabilities witness a greater reduction in the likelihood of default compared to their long-term counterparts. Additionally, within the realm of short-term derivatives, IR option derivatives appear to be more effective in reducing the probability of default than IR forwards. We also find that firm size influences the effect of IR swaps on default probability. Specifically, medium-sized enterprises demonstrate a more substantial decrease in default risk when utilizing IR swaps. In contrast, both small and large corporations exhibit statistically insignificant reductions in their probability of default when employing these financial instruments.

5.2 Research implications

In Chapter 2, we find that the role of creditor rights emerges as a crucial factor influencing the relationship between derivative use and default risk. The findings align with the notion that in countries with robust creditor protection, firms are more inclined to actively hedge and, consequently, experience more substantial risk reduction. This underscores the importance of legal and institutional frameworks in shaping corporate risk management practices. Policymakers and regulatory bodies in countries with weaker creditor protection might find impetus to strengthen legal safeguards to encourage more active risk mitigation strategies among firms. Furthermore, our findings indicate that derivative market policymakers should consider the potential repercussions of policies such as the financial transactions tax. Such measures, which may deter the use of derivatives for hedging, could negatively impact firms in nations with strong creditor rights. Additionally, the diminishing efficacy of derivatives in the presence of lower economic risk within a country provides a valuable cautionary note. While derivatives prove effective in high-risk environments, their impact wanes as economic risk decreases. This implies that firms and policymakers should adopt adaptive risk management strategies, tailoring approaches to the prevailing economic conditions. A one-size-fits-all approach to risk management may not be optimal, and an understanding of the economic context is essential for effective risk mitigation.

In Chapter 3, we find that hedging with FC debt, in general, does not seem to reduce default probability, whereas hedging with FX derivatives could lower default likelihood. Especially, the effect of FC debt on default risk becomes more positive in highly efficient debt enforcement environments. For policymakers, understanding the effectiveness of different currency hedging strategies can inform the development of appropriate regulations and policies related to derivatives and foreign currency debt. The results suggest that policymakers should encourage firms to consider using FX derivatives rather than relying solely on FC debt for hedging purposes. Promoting the use of more effective hedging strategies can help reduce default risk and enhance financial stability in the economy. For firms, the findings provide insights into the optimal currency hedging strategies to manage the probability of default. Especially, firms should be careful employing FC debt for hedging purposes in a highly efficient debt enforcement environment. Investors and creditors can benefit from the study's findings by gaining a deeper understanding of the effectiveness of different currency hedging strategies employed by firms. Furthermore, our findings underscore the importance of tailoring hedging strategies to align with the specific characteristics of firms, particularly their growth aspect. Firms experiencing high growth stand to benefit significantly from non-linear hedging strategies, suggesting that they should prioritize the adoption of such approaches to mitigate risk effectively. Conversely, for firms with lower growth or smaller investment programs, alternative hedging methods may be more suitable. This highlights the necessity for firms to conduct thorough assessments of their investment programs and risk exposure to identify the most appropriate hedging strategies.

In Chapter 4, our findings suggest the effectiveness in hedging both short and long-term default risk of IR swaps. For investors and creditors, understanding the effectiveness of IR derivatives, particularly long-term instruments like swaps, can aid in assessing a firm's default risk and overall financial stability. In addition, our research reveals that the effectiveness of IR derivatives is context-dependent, with the optimal choice of derivative instrument varying based on the financial system of the country in which firms operate. Specifically, firms operating in bank-based countries that prioritize short-term liabilities stand to benefit more from short-term derivatives. Practitioners can leverage this insight to design risk management frameworks that are aligned with the prevailing financial system dynamics, thereby maximizing the effectiveness of their risk mitigation efforts. Furthermore, firms, especially medium-sized enterprises, should explore IR swaps as a tool to reduce default risk, while acknowledging that the effectiveness of these instruments may vary based on company size.

5.3 Research limitations

This section acknowledges several limitations inherent in the present research. Firstly, there is a disparity in the number of countries included across different Chapters. While Chapters 2 and 4 encompass data from nine countries, Chapter 3 only includes data from six countries due to insufficient information regarding FC debt in certain nations. Expanding the number of countries in Chapter 3 would enhance the breadth and depth of the analysis.

Secondly, this thesis examines data from the period between 1999 and 2015. The process of gathering such extensive and complex data is time-consuming, which inevitably extends the duration of the project. Therefore, data collection must be concluded at a certain point. While the rationales behind the choice of these specific time periods has been explained, expanding the timeframe could potentially offer a more in-depth and comprehensive analysis of the dynamics being studied.

Thirdly, the absence of data from the United States represents another limitation. Incorporating data from the US would enrich the analysis by enabling comparisons between US and European countries, thereby offering valuable insights into the differences and similarities in derivative usage and its impact on default risk.

Lastly, the lack of notional value of derivative data poses a constraint on the analysis. Having access to more comprehensive data on the notional value of derivatives would facilitate a deeper examination of the relationship between hedging practices and default risk, particularly in exploring whether firms with higher levels of hedging exhibit different default risk profiles.

5.4 Future research

Chapters 2 and 3 underscore the importance of considering the international country setting in examining the real effects of hedging on firms' default probability. These Chapters reveal that the impact of hedging practices on default risk is contingent upon factors such as creditor rights, economic risk, and debt enforcement within a given country. Consequently, scholars interested in exploring the tangible outcomes of hedging strategies should carefully consider the legal frameworks and institutional environments across different nations.

The findings presented in Chapter 3 indicate that FC debt is generally suboptimal as a hedging instrument when compared to FX derivatives in terms of default risk mitigation. However, this conclusion warrants further investigation, particularly in the context of emerging markets. In these developing economies, where financial markets are often less sophisticated, FC debt has traditionally been regarded as a crucial hedging mechanism. This disparity between our results and the conventional wisdom in emerging markets presents an intriguing avenue for further research. Given the unique characteristics of emerging market economies, it is both pertinent and academically valuable to conduct a comparative analysis of the efficacy of various hedging strategies, specifically focusing on FC debt and FX derivatives. Such an investigation would not only contribute to the broader literature on corporate risk management but also provide nuanced insights into the applicability of different hedging instruments across diverse economic environments.

In Chapter 4, a notable finding emerges regarding the non-linear effect of hedging on default risk, particularly in the context of IR swaps. This discovery suggests that the influence of using financial derivatives on firm value or firm investment may exhibit non-linear dynamics. Therefore, future studies could delve deeper into investigating the nuanced and potentially non-linear impact of financial derivatives on various aspects of firm behaviour and performance.

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