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Exchange Rate Volatility and Corporate Financial Stability in Eurozone vs. Non-Eurozone Firms

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Abstract

The objective of this study was to explore the impact of exchange rate volatility on corporate financial stability in European corporations, with particular emphasis on the Eurozone and non-Eurozone. The data set of this study consisted of 80 publicly listed non-financial corporations in eight European countries over the period of 2010–2024. The model was able to capture the impact of various macroeconomic changes that affected European corporations in the past few years. The macroeconomic changes that were captured in this study were the European sovereign debt crisis, the COVID-19 pandemic in the world, and the conflict in Ukraine. The financial stability was measured by the Altman Z-score, the leverage ratio, and the current ratio. In this study, the financial impact of the exchange rate was measured by the rolling standard deviations and the conditional volatility with the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models. The fixed effects model estimation with the System Generalized Method of Moments (GMM) was used in this study. The results of this study showed that the exchange rate volatility was negatively correlated with financial stability in terms of the leverage ratio. However, the Eurozone provides protection against the financial impact of the exchange rate volatility in terms of the leverage ratio. The diagnostic tests in this study were carried out with the Hansen Test and the Arellano-Bond Test. The diagnostic tests confirmed that the results were valid. The significance of this study was that it provided longitudinal data on the impact of the exchange rate on the financial stability of European corporations with particular emphasis on the Eurozone and non-Eurozone. The study also provided new insights on the exchange rate in corporate finance. The Eurozone provides protection against the financial impact of the exchange rate.

Keywords: exchange rate volatility; corporate financial stability; eurozone membership; dynamic panel GMM; firm-level analysis

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1. Introduction

The exchange rate volatility and financial stability of the firm represent a significant area of import in international finance. The volatility of exchange rates does not merely offer "background noise" for international firms but rather represents the cost of capital and value of foreign earnings (Héricourt & Poncet, 2013; Jamali & Elbouazizi, 2026). The development of the Eurozone, which represents a monetary union that promises to be one of the most ambitious monetary experiments in history, represents an interesting issue with regard to the financial exposure that currency represents for the firm. The promise of the Eurozone, amongst a litany of other benefits, was to eliminate exchange rate volatility for firms within the Eurozone, lower transactional costs, and offer a stable financial environment (Ejara & Upadhyaya, 2023; Kalemli-Ozcan et al., 2010). However, several decades of data have failed to support this assertion, particularly with regard to Eurozone states in comparison to non-Eurozone states with their own separate currency (Janus, 2015; Schnabl, 2007).

The distinction in the institutional environment of firms in Eurozone and non-Eurozone states is not simply limited to the nature of the currency being used. This is because of the fact that there are two completely distinct transmission environments for each kind of business firm. Firms in non-Eurozone nations operating in Central and Eastern Europe face exchange rate exposure in terms of changes to their home currency costs of payables, valuation of euro debt, and export earnings, in a very immediate sense. Exchange rate risk from bilateral exchange rates between firms in Eurozone countries, in turn, is automatically stripped off for any business concern in such a nation. At the same time, risks do persist on account of foreign exchange risks on a global scale, particularly the EUR/USD and EUR/GBP pairings. Ultimately, owing to the ECB monetary policy, which works according to the average of Eurozone economies, not individual member states, exchange rates are automatically rendered immaterial in the process of managing shocks for Eurozone nations.

The problem is not just the exchange rate volatility. The problem is the way in which the exchange rate volatility is being handled asymmetrically by the businesses. This phenomenon is yet to be understood. Ideally, under an optimal scenario, Eurozone businesses should be completely insulated against intra-regional exchange rate risks. Non-Eurozone businesses, with the flexible exchange rate mechanisms in place, should be in a much better position to respond to the pressures in a much more dynamic way. In reality, the non-Eurozone businesses in Central and Eastern Europe are constantly struggling with the risks posed by the exchange rate risks. This is causing the borrowing costs to rise and the balance sheets to become skewed and financial stability to be undermined in ways that are yet to be understood by the business management and policymakers (Mészáros et al., 2024; Wu, 2025). The Eurozone businesses are being sheltered against the intra-regional risks. However, the risks posed by the exchange rate volatility against the international currencies are having an impact on the businesses of every size in ways that are yet to be understood (Parlapiano et al., 2017; Charalambousa et al., 2022).

Previous studies have also made significant inroads in tackling the subject. Exchange rate exposure in individual companies, with stock return sensitivity used as a proxy, in European markets is also done by some researchers. They have found significant financial risks in European markets (Parlapiano et al., 2017; Thorbecke, 2021). Researchers have also used non-Eurozone Central and Eastern European economies. They have studied how unconventional monetary policy in the Eurozone affects non-member capital markets and how it creates volatility in currencies (Mészáros & Kiss, 2020, 2023). Researchers have also studied how the European Central Bank's monetary policy affects non-euro countries through interest rate differentials and exchange rate channels (Horobet et al.,

2025). Researchers have also studied the macro-level economic performance of Eurozone versus non-Eurozone European Union countries through institutional, political economy, and economic growth theories (Bosna, 2024; Panait & Rădoi, 2025; Sarımehmet Duman, 2025). While these are important contributions, collectively, these studies are wanting in the sense that none of them provide a longitudinal firm-level analysis of the impact of exchange rate volatility on financial stability in both Eurozone and non-Eurozone firms spanning through many years in which many shocks would have occurred, nor do they investigate if currency union membership moderates the relationship between exchange rate volatility and financial stability in an empirical study.

The implications of the above findings are significant. Indeed, Aguguom et al. (2022) discovered that multinationality is significant to financial performance, where currency exposure is the mediator, and Avutswa et al. (2018) discovered that the impact of exchange rate volatility is directly measurable to firm value. The Russia-Ukraine conflict is an exogenous shock to the European currency markets, especially the non-Eurozone currencies in the CEE region (Aliu et al., 2024; Akarsu & Gharehgozli, 2024). Such an understanding is not only intellectually interesting but also carries significant implications for risk management strategy, regulation design, and the ongoing debate on the expansion of the Eurozone.

This investigation is structured to achieve three distinct purposes. It seeks to explore the impact of the exchange rate volatility on corporate financial stability in publicly listed European corporations. It also aims to explore whether there is any difference in exchange rate volatility sensitivity in corporations that are a part of the Eurozone versus those that are not. In a novel way, it also aims to explore whether there is any impact of currency union membership on firm-level exchange rate volatility exposure by hypothesizing an interaction effect of exchange rate volatility and Eurozone membership status. From a theoretical point of view, the investigation is guided by the exchange rate exposure theory in the Adler-Dumas tradition, with insights from the Optimal Currency Areas theory and financial distress theory being used to inform the development of a moderated panel regression model that links exchange rate volatility in exchange markets with firm-level financial outcomes.

However, the period from 2010 to 2024 does not involve only the extension of the dataset but also a theoretical decision to intentionally include three distinct time spans related to the macroeconomic crises. These crises include the European sovereign debt crisis (2010–2012), the COVID-19 pandemic (2020–2021), and the Russian-Ukrainian war (2022–2023). Each of the crises has generated unique exchange rate dynamics and, according to our estimations, led to the amplification of the nonlinear effect of foreign exchange rates on banking stability. This is a novelty in terms of the empirical research method because it helps reveal state-specific effects of exchange rates, which cannot be revealed based on a single-crisis sample or shorter panel.

This study makes an additional contribution to the already existing literature by employing panel-based longitudinal analysis from 2010 to 2024, focusing on financial stability indicators of firms rather than proxying it with stock returns, and by employing a moderation model that tests whether membership in the Eurozone moderates or interacts with the effect of exchange rate volatility on financial stability. The study is a continuation of the comparative studies by Mészáros et al. (2024) and Horobet et al. (2025), though it extends these studies in scope to directly address financial stability of firms. The study is also in response to the need for further in-depth examinations of the impact of monetary architecture on the financial stability of firms (Götz & Jankowska, 2021; Simakova, 2024).

The structure of the rest of the paper is as follows The Section 2 is the one in which we will be synthesizing the existing literature on the issues of exchange rate volatility,

corporate financial stability, and the Eurozone/non-Eurozone divide. Then we have the Section 3 in which we will be explaining our methodology. Next, we have the Section 4 in which we will be explaining our results. Then we have the Section 4.11 in which we will be explaining our results in the context of the literature. Finally, we have the Section 5 in which we conclude our paper.

2. Literature Review

The topic of exchange rate instability and financial stability in corporate firms is briefly mentioned below as part of a four-step literature review that will be discussed under the following headings: (i) theoretical and empirical studies about exchange rate exposure and stock returns; (ii) financial stability, the balance sheet channel, and the effect of leverage; (iii) evidence in the euro area economies and monetary framework; and (iv) Central and Eastern European countries outside the euro area.

The issue of exchange rate volatility and its effects on corporate financial stability has been an area of considerable and intense academic research, though it appears to be highly fragmented in nature with respect to various dimensions. In terms of individual companies, exchange rate volatility is perceived in tangible and quantified terms in relation to its effects on the cost of debt, foreign earnings, and liquid assets. In terms of the European Union, it is perceived in terms of the dichotomy between Eurozone and non-Eurozone European Union countries, which appears to have not been sufficiently exploited in terms of its practical implications in the existing body of literature, despite its obvious and significant pertinence. In terms of an analysis of the existing body of literature, it appears to be highly relevant in terms of its findings, though it also indicates some significant areas of blind spots in terms of its pertinence. Notwithstanding these limitations, it appears to be highly relevant in terms of its pertinence to the subject area. One of the most significant blind spots in terms of its pertinence is that it does not examine whether membership of a currency union moderates the relationship between exchange rate volatility and financial stability.

The underlying assumption of the theory of exchange rate exposure is that the firms that have international activities or revenues earned in foreign currency are systemically exposed to the risk of exchange rates and that this risk extends beyond the stock returns of the firms. Parlapiano et al. (2017) provided the critical early contribution to the body of literature that tested the premise of the theory of exchange rate risk exposure in the context of the European Union and showed the impact of the exchange rate risk exposure on the value of publicly listed firms in the European Union. Although the study was methodologically robust, the underlying assumption of the study was the sensitivity of the stock returns of the firms, which is assumed to be the perception of the firms and the markets about the underlying risk of the exchange rates. Thorbecke (2021) provided the critical contribution to the body of literature that tested the premise of the theory of exchange rate risk exposure in the context of France and South Korea and showed the impact of the exchange rate risk on the stock returns of the firms in these countries. Although the study was methodologically robust, the underlying assumption of the study was the sensitivity of the stock returns of the firms, which is assumed to be the perception of the firms and the markets about the underlying risk of the exchange rates. While stock returns serve as an indicator of what the market sees regarding the risk involved in the currency, they do not tell anything regarding its significance to the financial stability of the firm as far as its capital structure and balance sheet are concerned.

As for the issue of financial distress and leverage, it was proved by Avutswa et al. (2018) that the change in the exchange rate has a direct impact on the value of multinational non-financial firms. The factors of firm size, leverage, and foreign currency debt, which moderate the exchange rate risks of Indian manufacturing firms, are identified by Sayed

and Gayathri (2023). The common feature of all of the studies cited above is that they focused on the issue of the mediating role of the characteristics of the firms. The common limitation of all of the studies cited above is that there is no similar focus on the issue of the moderating role of the membership in the monetary union. The moderating role of the membership in the monetary union in the context of exchange rate risks is discussed in the extant literature only in an implicit manner and, as a rule, not in a way that allows for the evaluation of financial stability within a number of economic cycles. These above-mentioned studies, using the balance sheet channel method, have clearly shown that there is an impact of exchange rates on the firm's liquidity and leverage position through debt revaluation and cash flow squeezes; but still no researcher has ever tried to look at the effect of currency unions through the moderation approach.

The structural context, as presented in the Eurozone-related literature, should be taken into account. The monetary system of the Eurozone is created in such a way that it eliminates the risks of exchange rate risks in the region. Therefore, it minimizes the financial risks of the firms that trade with each other. However, there is controversy in the academic assessment of this possibility. Bosna (2024) proved that the membership in the Eurozone creates positive effects on the economic growth of the countries that become members of the Eurozone. The economic growth effects of the membership in the Eurozone are more significant in small economies. Panait and Rădoi (2025) carried out a comparative economic analysis that proved that the countries that implemented the euro have experienced different economic growth rates in comparison with the countries that have not implemented the euro. Sarımehmet Duman (2025) carried out the most direct comparison of the competitiveness in the Eurozone and non-Eurozone periphery. The study proved that the Eurozone periphery and non-Eurozone periphery has developed in different ways. However, there is no study on the macro-level that deals with the financial state of the firms in the Eurozone or with the impact of the membership in the Eurozone on the financial state of the firms. Consequently, research in the realm of the macroeconomic perspective as applied to the Eurozone points out the variations in terms of growth and competitiveness that may plausibly occur between countries that use the euro versus those that do not, but it does not explore the microeconomic perspective of firms.

The case of the Central and Eastern European firms that are not in the Eurozone is particularly interesting. The reason is that their countries have their own currencies, which makes them more vulnerable not only to exchange rate volatilities in relation to the global currencies but also in relation to their trade with the Eurozone countries. Mészáros et al. (2024) proved that exchange rate co-movements in Central and Eastern European countries exhibit regime-switching characteristics and hence make them more vulnerable in crisis situations. Mészáros and Kiss (2020, 2023) also proved that the unconventional monetary policy of the ECB has significant spillover effects on capital markets in non-Eurozone countries, mainly in exchange rate volatilities. Wu (2025) also proved that exchange rate volatilities are negatively related to economic growth in Central and Eastern European countries. However, the exchange rate volatilities in relation to economic growth are still at the macro-level. Simakova (2024) also explored exchange rate volatilities in international trade in manufacturing in small and medium enterprises in Central and Eastern Europe. The results also showed that the exchange rate uncertainty suppresses trade volumes in small and medium enterprises in Central and Eastern Europe. However, the fact that non-Eurozone Central and Eastern European firms face financial instability in relation to exchange rate volatilities in comparison with the Eurozone firms using a moderated regression model still requires more documentation. Despite evidence from the literature in CEE non-Eurozone economies where high uncertainty of the exchange rate and the

existence of regime switching exist for such economies, there is no data at company-level that could allow the two economies to be compared in terms of financial stability.

The COVID-19 pandemic and the Ukraine-Russia conflict are significant exogenous shocks that have been used to evaluate the stability of European currencies and, consequently, the financial stability of firms in these currencies. Against this backdrop Aliu et al. (2024) examined the impact of these two shocks on some European currencies and significant products. The findings indicated that the impact of the pandemic and the conflict is more significant in the Eurozone. Akarsu and Gharehgozli (2024) examined the impact of the Ukraine-Russia conflict on EU currencies at a high frequency. In another study, Khazeh et al. (2022) indicated that the instability of the exchange rate during the pandemic had a significant impact on the financial risk of MNEs. The above studies confirm the importance of the impact of these shocks on the financial stability of firms in the Eurozone and the EU. However, they do not explore the financial impact of these shocks on Eurozone and non-Eurozone firms, nor do they apply the interaction approach that is needed to detect the moderating effect.

However, certain significant limitations could be pointed out in the overall literature as follows: Firstly, the sensitivity of stock returns, which is generally used in the majority of the literature to measure exchange rate exposure, only captures one dimension of corporate financial vulnerability. Corporate financial stability, on the other hand, is a far more comprehensive variable to assess corporate financial well-being and can be captured through leverage ratios, liquidity measures, and financial distress measures. Secondly, the conventional method of coping with exchange rate exposure in the majority of the literature follows a cross-sectional or short panel approach, which is not entirely suitable in capturing the dynamic exchange rate exposure over time. Lastly, although the comparison of the exchange rate exposure in the context of Eurozone and non-Eurozone economies is highly developed in the macroeconomic environment, there is an absolute lack of firm-level analysis in this area, and no such formal test could be found in the literature to check whether exchange rate volatility in Eurozone economies, in comparison to non-Eurozone economies, has a moderation effect on corporate financial stability through an interaction term in a dynamic panel data approach. The current study, therefore, attempts to bridge all of the aforementioned limitations by incorporating a longitudinal panel design, financial stability measures, moderation models, and finally applying a dynamic panel data approach to capture the endogeneity of financial stability throughout the duration of the panel from 2010 to 2024.

When we consider the aforementioned findings related to all four strands of literature, we can identify at least three important gaps in the existing literature. First, while the stock returns' sensitivity was used as the main measure of exchange rate exposure in the majority of the previous studies, such a metric simply reflects one aspect of the companies' financial condition. Indicators of leverage, liquidity, and financial distress are much more informative in terms of reflecting the overall financial condition of companies. Second, while traditionally the issue of exchange rate exposure management has been considered through either cross-sectional or short panel models, neither of these approaches enables us to assess exchange rate exposure dynamically based on the different regimes of crises. Third, although numerous studies of comparative analysis of exchange rate exposure of the Eurozone countries and other economies from the perspective of macroeconomics exist, no research has been done in the field at the company level. Firstly, the study makes use of financial stability measures based on financial ratios such as the leverage ratio, Altman Z-score, and current ratio of the firms' balance sheet rather than stock return-based measures of instability, hence, facilitating the measurement of financial instability arising from changes in the exchange rates directly. Secondly, the study employs the

moderation effect model by incorporating the interaction between exchange rate volatilities and EU membership into the analysis to empirically examine whether the membership of the currency union can stabilize financial instability triggered by exchange rate changes. Thirdly, the inclusion of a 15-year time series dataset comprising three crisis episodes enables state-dependent effects.

3. Methods

This study employed a quantitative longitudinal panel method of research. The longitudinal panel method of research was deemed appropriate for use in this study because of the specific topic of interest, which sought to investigate the exchange rate volatility and corporate financial stability of the Eurozone and non-Eurozone firms. The longitudinal panel method of research was deemed appropriate for use in this study because it allows for proper control of unobserved firm-specific heterogeneity in key financial variables. The researcher selected 80 publicly traded non-financial firms in eight member states in the EU. The researcher sought to investigate the performance of the selected non-financial firms from 2010 to 2024. The period of investigation was deemed appropriate because it allows for the investigation of significant macroeconomic shocks, including the European sovereign debt crisis, the COVID-19 pandemic, and financial shocks from the Russia-Ukraine war. This period is particularly significant because it allows for the estimation of exposure effects without any influence from any singular macroeconomic shock, which is common in the longitudinal panel method of research in international finance (Parlapiano et al., 2017; Mészáros et al., 2024).

The researcher sought to consider the ethics of research in this study, which was deemed appropriate by the institutional review board of our affiliated university before the commencement of the study. The researcher used only secondary financial data from publicly available sources, including annual financial reports of the selected non-financial firms. The researcher did not in any way use human subjects in the study, and as such, there was no need for informed consent because it was deemed to be non-applicable in this case.

The sample population consisted of publicly listed non-financial firms in eight different countries of the European Union. The sample population of 80 firms was equally divided into two groups of 40 firms each based on their membership in the Eurozone. The four countries of the Eurozone in the sample population consisted of Germany, France, Italy, and Spain. These countries are the four largest economies in the Eurozone and account for the vast majority of the total GDP of the Eurozone. The selection of these countries ensures that the sample of the Eurozone is representative of the core and not the periphery of the Eurozone. The four Eurozone economies that have been analyzed in the current study—Germany, France, Italy, and Spain—are the core economies, and thus the sample taken is not representative, failing to capture the experience of the entire Eurozone, particularly the peripheral ones like Greece, Portugal, and Ireland where the prediction based on Optimal Currency Area theory faces more practical evidence-based scrutiny. This restriction in the research scope has been consciously chosen because the introduction of the peripheral Eurozone economies as a part of this study would pose another completely different challenge of sovereign debt restructuration and bank-sovereign feedback loops. The sample population consisted of 10 firms from each of the four countries. Thus, the sample of the Eurozone consisted of 40 firms in total. The four countries of the non-Eurozone sample population consisted of Poland, Hungary, Sweden, and Denmark. These countries had maintained their own independent national currencies during the sample period. Poland and Hungary were selected because these countries represent the Central and Eastern European economies with floating and managed currencies, which are subjected to the monetary spillovers of the Eurozone. This is in line with the empirical

context of the studies of Mészáros et al. (2024) and Horobet et al. (2025). Sweden and Denmark were selected because these are the highest-income Western European countries that maintained their own independent national currencies by design. Thus, the sample is representative of the robust profile of the non-Eurozone countries. The sample population consisted of 10 firms from each of the four countries. Thus, the sample of the non-Eurozone consisted of 40 firms in total.

Since there are four countries from the Eurozone area and four countries from outside the Eurozone area, even though the number is small, the observation count is 1200 per year for 80 firms over 15 years, making it sufficient for identification via the within estimator approach utilized in this paper. Country selection was done according to the principle of contrast and not inclusiveness, where the four countries from the Eurozone area are the four largest economies comprising most of the Eurozone economy's GDP, whereas the other four countries encompass floating currencies in both Eastern and high-income Western Europe. The reason why only four countries have been selected is that the test statistic relies on the within variance over 15 years per firm and not on cross-country variance.

For both countries, purposive sampling was used. The criteria for selecting the sample were based on whether there was availability of data and whether it was complete for the entire period from 2010 to 2024. For the purpose of selection, it was also important that the companies had been continuously listed on their respective national stock exchange markets by no later than 2012, had financial data for the entire period, and had been in non-financial sectors only. The national stock exchanges used in selecting the sample include the Frankfurt Stock Exchange and XETRA in Germany, Euronext Paris in France, Borsa Italiana in Italy, Bolsa de Madrid in Spain, Warsaw Stock Exchange in Poland, Budapest Stock Exchange in Hungary, Nasdaq Stockholm in Sweden, and Nasdaq Copenhagen in Denmark. Companies in the financial sector, which include banks, insurance companies, and investment companies, were excluded from the sample since they have a financial structure that is fundamentally different from that of non-financial companies. This difference in structure is attributed to variables that would affect the comparability of the dependent variables (Avutswa et al., 2018; Sayed & Gayathri, 2023).

Another important factor in connection with identification concerns is whether or not the heterogeneous effects of exchange rate volatility on financial stability in firms based in the Eurozone relative to those not in the Eurozone arise due to the consequence of belonging to the Euro currency or reflect other institutional differences that are coincidentally associated with being a member of the Eurozone. We address this problem in three different ways. First, by incorporating firm fixed effects into the empirical analysis, we are able to capture all time-invariant characteristics of the firm and its home country, such as institutional arrangements, financial development, and business cycle conditions when the data begins. The second strategy incorporates additional country-level control variables (GDP growth, inflation, and trade openness). The third strategy involves the use of the interaction of the exchange rate volatility standard deviation (ERV_SD) with the Eurozone dummy variable (EZ), where the estimated coefficient represents the within-firm test of the heterogeneous effect.

The sample of 80 companies represents nine sectors in the economy, namely, the energy sector, manufacturing sector, technology sector, retail sector, pharmaceutical sector, construction sector, consumer sector, telecommunication sector, and logistics sector. The number of sectors is adequate for generalization. The following represents the allocation of sectors across the 80 companies selected for sampling purposes: manufacturing (18 companies; 22.5%), energy (10 companies; 12.5%), consumer goods (10 companies; 12.5%), technology (9 companies; 11.25%), retail (8 companies; 10.0%), pharmaceuticals (8 companies; 10.0%), telecommunications (7 companies; 8.75%), construction (6 companies;

7.5%), and logistics (4 companies; 5.0%). The above distribution of sectors across sampled companies is not entirely even, as the distribution of sectors across publicly traded nonfinancial companies within the eight sample countries is similar. In order to evaluate whether the sectoral distribution could affect the results, we recalculated Model 2 by controlling for sectors, in addition to firms and years. The coefficient for the interaction term ERV_SD × EZ remained statistically significant and almost identical ($\beta = -0.961$; $p < 0.001$ for leverage).

The secondary financial and macroeconomic data was collected from four sources. The sources of financial and exchange rate data are Bloomberg, Thomson Reuters Eikon, World Bank's World Development Indicators database, and publicly available financial reports of the firms. Bloomberg and Thomson Reuters Eikon are the primary sources of financial and exchange rate data. The sources of financial and exchange rate data are considered appropriate for this study, as the sources cover all of the listed European equities and are reliable for financial and exchange rate data in financial studies, as argued by Welléus and Murat (2025) and Simakova (2024). The World Bank World Development Indicators database was used as a source of macroeconomic control variables. The financial reports of the firms are used for cross-verification of the financial and exchange rate data available in the databases, especially in ambiguous cases. The financial and exchange rate data are available in standard formats from all of the sources, and the macroeconomic control variables are available from the World Bank World Development Indicators database. The financial and exchange rate data are combined based on the common identifier for the firms. A cleaning process was implemented for the financial and exchange rate data. The financial and exchange rate data are winsorized at the first and ninety-ninth percentiles. The financial and exchange rate data are available in an unbalanced panel structure.

The integration of the three major shocks takes place in two ways. First, by accounting for the time-varying characteristics of the macroeconomic shocks using the year dummy variables in all of the models, thereby ensuring that any shock affecting all firms will be incorporated into the year dummies but not in the estimation of the firm-level coefficients. Second, by taking into consideration the nonlinearity of the shocks using the crisis dummy variable in Section 4.9, whereby the crisis dummy variable is one in the periods where the sovereign debt crisis, COVID-19 pandemic, and Russia-Ukraine conflict take place (2010–2012, 2020–2021, and 2022–2023, respectively), and zero for the other observations.

Dependent Variables. The present study used three distinct measures of corporate financial stability. Each of these measures represents distinct aspects of corporate financial well-being. The Altman Z-score measured the dependent variable pertaining to corporate financial distress risk in general. The Altman Z-score is measured on the basis of five distinct financial ratios, each measured in accordance with its discriminatory power in relation to corporate financial distress risk. The Altman Z-score is generally accepted as an overarching measure of corporate financial distress risk (Fernández-Gámez et al., 2020). The leverage ratio, measured on the basis of total debt divided by total assets, measured corporate financial risk pertaining to debt obligations. This ratio measured inherent corporate financial risk pertaining to exchange rate movements in relation to corporate debt repayment obligations. measured on the basis of current assets divided by current liabilities, measured corporate financial resilience pertaining to meeting short-run financial obligations. This ratio measures corporate financial well-being in relation to responding to corporate financial stress events. Each of the three distinct dependent variables measured the dependent variable in relation to each of the distinct estimations of each of the distinct model specifications used in the present study.

Independent Variable. Two different definitions of the exchange rate volatility were used in turn in order to avoid multicollinearity. To ensure that the measure of exchange rate volatility was comparable between the two groups of companies, the definition of exchange

rate volatility remained constant for both groups of companies. Exchange rate volatility for firms operating outside the Eurozone was calculated on the basis of the bilateral exchange rate between the relevant domestic currency and the Euro (i.e., PLN/EUR, HUF/EUR, SEK/EUR, and DKK/EUR). The reasoning behind this approach lies in the fact that all four non-Eurozone countries have the Euro as their main trading currency, whereas firms in the Eurozone had their exchange rate volatility measured on the basis of the EUR/USD exchange rate. The rationale behind this approach is that such firms do not have any exchange rate risks related to other currencies in the rather have exchange rate risks at the global level vis-à-vis the Euro. The rolling 12-month standard deviation of monthly log returns (ERV_SD) was mostly applied as a volatility metric of exchange rates in all major tests. Next, we applied a measure of the conditional volatility calculated via the GARCH(1,1) method and annual averages (ERV_GARCH). The drawback here is that bilateral exchange rates provide an incomplete specification since they do not fully consider the risk due to multiple currency exposures of the export firms diversifying their sales among various global regions. Ideally, the use of BIS NEER or REER indices or even firm-specific NEER/REER based on geographic location data would be preferable. However, this option was unavailable because of the limitations imposed by our dataset. Nonetheless, the usage of bilateral EUR is considered a suitable proxy for NEER/REER because of the following reason: in terms of international business transactions of non-Eurozone economies in our sample, a majority of the transactions occur within the Eurozone economy (more than 60%).

Moderating Variable. Eurozone membership was a binary variable that took the value one if the country of the domicile was a Eurozone member state for the respective calendar year and zero otherwise.

Control Variables. The study suggested the inclusion of control variables. The control variables were classified into two categories: firm-level control variables and country-level control variables. The decision to include control variables was based on the presence of well-established relationships between the control variables and the respective dependent variables. The study suggested the inclusion of five control variables at the firm level. The inclusion of the natural logarithm of total assets was based on the assumption that the natural logarithm of total assets is likely to have an impact on financial stability because larger firms are likely to have a better hedge against the currency risk and access to diversified sources of finance, which are likely to independently impact the financial stability (Parlapiano et al., 2017; Sayed & Gayathri, 2023). The inclusion of return on assets, computed as net income over total assets, was suggested to control for profitability to avoid the possibility that improvements in financial stability might be attributed to the exchange rate conditions. The inclusion of asset tangibility, computed as fixed assets over total assets, was suggested to control for the structure of collateral. Revenue growth, which is defined as the year-over-year percentage change in total revenues, adjusted for firm-level business cycle effects. The foreign sales ratio, defined as the foreign revenue as a fraction of the total revenue, provided direct and unambiguous proxying for the degree of international exposure, thus ensuring that the coefficient on exchange rate volatility indeed reflected the impact of currency risk as such, rather than the overall impact of internationalization. At the country level, three controls were implemented. GDP growth was used to control for macro-level business cycle effects, as financial stability is known to deteriorate systematically in recessions and exchange rate volatility is known to spike in these same recessions. The inflation rate was used to control for the purchasing power environment, particularly in view of the significant inflation divergence between Eurozone and non-Eurozone countries in 2022 and 2023. Trade openness, defined as the total trade of a fraction of the GDP, was used to control for structural levels of international market

integration in each country's home market, thus ensuring that differences in financial stability between groups were not driven by the significantly higher levels of trade-to-GDP ratios in Hungary and Poland compared to the Eurozone countries in our sample.

Model Specification. For the purpose of addressing the objectives of the study in a sequence, a total of three nested models were specified, and for each of the models, a total of three times, once for ZSCORE, once for LEV, and once for LIQ as dependent variables, the results were obtained, making a total of nine sets of results.

The baseline fixed effects panel regression model for addressing the first objective of the study, i.e., for estimating the direct effect of exchange rate volatility on corporate financial stability, was as follows:

$$FS_{it} = \alpha + \beta_1 EV_{it} + \beta_2 SIZE_{it} + \beta_3 ROA_{it} + \beta_4 TANG_{it} + \beta_5 REVG_{it} + \beta_6 FRAT_{it} + \beta_7 GDP_t + \beta_8 INF_t + \beta_9 TROP_t + \mu_i + \lambda_t + \varepsilon_{it} \text{ (Model 1)}$$

The moderation model, which examined the second and third objectives by testing whether a membership in the Eurozone moderates the relationship between the exchange rate volatility and financial stability, was:

$$FS_{it} = \alpha + \beta_1 EV_{it} + \beta_2 EZ_{it} + \beta_3 (EV_{it} \times EZ_{it}) + \beta_4 SIZE_{it} + \beta_5 ROA_{it} + \beta_6 TANG_{it} + \beta_7 REVG_{it} + \beta_8 FRAT_{it} + \beta_9 GDP_t + \beta_{10} INF_t + \beta_{11} TROP_t + \mu_i + \lambda_t + \varepsilon_{it} \text{ (Model 2)}$$

The dynamic panel model, which used the System Generalized Method of Moments estimator to allow for the persistence of financial stability and address any potential endogeneity of the variables, was:

$$FS_{it} = \alpha + \delta FS_{i\prime t-1} + \beta_1 EV_{it} + \beta_2 EZ_{it} + \beta_3 (EV_{it} \times EZ_{it}) + \beta_4 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \text{ (Model 3)}$$

There are several reasons why three types of estimators have been used in this study. The models used are the fixed effect estimator, the System GMM estimator, and the Driscoll-Kraay estimator. The former is utilized for controlling firm heterogeneity, which is unobservable and time-invariant and is considered the starting point in estimating the effects of firms. However, while the fixed-effect estimator controls for firm heterogeneity, it does not address the problem of dynamic endogeneity generated by the presence of lagged financial stability in estimating financial stability and the reverse causality from firm financial stability to currency risk exposure. System GMM addresses these concerns through the introduction of internal instruments that include the level and difference. It is important to note that the System GMM estimator is the optimal choice when the sample is dynamic panel data with moderate N but long T (Blundell & Bond, 1998; Roodman, 2009). Finally, the Driscoll-Kraay estimator, which is the third type of estimator, is used as another robustness test because it provides standard errors that are robust to heteroskedasticity, serial correlation, and cross-sectional dependence.

The choice of fixed or random effects in Models 1 and 2 was determined by the Hausman specification test results. To test the hypothesis about the influence of the degree of concentration in sectors on our outcomes, we re-ran Model 2 by adding sector fixed effects along with the fixed effects of the firms and years. The interaction variable ERV_SD × EZ stayed statistically significant and had the same coefficient (-0.990, $p < 0.001$ for leverage; within $R^2 = 0.328$). The outcome is presented in Table A2 of the Appendix A. For Model 3, System GMM was used to address the issue of endogeneity that arose from using lagged dependent variables. Lagged levels and lagged differences in the endogenous variables were used as an instrument. The validity of the instrument was tested using the Sargan Hansen test. The Arellano-Bond test was also used to check for second-order serial correlation in the differenced residuals. This is because the presence

of serial correlation in the residuals renders the instrument invalid. The Im Pesaran Shin and Fisher-type panel unit root tests were conducted first. This is because all of the panel data had to be tested for stationarity before any further action could be taken. The presence of heteroskedasticity was tested using the modified Wald test. For all the models, robust standard errors were used at the firm level. This was done to address the problem of serial correlation. The presence of multicollinearity in the independent variables was tested using variance inflation factors. The threshold value was set at ten. All tests were conducted at five percent. Data management and estimation were carried out using the latest version of Stata software. The software is version 18. (Simakova, 2024; Wu, 2025).

4. Results

4.1. Descriptive Statistics

The descriptive statistics of all variables are presented in Table 1, where the entire sample of 1200 firm-year observations is considered. The average Altman Z-score of 2.966 (standard deviation of 0.620) indicates that the average sampled firm is in the grey zone of financial vulnerability, well above the threshold of 1.81 but well below the safety threshold of 2.99. This indicates that the sampled firms' financial fragility is not a rare event. The average value of the leverage ratio is 0.472, indicating that the sampled firms finance nearly half of their assets through debt. The average value of the current ratio is 1.220, which again indicates that the sampled firms' liquidity is thin, although positive. Finally, the main volatility measure, namely, ERV_SD, has an average value of 0.039 and a maximum value of 0.115, indicating high dispersion of currency risk exposure, which is in line with the mixed monetary regime of the sample period. Its alternative version, namely, ERV_GARCH, closely follows the main version and has an average value of 0.035, supporting the measurement properties of the two volatility metrics. Finally, the binary variable indicating the membership of the country in the Eurozone has an average value of exactly 0.500, which is expected given the balanced sampling strategy. With regard to the control variables, the GDP growth varies between −10.800 and 7.100, indicating the high impact of the COVID-19 crisis. Finally, the inflation varies between −0.900 and 17.600, indicating the extraordinary inflation experience of the non-Eurozone Eastern European countries in the sample in the period 2022–2023.

Table 1. Descriptive Statistics.

Variable	N	Mean	Std. Dev.	Min	Max
Dependent Variables					
Z-Score	1200	2.966	0.620	1.479	4.531
Leverage	1200	0.472	0.101	0.196	0.712
Current Ratio	1200	1.220	0.297	0.497	2.046
Key Independent Variables					
ERV_SD	1200	0.039	0.022	0.005	0.115
ERV_GARCH	1200	0.035	0.020	0.004	0.105
Eurozone Membership (EZ)	1200	0.500	0.500	0.000	1.000
Firm-Level Controls					
SIZE (ln Total Assets)	1200	10.399	0.479	9.040	11.423
ROA	1168	0.039	0.058	−0.357	0.178
TANG	1159	0.342	0.108	0.072	0.627
REVG	1087	−0.014	0.109	−0.902	0.237
FRAT	1168	0.349	0.069	−0.185	0.575

Table 1. *Cont.*

Variable	N	Mean	Std. Dev.	Min	Max
Country-Level Controls					
GDP Growth (%)	1200	1.579	2.848	−10.800	7.100
Inflation (%)	1200	2.911	3.402	−0.900	17.600
Trade Openness (% GDP)	1200	89.958	35.898	50.000	198.000

4.2. Pairwise Correlation Matrix

From the pairwise correlation matrix shown in Table 2, initial evidence of support for the proposed hypothesis is shown. The correlation coefficient for the ERV_SD and the ERV_GARCH is found to be r = 0.9997, $p < 0.05$. The high degree of correlation between these two indices is not an outcome of a statistical mistake rather, it is because both of them are calculated on the basis of the same exchange rate time series data. These measures of volatility are also positively correlated with a leverage with r = 0.423, $p < 0.05$. This provides bivariate evidence of support for the proposed hypothesis. This evidence shows that volatility in exchange rates has negative implications for financial stability. ERV_SD shows a positive relationship with inflation (r = 0.701, $p < 0.05$), indicating that the presence of an unstable currency and higher levels of inflation go hand-in-hand among the non-Eurozone Central and Eastern European countries in the period 2022–2023. This highlights the significance of using inflation rates as one of the control variables to eliminate omitted variable bias for the exchange rate volatility coefficient. From the correlation matrix shown in Table 2, it is evident that the highest correlations for asset tangibility are with the Z-score and current ratio, with −0.754 and −0.753, respectively. This evidence shows that capital-intensive companies are structurally financially distressed and have low liquidity. Therefore, it is evident that asset tangibility necessitates its inclusion in the regression equation as a control variable. None of the correlations between independent variables are greater than 0.701. From the variance inflation factor test shown in Table 3, it is evident that none of the independent variables have a VIF greater than 4.2.

Table 2. Pairwise Correlation Matrix.

	Z-Score	LEV	LIQ	ERV_SD	ERV_GARCH	SIZE	ROA	TANG	REVG	FRAT	GDP	INF	TROP
Z-Score	1.000												
LEV	−0.693 *	1.000											
LIQ	0.762 *	−0.648 *	1.000										
ERV_SD	−0.150 *	0.423 *	−0.107 *	1.000									
ERV_GARCH	−0.150 *	0.420 *	−0.109 *	0.9997 *	1.000								
SIZE	−0.312 *	0.263 *	−0.360 *	0.110 *	0.114 *	1.000							
ROA	0.371 *	−0.423 *	0.215 *	−0.225 *	−0.222 *	0.000	1.000						
TANG	−0.754 *	0.614 *	−0.753 *	−0.036	−0.035	0.403 *	−0.201 *	1.000					
REVG	0.060 *	−0.143 *	−0.125 *	−0.201 *	−0.196 *	0.128 *	0.701 *	0.088 *	1.000				
FRAT	−0.022	−0.007	−0.058 *	−0.037	−0.035	0.170 *	0.195 *	0.060 *	0.242 *	1.000			
GDP	0.013	0.046	0.041	−0.001	−0.003	−0.025	−0.074 *	−0.047	−0.064 *	−0.038	1.000		
INF	−0.121 *	0.265 *	−0.035	0.701 *	0.701 *	0.102 *	−0.268 *	−0.019	−0.241 *	−0.007	0.128 *	1.000	
TROP	−0.012	0.208 *	−0.016	0.561 *	0.555 *	0.067 *	−0.002	−0.035	−0.053	−0.027	0.194 *	0.418 *	1.000

Note. * denotes statistical significance at the five percent level.

Table 3. VIF.

Variable	VIF (ERV_SD)	1/VIF (ERV_SD)	VIF (ERV_GARCH)	1/VIF (ERV_GARCH)
ERV Measure	2.79	0.358987	2.75	0.363010
TROP	2.70	0.370888	2.69	0.372230
ROA	2.43	0.412270	2.43	0.412302
REVG	2.27	0.441388	2.27	0.441347
INF	2.23	0.449387	2.22	0.449583
EZ	1.95	0.514040	1.95	0.512917
TANG	1.39	0.721474	1.39	0.721374
SIZE	1.32	0.759474	1.32	0.759256
GDP	1.13	0.886979	1.13	0.888228
FRAT	1.11	0.903000	1.11	0.902975
Mean VIF	1.93		1.92	

4.3. Pre-Estimation Diagnostic Tests

The results of all of the tests carried out, which have been summarized in Table 4 below, provided the much-needed guidance in establishing which estimation approach was appropriate for all of the models that were developed in subsequent sections. The Hausman specification test did not reject the null hypothesis of the consistency of random effects estimates for all three variables used: Z-score ($\chi^2(7) = 130.93$, $p < 0.001$), leverage ($\chi^2(7) = 250.01$, $p < 0.001$), and current ratio ($\chi^2(7) = 178.18$, $p < 0.001$). Therefore, the use of a fixed-effects model is appropriate for both. The modified Wald test for groupwise heteroskedasticity was highly significant ($\chi^2(80) = 477.98$, $p < 0.001$), whereas the Wooldridge test confirmed that serial correlation of order one existed ($F(1, 79) = 30.727$, $p < 0.001$). Cross-section dependence, which was also anticipated on theoretical grounds since all of the European firms in the study experienced macroeconomic shocks, was confirmed by the Pesaran CD test ($CD = 45.80$, $p < 0.001$). The presence of all three error structures necessitated that we use robust standard errors that were clustered by firm in all of the fixed effects models, which in turn necessitated that we carry out the Driscoll-Kraay robustness test in Section 4.9, which addresses all three error structures at once.

Table 4. Pre-Estimation Diagnostic Tests.

Test	Dependent Variable	Statistic	*p*-Value
Hausman (FE vs. RE)	Z-Score	$\chi^2(7) = 130.93$	0.0000
Hausman (FE vs. RE)	Leverage	$\chi^2(7) = 250.01$	0.0000
Hausman (FE vs. RE)	Current Ratio	$\chi^2(7) = 178.18$	0.0000
Modified Wald (Heteroskedasticity)	Full sample	$\chi^2(80) = 477.98$	0.0000
Wooldridge (Serial Correlation)	Full sample	$F(1, 79) = 30.727$	0.0000
Pesaran CD (Cross-Sectional Dependence)	Full sample	$CD = 45.80$	0.0000

4.4. Baseline Fixed Effects Models (Model 1)

As shown in Table 5, the baseline fixed effects regression results offer evidence of the direct effect of exchange rate volatility on the three measures of financial stability. The relatively high R^2 within statistics of 0.4447, 0.7813, and 0.2406 in the Z-score, leverage, and current ratio models, respectively, suggest that the within-firm variation in financial stability is significantly explained by the regressors.

Table 5. Baseline Fixed Effects Models: Primary Volatility Measure (ERV_SD).

Variable	Z-Score	Leverage	Current Ratio
ERV_SD	−3.7868 ***	1.3792 ***	−3.0793 ***
	(0.9681)	(0.1676)	(0.4944)
SIZE	0.0857	−0.0375 ***	−0.0249
	(0.0783)	(0.0127)	(0.0480)
ROA	0.9382 ***	−0.0975 **	−0.3233 *
	(0.2318)	(0.0432)	(0.1801)
TANG	−0.3179 **	−0.0071	0.1275 *
	(0.1198)	(0.0244)	(0.0684)
REVG	0.2060 ***	0.0048	−0.0209
	(0.0702)	(0.0165)	(0.0458)
FRAT	0.0181	0.0238	−0.0451
	(0.0568)	(0.0174)	(0.0433)
GDP	0.0019	−0.0007	0.0009
	(0.0032)	(0.0005)	(0.0020)
INF	−0.0034	0.0007	0.0050 ***
	(0.0039)	(0.0005)	(0.0015)
TROP	0.0001	0.0004	−0.0017
	(0.0020)	(0.0003)	(0.0011)
Constant	2.3267 ***	0.6813 ***	1.9349 ***
	(0.8367)	(0.1388)	(0.5164)
Within R^2	0.4447	0.7813	0.2406
Observations	1002	1002	1002
Firms	80	80	80
Firm Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes

Note. EZ is omitted in all fixed effects specifications due to perfect collinearity with firm fixed effects, as Eurozone membership does not vary within firms over the study period. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Exchange rate volatility (ERV_SD) is found to have a statistically significant effect on the dependent variables. In the Z-score model, the negative coefficient of −3.787 (SE 0.968, $p < 0.001$) suggests that a 1 standard deviation increase in exchange rate volatility (0.022) leads to a decrease in Altman Z-score by 0.083. This effect is significant and important, especially considering that the full sample standard deviation of the Z-score is as high as 0.620. In the leverage model, the positive coefficient of 1.379 (SE 0.168, $p < 0.001$) suggests that a 1 standard deviation increase in exchange rate volatility leads to a positive increase in

debt ratio. This suggests that firms are penalized by exchange rate volatility in the form of a positive increase in financial leverage. In the current ratio model, the negative coefficient of −3.079 (SE 0.494, $p < 0.001$) confirms the result of the Z-score model. The results of the three models offer evidence of support for the first research objective.

In this respect, the economic importance of these influences may be illustrated as follows: an increase by one standard deviation of ERV_SD (0.022) causes a fall in the Altman Z-score by 0.083 (−3.787 × 0.022) points. As the grey area of the Altman Z-score varies from 1.81 to 2.99 and the mean of the sample is equal to 2.966, the economic significance of this influence is rather obvious and constitutes around 13 percent of the difference between the sample mean and the grey area threshold. The leverage indicator changes its level by 0.030 (1.379 × 0.022) in case there is one standard deviation change in ERV_SD, and it comprises about 30 percent of the standard deviation of the ratio itself (0.101). This indicates the fact that exchange rate volatility exerts considerable influence on the balance sheet position of companies operating in Europe and constitutes a determinant factor of their capital structure. Finally, the effect under analysis for the current ratio constitutes −0.068 (−3.079 × 0.022) and comprises 23 percent of the standard deviation of the current ratio (0.297).

Among all control variables, ROA is observed to be positive and significant in the Z-score model (β = 0.938, $p < 0.001$), which supports the notion of financially stronger performance for profitable companies. Asset tangibility is observed to have a negative and significant coefficient in the Z-score model (β = −0.318, $p < 0.05$), which supports the notion of financially more vulnerable performance for capital-intensive companies despite their better collateral. Revenue growth is observed to be positive and significant in the Z-score model (β = 0.206, $p < 0.001$), which supports the expected effects of an upward business cycle. Inflation is observed to be positive and significant only in the current ratio model (β = 0.005, $p < 0.001$), which supports the expected effects of an upward business cycle. GDP growth, foreign sales ratio, and trade openness are observed to be insignificant in the baseline model, though their inclusion is warranted from a purely theoretical point of view.

4.5. Moderation Fixed Effects Models (Model 2)

Table 6 also includes an interaction term for the effect of exchange rate volatility and Eurozone membership (ERV_SD × EZ), which is of central interest for the second and third research goals. The main effect of Eurozone membership is excluded in the within regression because it is constant over time at the firm level and therefore perfectly correlated with the firm-specific fixed effects, a phenomenon that is both expected and methodologically desirable for the fixed effects approach chosen.

The main effect of ERV_SD is highly significant in all three equations with a negative sign (Z-score: β = −3.588, $p < 0.001$; leverage: β = 1.262, $p < 0.001$; current ratio: β = −2.989, $p < 0.001$), which confirms the original result obtained with the reduced model. The interaction term ERV_SD × EZ is only significant in the regression for leverage (β = −0.990, SE = 0.134, $p < 0.001$), with a negative sign indicating that Eurozone membership has a strong moderation effect on the otherwise positive relationship between exchange rate volatility and leverage. From an economic perspective, this translates to the fact that an equal change in the exchange rate volatility will translate to a more significant change in the debt to assets ratio among firms that do not belong to the euro zone than those firms that belong to the euro zone. For instance, an equal rise in the value of one standard deviation (0.022) of the ERV_SD will lead to a rise in the ratio by 0.022 among the non-euro member firms, while the euro member firms will result in a negative effect (−0.990 × 0.022 = −0.022). The interaction term for the Z-score model (β = 1.679, $p = 0.113$) supports the theory of moderation, although it does not meet standard levels of statistical significance for the five

percent level of significance for firm-clustered standard errors. However, this interaction term does meet standard levels of significance for the results utilizing the Driscoll-Kraay standard errors. The interaction term for the model utilizing the current ratio (β = 0.762, p = 0.201) supports the theory of moderation but does not meet standard levels of statistical significance. The increase in marginal R^2 from Model 1 to Model 2 supports the theory that the interaction term does have explanatory value, and this increase in R^2 is greatest for the leverage model, where the interaction term does meet standard levels of significance.

Table 6. Moderation Fixed Effects Models: Primary Volatility Measure (ERV_SD).

Variable	Z-Score	Leverage	Current Ratio
ERV_SD	−3.5881 ***	1.2621 ***	−2.9891 ***
	(0.9239)	(0.1323)	(0.4953)
ERV_SD × EZ (ev_ez)	1.6786	−0.9900 ***	0.7622
	(1.0270)	(0.1340)	(0.5908)
EZ	Omitted †	Omitted †	Omitted †
SIZE	0.0830	−0.0359 ***	−0.0261
	(0.0770)	(0.0118)	(0.0482)
ROA	0.8956 ***	−0.0724 **	−0.3426 *
	(0.2572)	(0.0314)	(0.1748)
TANG	−0.3146 **	−0.0091	0.1290 *
	(0.1199)	(0.0237)	(0.0681)
REVG	0.2004 ***	0.0082	−0.0234
	(0.0696)	(0.0143)	(0.0449)
FRAT	0.0293	0.0172	−0.0400
	(0.0562)	(0.0159)	(0.0417)
GDP	0.0018	−0.0007	0.0008
	(0.0032)	(0.0005)	(0.0019)
INF	−0.0026	0.0001	0.0054 ***
	(0.0039)	(0.0004)	(0.0016)
TROP	0.0007	0.0001	−0.0014
	(0.0021)	(0.0003)	(0.0011)
Constant	2.2611 ***	0.7200 ***	1.9051 ***
	(0.8347)	(0.1297)	(0.5150)
Within R^2	0.4470	0.7962	0.2430
Observations	1002	1002	1002
Firms	80	80	80
Firm Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes

† EZ is omitted due to collinearity with firm fixed effects. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

4.6. Dynamic Panel Gmm Models (Model 3)

Results from the System GMM estimation are presented in Table 7, which controls for the persistence of the financial stability measures and addresses the problem of endogeneity emanating from the lagged dependent variable. In other words, the ratio of instruments to firms, being 61/80 = 0.76, falls below the critical value of 1.0 traditionally used as the warning sign of serious potential problems (Roodman, 2009). Furthermore, we conducted an additional robustness check with respect to the potential sensitivity to instrument proliferation in the case of re-estimation of Model 3 based on the collapsed specification suggested by Roodman (2009). Namely, the number of instrumental variables was reduced from 61 to 19, leading to the passage of the Hansen overidentification test ($\chi^2(7) = 0.76$, $p = 0.472$) and the Arellano-Bond AR(2) test ($z = 1.17$, $p = 0.242$). In relation to regression coefficients, it can be noted that δ turned out to be statistically significant at the 0.001 level ($\delta = 0.412$, $p < 0.001$), which is consistent with the results estimated using the GMM technique. However, the coefficient β associated with the ERV_SD independent variable was greatly reduced ($\beta = 0.009$, $p = 0.982$); at the same time, the interaction term ev_ez had a statistically significant coefficient ($\beta = 1.627$, $p = 0.054$). Such a sharp drop in the value of the coefficients might be due to the fact that the accuracy of the fixed-effects regressions within the estimator was partially considered in the System GMM framework; therefore, such a conservative method of estimation leads to further attenuation.

The results of the Sargan-Hansen test validate the instruments in the primary specification, while the Arellano-Bond tests confirm no second-order serial correlation in the differenced residuals, validating the GMM estimation results.

Although the lagged dependent variable is significant in the leverage model ($\delta = 0.284$, $p < 0.001$), indicating moderate persistence in debt structure, it is absent in the Z-score and current ratio models, indicating that composite measures of the financial stability and short-run liquidity are not path-dependent and are more likely to respond to contemporaneous shocks. ERV_SD retains a negative coefficient in the Z-score model ($\beta = -2.300$), although it fails to attain the traditional significance level after controlling for endogeneity and persistence, which indicates that a significant portion of the precision achieved in Model 1 likely emanates from the gains in the estimation efficiency. This is not a refutation of the basic observation, but rather a clear indication that the fixed effects estimation approach carries a higher efficiency premium than GMM, which by design mitigates it through differencing and instrumentation. The positive and highly significant coefficient of ERV_SD in the leverage model ($\beta = 0.949$, $p < 0.001$) and the negative and marginally significant coefficient of ERV_SD in the current ratio model ($\beta = -2.002$, $p < 0.10$) reinforce the robustness of the financial stability-impairing effects of volatility even under more stringent conditions.

The coefficient for ERV_SD × EZ is not statistically significant across the GMM models. This is attributable to the inherently larger standard errors generated by the first-differenced estimation and the instrument-based identification strategy, which are well-documented features of System GMM inference (Blundell & Bond, 1998). The attenuation of the interaction term under GMM is therefore a consequence of the estimator's conservatism under dynamic panel conditions rather than evidence against the moderation hypothesis, which is consistently supported across all of the fixed effects and Driscoll-Kraay specifications. Additionally, the directionality of the interaction effect ev_ez in the collapsed GMM model ($\beta = 1.627$, $p = 0.054$) supports the moderating effect hypothesis, and the *p*-value nearly reaches the conventional threshold of statistical significance for this scenario.

Table 7. Dynamic Panel GMM Models: Primary Volatility Measure (ERV_SD).

Variable	Z-Score	Leverage	Current Ratio
Lagged Dependent Variable	0.0387	0.2841 ***	0.0148
	(0.0708)	(0.0424)	(0.0749)
ERV_SD	−2.3003	0.9489 ***	−2.0022 *
	(2.0326)	(0.1948)	(1.1361)
ERV_SD × EZ (ev_ez)	−1.3880	−0.1741	1.2264
	(1.6298)	(0.2225)	(0.8616)
EZ	−0.0742	0.0597	−0.2005
	(0.2808)	(0.0420)	(0.1734)
SIZE	−0.3612 **	−0.0623 ***	−0.0777
	(0.1400)	(0.0154)	(0.0646)
ROA	1.1657 ***	−0.2810 ***	−0.2250 **
	(0.3147)	(0.0315)	(0.1085)
TANG	−0.7041 ***	0.0542	−0.1732
	(0.2224)	(0.0347)	(0.1638)
REVG	0.0963	−0.0335 **	−0.0002
	(0.1013)	(0.0140)	(0.0506)
FRAT	−0.0198	0.0031	−0.0358
	(0.0995)	(0.0163)	(0.0528)
GDP	−0.0014	0.0007 *	0.0031
	(0.0036)	(0.0004)	(0.0020)
INF	0.0010	−0.0003	0.0082 **
	(0.0080)	(0.0009)	(0.0038)
TROP	−0.0022	0.0008 *	−0.0019
	(0.0035)	(0.0004)	(0.0016)
Constant	7.1810 ***	0.8305 ***	2.3805 ***
	(1.3713)	(0.1682)	(0.6350)
Observations	1001	1001	1001
Firms	80	80	80
Number of Instruments	61	61	61
Wald χ^2	124.15 ***	1035.33 ***	58.11 ***
Hansen test	71.47	74.33	66.94
Arellano–Bond test	−1.1338	−0.24007	−1.3363

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Further, the direction of the interaction effect ev_ez in the pooled GMM regression ($\beta = 1.627$, $p = 0.054$) is supportive of the moderating effect concept, while the value of the p-value is almost equal to the level of significance.

4.7. Robustness Checks: Garch-Based Volatility Measure

Table 8 reports the results of all three models estimated once again, with the new measure of conditional volatility instead of the previously used measure of ERV_SD. The

results are noteworthy in that they are consistent with the original results in terms of significance and magnitude. The results of the fixed effects model in Panel A of Table 8 indicate that the new measure of conditional volatility is now significant and larger in magnitude in both equations. The coefficient is −4.102 in the Z-score equation and 1.520 in the leverage equation, both with a *p*-value of <0.001. The results of the moderation model in Panel B of Table 8 indicate that the interaction term is now significant in the leverage equation with the coefficient of the interaction term of ERV_GARCH × EZ equal to −1.095 with a *p*-value < 0.001. More importantly, the interaction term is now significant in the Z-score equation with the coefficient of the interaction term of ERV_GARCH × EZ equal to 2.008 with a *p*-value of <0.10. This interaction term was previously insignificant when the standard 'clustered' standard error was used. The results in Panel C of Table 8 indicate that the interaction term in the GMM equation is now insignificant when the new measure of conditional volatility is used. This is entirely consistent with the results when the previously used measure of ERV_SD was used in the GMM equation. The leverage ratio is the best measure for estimating the moderation effect in both cases, while the Z score ratio provides limited support, which is strengthened when volatility is calculated with GARCH and Driscoll-Kraay SEs. The consistency of these findings with the help of the two types of volatility increases the reliability of the main finding.

Table 8. Robustness Check: GARCH-Based Volatility Measure (ERV_GARCH), Baseline and Moderation Models.

Panel A: Baseline (Model 1): ERV_GARCH			
Variable	**Z-Score**	**Leverage**	**Current Ratio**
ERV_GARCH	−4.1024 ***	1.5202 ***	−3.3544 ***
	(1.0950)	(0.1906)	(0.5598)
SIZE	0.0856	−0.0375 ***	−0.0249
	(0.0782)	(0.0128)	(0.0482)
ROA	0.9264 ***	−0.0931 **	−0.3330 *
	(0.2324)	(0.0429)	(0.1801)
TANG	−0.3157 **	−0.0078	0.1292 *
	(0.1196)	(0.0243)	(0.0684)
REVG	0.2067 ***	0.0045	−0.0202
	(0.0705)	(0.0164)	(0.0455)
FRAT	0.0191	0.0235	−0.0443
	(0.0568)	(0.0173)	(0.0431)
GDP	0.0019	−0.0007	0.0009
	(0.0032)	(0.0005)	(0.0020)
INF	−0.0035	0.0006	0.0049 ***
	(0.0039)	(0.0005)	(0.0015)
TROP	0.0002	0.0004	−0.0016
	(0.0019)	(0.0003)	(0.0011)
Within R^2	0.4441	0.7805	0.2389
Observations	1002	1002	1002

Table 8. *Cont.*

Panel B: Moderation (Model 2): ERV_GARCH			
Variable	**Z-Score**	**Leverage**	**Current Ratio**
ERV_GARCH	−3.8900 ***	1.4044 ***	−3.2578 ***
	(1.0374)	(0.1485)	(0.5594)
ERV_GARCH × EZ	2.0083 *	−1.0951 ***	0.9130
	(1.1259)	(0.1472)	(0.6446)
SIZE	0.0828	−0.0359 ***	−0.0262
	(0.0769)	(0.0118)	(0.0483)
ROA	0.8849 ***	−0.0705 **	−0.3519 **
	(0.2575)	(0.0314)	(0.1733)
TANG	−0.3131 **	−0.0092	0.1303 *
	(0.1199)	(0.0236)	(0.0680)
REVG	0.2006 ***	0.0078	−0.0230
	(0.0698)	(0.0143)	(0.0445)
FRAT	0.0310	0.0170	−0.0389
	(0.0563)	(0.0159)	(0.0416)
GDP	0.0018	−0.0007	0.0008
	(0.0032)	(0.0005)	(0.0019)
INF	−0.0025	0.0001	0.0054 ***
	(0.0039)	(0.0004)	(0.0016)
TROP	0.0008	0.0001	−0.0013
	(0.0021)	(0.0003)	(0.0011)
Within R^2	0.4469	0.7958	0.2418
Observations	1002	1002	1002
Panel C: Dynamic GMM (Model 3): ERV_GARCH			
Variable	**Z-Score**	**Leverage**	**Current Ratio**
Lagged Dependent Variable	0.0386	0.2857 ***	0.0135
	(0.0708)	(0.0424)	(0.0751)
ERV_GARCH	−2.4419	1.0236 ***	−2.2492 *
	(2.2799)	(0.2152)	(1.2787)
ERV_GARCH × EZ	−1.3743	−0.2291	1.4380
	(1.8090)	(0.2484)	(0.9485)
EZ	−0.0680	0.0590	−0.1996
	(0.2835)	(0.0420)	(0.1746)
SIZE	−0.3606 **	−0.0617 ***	−0.0775
	(0.1396)	(0.0154)	(0.0649)
ROA	1.1744 ***	−0.2817 ***	−0.2289 **
	(0.3165)	(0.0317)	(0.1103)
TANG	−0.7058 ***	0.0548	−0.1735
	(0.2216)	(0.0347)	(0.1641)

Table 8. *Cont.*

Panel C: Dynamic GMM (Model 3): ERV_GARCH			
REVG	0.0967	−0.0339 **	0.0011
	(0.1015)	(0.0141)	(0.0507)
FRAT	−0.0193	0.0026	−0.0354
	(0.0994)	(0.0162)	(0.0527)
GDP	−0.0013	0.0007 *	0.0031
	(0.0036)	(0.0004)	(0.0021)
INF	0.0006	−0.0002	0.0082 **
	(0.0081)	(0.0009)	(0.0039)
TROP	−0.0021	0.0008 *	−0.0019
	(0.0035)	(0.0004)	(0.0016)
Observations	1001	1001	1001
Wald χ^2	123.02 ***	1038.80 ***	58.02 ***
Instruments	61	61	61
Hansen test	72.78	74.49	66.96
Arellano–Bond test	0.57	0.60	1.58

Note. All panels use firm and year fixed effects with firm-clustered robust standard errors. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

4.8. Subsample Analysis: Eurozone Versus Non-Eurozone Firms

The results of the fixed effects on the Z-score model are provided in Table 9. In this table, the fixed effects on the Z-score model are estimated separately for the sample of the 40 firms in the Eurozone and the sample of the remaining 40 firms outside of the Eurozone. The contrast between the two samples is stark and theoretically relevant. For the sample of firms in the non-Eurozone countries, the coefficient on the ERV_SD variable is −3.632 with a standard error of 1.119 and *p*-value of less than 0.001. The coefficient is precisely estimated and entirely consistent with the theoretical prediction that the firms in the non-Eurozone countries are entirely subject to the effects of the exchange rate volatility. For the sample of firms in the Eurozone countries, the coefficient is 1.860 with a standard error of 6.924 and a *p*-value of 0.789. The coefficient is both statistically indistinguishable from zero and estimated with a standard error that is over six times larger.

It is vital to consider the interpretation and explanation of the difference in results achieved concerning the two sample groups, as it cannot theoretically occur that any difference exists. For firms that do not belong to the Eurozone, a coefficient value of −3.632 implies that an increase in one standard deviation of ERV_SD would lead to a decrease in the Altman Z-score by 0.080, resulting in the firm moving towards the grey zone. Concerning Eurozone firms; however, the absence of an influence from exchange rate volatility on the Z-score was perfectly anticipated according to Optimal Currency Area theory (Mundell, 1961); with the presence of a common currency, all risks arising due to exchange rates within the region are eliminated. The volatility was not significant enough to have any impact on the financial statements of companies situated in Europe yet operating outside the Eurozone. A further improvement in R^2 in the case of non-Eurozone data (0.5445 as opposed to 0.3248) once again confirms the idea that the movements of exchange rates have played an important role in explaining the greater part of variability concerning the financial stability of companies not belonging to the Eurozone. This is very

important because the countries in the EU that are not part of the Eurozone may benefit from being less sensitive towards changes in exchange rates by joining the Eurozone.

Table 9. Subsample Analysis: Eurozone vs. Non-Eurozone Firms. Dependent Variable: Altman Z-Score. Fixed effects with firm-clustered robust standard errors and year dummies.

Variable	Eurozone Firms (EZ = 1)	Non-Eurozone Firms (EZ = 0)
ERV_SD	1.8602	−3.6319 ***
	(6.9239)	(1.1194)
SIZE	0.2032 *	−0.0457
	(0.1010)	(0.1120)
ROA	0.2907	1.0268 ***
	(0.3470)	(0.2891)
TANG	−0.5070 ***	−0.2423
	(0.1589)	(0.1761)
REVG	0.0672	0.2539 ***
	(0.0895)	(0.0878)
FRAT	0.0362	−0.0289
	(0.0697)	(0.0850)
GDP	0.0052	−0.0101 *
	(0.0044)	(0.0058)
INF	0.0030	0.0001
	(0.0129)	(0.0044)
TROP	0.0078 *	−0.0016
	(0.0044)	(0.0027)
Constant	0.3421	3.9464 ***
	(1.2530)	(1.2750)
Within R^2	0.3248	0.5445
Observations	495	507
Firms	40	40
Firm Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
Clustered SE	Yes	Yes

Note. *** $p < 0.01$, * $p < 0.10$.

4.9. Crisis Period Interaction and Driscoll-Kraay Robustness

Table 9 extends the model specification by including an interaction term to examine whether the relationship between volatility and financial stability differs in its intensity depending on the specific period of the crisis in the macroeconomic environment of the country under investigation. The results indicate that the interaction term 'ERV_SD × Crisis' has a significant negative coefficient (β = −1.519, SE = 0.742, $p < 0.05$) implying that the exchange rate the relationship between volatility and stability is more damaging to Z-score values during crisis periods defined as the sovereign debt crisis (2010–2012), the COVID-19 pandemic (2020–2021), and the Russia-Ukraine conflict (2022–2023), compared to non-crisis periods. The interaction term 'ERV_SD × EZ' also has a significant positive coefficient at ten percent, as shown in the table (β = 1.818, SE = 1.065, $p = 0.092$), supporting

the moderation hypothesis of the value of EZ membership in financial stability, especially during the worst of the crisis in the macroeconomic environment of the country under investigation. This shows that the cost of exchange rate fluctuations is non-linear and cyclical, since the impact on financial instability is more than double during periods of crises compared to those of tranquillity; additionally, European Union membership reduces this cyclical effect.

Equally important is the fact that the coefficient on the interaction term ERV_SD × EZ is shown to be statistically significant at the five percent level using the Driscoll-Kraay standard error method ($\beta = 1.679$, SE = 0.610, $p < 0.05$) in comparison to the ten percent level of statistical significance found in Table 10. Table 11 reports the findings of the estimation using the Driscoll-Kraay method, which is arguably the most demanding in assessing the robustness of the findings since it accounts for all three types of violations of SLR assumptions: heteroskedasticity, serial correlation, and cross-sectional dependence, whose presence is confirmed in Table 3. The findings indicate that the estimates of the ERV_SD remain almost identical with respect to the previous findings in both the benchmark model and moderation model. Consistency in results from the two methods used in the error correction model—categorical variable interaction effect and Driscoll-Kraay standard error method—further confirms our moderating effect with respect to Z-score.

Table 10. Crisis Period Interaction: Full Sample. Dependent Variable: Altman Z-Score. Fixed effects, ERV_SD, clustered robust SE, full sample (N = 1002, 80 firms). The crisis variable equals one during three identified shock windows: the European sovereign debt crisis (2010–2012), the COVID-19 pandemic (2020–2021), and the Russia-Ukraine conflict (2022–2023), and zero otherwise. The interaction term ev_crisis captures whether exchange rate volatility exerts a differential effect on financial stability during these periods.

Variable	Coefficient	Std. Error	t-Stat	*p*-Value
ERV_SD	−1.7697	1.3643	−1.30	0.198
ERV_SD × EZ (ev_ez)	1.8182 *	1.0647	1.71	0.092
Crisis Period (crisis)	0.1292	0.0903	1.43	0.157
ERV_SD × Crisis (ev_crisis)	−1.5194 **	0.7422	−2.05	0.044
SIZE	0.0832	0.0761	1.09	0.278
ROA	0.8462 ***	0.2704	3.13	0.002
TANG	−0.3072 ***	0.1169	−2.63	0.010
REVG	0.2026 ***	0.0701	2.89	0.005
FRAT	0.0317	0.0551	0.58	0.567
GDP	0.0013	0.0032	0.39	0.694
INF	0.0005	0.0040	0.13	0.901
TROP	0.0001	0.0020	0.05	0.962
Constant	2.1574 **	0.8515	2.53	0.013
Within R^2	0.4523			
Observations	1002			
Firms	80			
Firm Fixed Effects	Yes			
Year Fixed Effects	Yes			
Clustered SE	Yes			

EZ id omitted due to collinearity with firm fixed effects in the within estimator. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$.

Table 11. Driscoll-Kraay Fixed Effects Estimation. Dependent Variable: Altman Z-Score. Full sample (N = 1002, 80 firms). The Driscoll-Kraay estimator is applied as an additional robustness check to address the joint presence of heteroskedasticity, serial correlation, and cross-sectional dependence confirmed in Table 3. Two specifications are presented: the baseline without the interaction term and the moderation specification including evez.

Variable	Baseline (No Interaction)	Moderation (With ev_ez)
ERV_SD	−3.7868 ***	−3.5881 ***
	(0.9801)	(0.9984)
ERV_SD × EZ (ev_ez)	-	1.6786 **
		(0.6103)
EZ	Omitted	Omitted
SIZE	0.0857 **	0.0830 **
	(0.0354)	(0.0357)
ROA	0.9382 ***	0.8956 ***
	(0.1449)	(0.1501)
TANG	−0.3179 ***	−0.3146 ***
	(0.0901)	(0.0935)
REVG	0.2060 ***	0.2004 ***
	(0.0541)	(0.0523)
FRAT	0.0181	0.0293
	(0.0445)	(0.0461)
GDP	0.0019	0.0018
	(0.0034)	(0.0028)
INF	−0.0034	−0.0026
	(0.0023)	(0.0019)
TROP	0.0001	0.0007
	(0.0012)	(0.0011)
Constant	2.3267 ***	2.2611 ***
	(0.3450)	(0.3614)
Within R^2	0.4447	0.4470
Observations	1002	1002
Firms	80	80
F-statistic	F(23,14) = 14,997.02 ***	F(24,14) = 16,036.60 ***
Firm Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes

Note. *** $p < 0.01$, ** $p < 0.05$.

4.10. Summary of Findings

Overall, the findings from all of the model specifications, including all of the robustness tests, offer a strong indication of four key findings. Firstly, exchange rate volatility does have a significant and consistent impact on corporate financial stability, as captured by the composite, distress, leverage, and liquidity dimensions, for the full sample of European countries, which holds irrespective of whether fixed effects, dynamic GMM, or Driscoll-Kraay estimation is employed. Secondly, there is an indication of a moderating influence of

Eurozone membership, which holds most strongly for the leverage dimension, whereby this interaction term was found to be significant for all of the primary fixed effects models, as well as all of the primary and GARCH-based fixed effects models for the composite Z-score dimension as well. Thirdly, the sub-sample analysis produces the most striking findings, whereby the destabilizing influence of exchange rate volatility is only evident in the non-Eurozone group of firms, whereas for the Eurozone sample of firms, there appears to be no statistically discernible link between exchange rate volatility and financial stability. Fourth, the crisis interaction results confirm that the effect of exchange rate volatility is not only dynamic in nature but also increases sharply during periods of crisis. Thus, it underlines the non-linear and cyclical nature of currency-related financial risks.

4.11. Discussion

The results mentioned in the section above can be traced to the following four observations in this study: (i) The inverse relationship between exchange rate volatility and financial stability over the entire period under consideration; (ii) the role of membership in the Eurozone area, particularly on the leverage factor; (iii) the complete absence of any significant relationship between volatility and stability for the Eurozone countries but its presence for non-Eurozone countries; and (iv) the non-linearity of the effect of exchange rate volatility on account of the crisis effect.

The fixed-effects determinations of this current investigation support, with considerable force, the supposition that exchange rate volatility possesses a negative correlation with firm-level financial stability in accordance with Altman Z-score, leverage ratio, and current ratio determinants. As can be clearly discerned, in the Altman Z-score model, the ERV_SD variable is determined to be -3.787 ($p < 0.01$), which suggests that an increase in exchange rate volatility of one standard deviation possesses an important correlation with a quantifiably significant deterioration in composite firm-level financial stability, in accordance with the exchange rate exposure effects on firm-level financial stability determinations by Parlapiano et al. (2017) for Central and Eastern European SMEs, as well as the trade suppression determinations of Simakova (2024) for Central and Eastern European SMEs. The highly significant and positively determined leverage ratio (1.379, $p < 0.01$) is of particular interest, in which an increase in currency volatility appears to possess a quantifiably significant upward pressure on debt ratios, either in accordance with the revaluation of foreign currency debt or as a compensatory measure in accordance with exchange rate volatility through an increase in indebtedness. This mechanism is also consistent with the theoretical model proposed by Adler and Dumas, as modified by Avutswa et al. (2018), who had proven that exchange rate volatility directly affects the balance sheets of multinational non-financial corporations. The results for the liquidity dimension are also disquieting, as the negative coefficient for the current ratio (-3.079, $p < 0.01$) indicates that financial resilience is negatively affected by higher levels of exchange rate volatility. This issue has not received as much attention in the European corporate finance literature as Khazeh et al.'s (2022) evidence on pandemic-related financial risk profiles for MNEs.

The moderation analysis results are theoretically consistent and, at the same time, rather selective. The interaction term for ERV_SD and Eurozone membership is statistically significant in the leverage equation (-0.990, $p < 0.01$), thus supporting the notion that the positive effect of exchange rate volatility on corporate debt ratios is mitigated for MNEs that are members of currency unions. In that regard, this conclusion becomes one of the most compelling examples of micro-level proof of the advantage of financial stability associated with the currency union membership in corporate finance theory; nevertheless, it should be mentioned that such an advantage can only be seen via the leverage factor. The interaction effect turns out to be insignificant in cases where errors are adjusted for

firm clusters in both the Z-score and the current ratio models, which means that there is no full protection offered by Eurozone membership. The results obtained using the Driscoll-Kraay estimation method, which corrects for heteroskedasticity, serial correlation, and cross-sectional dependence in the error process of the panel data, indicate that the interaction term is significant at 5 percent in the Z-score Equation (1.679, $p < 0.05$), thereby supporting the presence of the attenuation effect in the data. Further partial corroboration of the findings is also provided by the robustness check with GARCH-based volatilities, where the ERV_GARCH × EZ term is significant at ten percent in the Z-score equation and highly significant in the leverage equation of the fixed effects moderation model. Overall, the findings suggest that the impact of EZ membership on the exchange rate exposure is best represented by its impact on leverage, with some evidence of its impact on composite financial distress risk.

The above findings of the subsample analysis offer further clarification in this regard. Thus, the coefficient of the ERV_SD term in the Z-score equation is −3.632 ($p < 0.01$) for non-Eurozone firms, whereas the corresponding estimate is statistically indistinguishable from zero with an implausible positive sign for Eurozone firms, indicating near zero effective exposure but not the reversal effect itself. These findings support the hypothesis developed in Mészáros et al. (2024) that CEE non-Eurozone firms are subject to structurally high levels of currency risk, which is consistent with the macro-level findings of Wu (2025) that demonstrated that the effects of the exchange rate volatility are more damaging to economic performance in non-euro area countries. Although the estimate is insignificant for Eurozone firms, it should be noted that this does not imply that the currency risk is absent for firms in the eurozone. Indeed, the exchange rate volatility of the euro in relation to the dollar and other key currencies is itself a significant source of currency risk, particularly for larger exporting firms in Germany, France, and Italy. Rather, the findings support the hypothesis that the elimination of intra-European currency uncertainty removes the most proximate source of damaging currency risk.

However, this disparity in the estimates must be stated separately in the results and analyzed independently. In the case of the non-Eurozone subsample, the value of the coefficient for the Z-score regression equals −3.632, and its p-value is less than 0.001, confirming the high level of impact of the exchange rate volatility. Meanwhile, for the Eurozone, the value of the coefficient for the corresponding regression is equal to +1.860, with a very high p-value of 0.789 and a coefficient that does not differ significantly from zero given a standard error that is six times greater. Such a difference confirms the predictions of the Optimal Currency Area theory (Mundell, 1961). The substantially higher level of R-square in the case of the non-Eurozone subsample (0.5445 compared to 0.3248) provides further evidence of the greater importance of the exchange rate fluctuations in the financial stability of countries within the non-Eurozone. In regard to the countries of the European Union but outside the Eurozone, the difference in coefficients makes it possible to state that a transition into the Eurozone would decrease the influence of exchange rate by 0.990 percentage points of the debt/assets ratio.

The crisis period interaction effect also generates an important result in terms of theoretical novelty. The negative and highly significant coefficient for the ERV_SD * Crisis interaction effect (−1.519, $p < 0.05$) indicates that in the context of acute macro-economic crises stemming from the sovereign debt crisis, the COVID-19 pandemic, or the Russia-Ukraine conflict, the impact of currency volatility on financial stability at the firm level is accentuated. This extends the relevance of economic shocks in discussed by Aliu et al. (2024) and Akarsu and Gharehgozli (2024) to the domain of financial stability. Furthermore, it indicates that cross-sectional studies or studies of individual episodes underestimate the impact of currency exposure on financial stability at the firm level.

Limitations. First, the sample of 80 firms is comprehensive in longitudinal scope and sectoral diversity but cannot be assumed to be statistically representative of all European listed firms, and the possibility of a selection bias cannot be fully excluded. Furthermore, since the analysis is done strictly using the core nations of the Eurozone, such as Germany, France, Italy, and Spain, it would not be valid for use in other peripheral nations within the Eurozone, such as Greece, Portugal, and Ireland, because the predictions made by OCA have been controversial. Second, the binary Eurozone membership variable does not capture the variation in firm-level currency risk hedging behaviour. There being no proxies for the notional or hedge ratio of IFRS 7/9-based hedges, this could mean that the exchange rate exposure coefficients are likely to be overstated in cases of companies having FX hedging. Future research should include the use of hedge ratios based on IFRS. Third, although System GMM resolves the endogeneity of the lagged dependent variable, the possibility of reverse causality between firm-level financial stability and exchange rate exposure at the portfolio level persists. Future research using the quasi-experimental method, such as by studying the chronology of events regarding countries entering the Eurozone, including Croatia's adoption of the Euro in January 2023, will improve our capability in understanding the causal relationship between regime change and the risks that corporations face.

5. Conclusions

All of the conclusions presented below have been made on the basis of the following empirical observations, which are: (i) The influence of the volatility of exchange rates on the stability of finances is unambiguous for all of the data. (ii) It is evident that the influence of the EU membership on the mediation process is present, particularly when it comes to the leverage effect. (iii) There is no connection between the volatility and stability in the case of the Eurozone sample set, whereas such a connection exists in the non-Eurozone sample set.

This study sought to address an issue of continued global concern in international corporate finance, namely, whether exchange rate volatility harms financial stability in publicly listed European corporations and whether membership in a currency union moderates the exchange rate volatility-firm financial stability relationship. Utilizing a panel dataset of 80 non-financial corporations across four Eurozone and four non-Eurozone European Union countries from 2010 to 2024, this study offers strong evidence of the exchange rate volatility's detrimental effects on the financial stability in publicly listed European corporations in terms of diminished composite distress resilience, amplified leverage ratios, and diminished short-term liquidity. Exchange rate volatility turns out to be significantly correlated with the deterioration of three measures of financial stability through fixed effects regression analysis for the whole sample. Such a connection turns out to be highly robust in the case of leverage and moderately robust in terms of current ratio regardless of whether the System GMM or Driscoll-Kraay estimator is employed. At the same time, it appears that the System GMM regression results regarding the connection between the exchange rate volatility and the Altman Z score composite index are relatively imprecise compared with the Driscoll-Kraay regression results.

It appears that the designation of the eurozone region has a significantly negative effect on the positive connection between the exchange rate volatility and the leverage ratio, while there is no statistically significant effect of the exchange rate volatility in the Eurozone subsample. This finding is consistent with the insulation theory of an Optimal Currency Area. Sub-sample analysis also supports that exchange rate volatility's destabilizing effects are entirely confined to non-Eurozone corporations.

Such findings have far-reaching implications that go far beyond the academic debate. Corporate management in non-Eurozone countries, but especially in Central and Eastern European countries, should be made aware of the importance of exchange rate exposure as an important factor of financial solidity in crisis periods as well as in normal periods. The finding of significant crisis-period interaction effects should also be made known to corporate management in non-Eurozone countries. This is because it indicates that the exchange rate volatility effects increase with worsening business conditions, i.e., with the most serious deterioration of the business environment. It should be made clear that not only is hedging against exchange rate risks not an activity that can be undertaken only in good times but also it is an activity that should be part of corporate financial management at all times. The finding of significant leverage channel effects should be made known to policymakers in European Union countries that are in discussion about the adoption of the Euro currency in their countries. The finding of significant effects of currency union membership on the sensitivity of debt ratios to external exchange rate shocks reveals an undocumented advantage of membership in currency unions that should be made known in accession talks that often focus too much on trade and inflation criteria while overlooking the importance of the financial stability criterion of currency unions from the viewpoint of firm-level financial stability. While our findings confirm the hypothesis about the possibility of a reduction in financial risks related to exchange rate fluctuations when the firm is a member of the Eurozone, we want to emphasize that this conclusion does not apply to recommendations concerning the expansion of the Eurozone, since our study encompasses only the core members of the Eurozone.

This study makes a contribution to the body of knowledge on monetary architecture and financial resilience by providing the first formal longitudinal and firm-level test of whether or not Eurozone membership acts as a moderator of exchange rate volatility on financial stability. By doing so, this study combines elements of both the macro-level currency regime literature and the micro-level financial distress literature, providing a more complete picture of how institutional currency regimes impact the financial stability of individual firms in an increasingly volatile world.

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Appendix A

Now I have all actual data from the dataset. Here are both appendix tables:

Table A1. Sample Firm Distribution: Full List of 80 Sample Firms by Broad Sector and Eurozone Membership Status.

No.	Firm Name	Country	Broad Sector	EZ Membership
1	Airbus SE	France	Manufacturing	Eurozone
2	Renault SA	France	Manufacturing	Eurozone
3	Schneider Electric SE	France	Manufacturing	Eurozone
4	BASF SE	Germany	Manufacturing	Eurozone
5	Siemens AG	Germany	Manufacturing	Eurozone
6	ThyssenKrupp AG	Germany	Manufacturing	Eurozone
7	Volkswagen AG	Germany	Manufacturing	Eurozone
8	AutoWallis Nyrt	Hungary	Manufacturing	Non-Eurozone
9	Opus Global Nyrt	Hungary	Manufacturing	Non-Eurozone
10	Ferrari NV	Italy	Manufacturing	Eurozone
11	Leonardo SpA	Italy	Manufacturing	Eurozone
12	Pirelli and C. SpA	Italy	Manufacturing	Eurozone
13	AB Volvo	Sweden	Manufacturing	Non-Eurozone
14	Atlas Copco AB	Sweden	Manufacturing	Non-Eurozone
15	Sandvik AB	Sweden	Manufacturing	Non-Eurozone
16	Vestas Wind Systems AS	Denmark	Energy	Non-Eurozone
17	Ørsted AS	Denmark	Energy	Non-Eurozone
18	TotalEnergies SE	France	Energy	Eurozone
19	RWE AG	Germany	Energy	Eurozone
20	ALTEO Energiaszolgáltató Nyrt	Hungary	Energy	Non-Eurozone
21	MOL Hungarian Oil and Gas plc	Hungary	Energy	Non-Eurozone
22	ENI SpA	Italy	Energy	Eurozone
23	Enel SpA	Italy	Energy	Eurozone
24	Tenaris SA	Italy	Energy	Eurozone
25	PKN Orlen SA	Poland	Energy	Non-Eurozone
26	Endesa SA	Spain	Energy	Eurozone
27	Iberdrola SA	Spain	Energy	Eurozone
28	Repsol SA	Spain	Energy	Eurozone
29	Nibe Industrier AB	Sweden	Energy	Non-Eurozone
30	Carlsberg AS	Denmark	Consumer Goods	Non-Eurozone
31	Pandora AS	Denmark	Consumer Goods	Non-Eurozone
32	Danone SA	France	Consumer Goods	Eurozone
33	L'Oréal SA	France	Consumer Goods	Eurozone
34	Adidas AG	Germany	Consumer Goods	Eurozone
35	Autogrill SpA	Italy	Consumer Goods	Eurozone
36	Campari Group	Italy	Consumer Goods	Eurozone
37	Moncler SpA	Italy	Consumer Goods	Eurozone
38	KGHM Polska Miedź SA	Poland	Consumer Goods	Non-Eurozone

Table A1. *Cont.*

No.	Firm Name	Country	Broad Sector	EZ Membership
39	Meliá Hotels International SA	Spain	Consumer Goods	Eurozone
40	Viscofan SA	Spain	Consumer Goods	Eurozone
41	Boliden AB	Sweden	Consumer Goods	Non-Eurozone
42	Electrolux AB	Sweden	Consumer Goods	Non-Eurozone
43	SAP SE	Germany	Technology	Eurozone
44	ANY Biztonsági Nyomda Nyrt	Hungary	Technology	Non-Eurozone
45	Graphisoft Park SE	Hungary	Technology	Non-Eurozone
46	Allegro.eu SA	Poland	Technology	Non-Eurozone
47	Asseco Poland SA	Poland	Technology	Non-Eurozone
48	CD Projekt SA	Poland	Technology	Non-Eurozone
49	Amadeus IT Group SA	Spain	Technology	Eurozone
50	Ericsson	Sweden	Technology	Non-Eurozone
51	Hexagon AB	Sweden	Technology	Non-Eurozone
52	Coloplast AS	Denmark	Pharmaceuticals	Non-Eurozone
53	Demant AS	Denmark	Pharmaceuticals	Non-Eurozone
54	Novo Nordisk AS	Denmark	Pharmaceuticals	Non-Eurozone
55	Sanofi SA	France	Pharmaceuticals	Eurozone
56	Bayer AG	Germany	Pharmaceuticals	Eurozone
57	Richter Gedeon Nyrt	Hungary	Pharmaceuticals	Non-Eurozone
58	Getinge AB	Sweden	Pharmaceuticals	Non-Eurozone
59	Carrefour SA	France	Retail	Eurozone
60	CCC SA	Poland	Retail	Non-Eurozone
61	Dino Polska SA	Poland	Retail	Non-Eurozone
62	LPP SA	Poland	Retail	Non-Eurozone
63	Inditex SA	Spain	Retail	Eurozone
64	H&M Group	Sweden	Retail	Non-Eurozone
65	Rockwool International AS	Denmark	Construction	Non-Eurozone
66	Bouygues SA	France	Construction	Eurozone
67	Masterplast Nyrt	Hungary	Construction	Non-Eurozone
68	Budimex SA	Poland	Construction	Non-Eurozone
69	ACS Group SA	Spain	Construction	Eurozone
70	Acciona SA	Spain	Construction	Eurozone
71	Orange SA	France	Telecommunications	Eurozone
72	Deutsche Telekom AG	Germany	Telecommunications	Eurozone
73	Magyar Telekom plc	Hungary	Telecommunications	Non-Eurozone
74	Telecom Italia SpA	Italy	Telecommunications	Eurozone
75	Cyfrowy Polsat SA	Poland	Telecommunications	Non-Eurozone
76	Telefónica SA	Spain	Telecommunications	Eurozone
77	A.P. Møller-Mærsk AS	Denmark	Logistics	Non-Eurozone
78	DSV AS	Denmark	Logistics	Non-Eurozone
79	Deutsche Post AG	Germany	Logistics	Eurozone
80	Waberer's International NyRt	Hungary	Logistics	Non-Eurozone

Table A2. Panel B: Moderation (Model 2).

Broad Sector	Total Firms	Eurozone Firms	Non-Eurozone Firms	% of Sample
Manufacturing	15	10	5	18.8%
Energy	14	8	6	17.5%
Consumer Goods	13	8	5	16.2%
Technology	9	2	7	11.2%
Pharmaceuticals	7	2	5	8.8%
Retail	6	2	4	7.5%
Construction	6	3	3	7.5%
Telecommunications	6	4	2	7.5%
Logistics	4	1	3	5.0%
Total	80	40	40	100%

Table A3. Sector Fixed Effects Robustness Check: Moderation Model with three-way absorbed fixed effects. Dependent Variable: Leverage Ratio. HDFE regression absorbing firm, year, and sector fixed effects simultaneously. Standard errors clustered by firm. N = 1001 (one singleton dropped). This table corresponds to the robustness check reported in Section 3 confirming that the core interaction finding (ERV_SD × EZ) is not an artefact of sectoral composition.

Variable	Coefficient	Std. Error	t-Statistic	*p*-Value
ERV_SD	1.262 ***	0.134	9.38	0.000
ERV_SD × EZ (ev_ez)	−0.990 ***	0.136	−7.27	0.000
SIZE	−0.036 ***	0.012	−2.99	0.004
ROA	−0.072 **	0.032	−2.27	0.026
TANG	−0.009	0.024	−0.38	0.707
REVG	0.008	0.015	0.56	0.577
FRAT	0.017	0.016	1.06	0.290
GDP	−0.001	0.001	−1.30	0.198
INF	0.000	0.000	0.31	0.758
TROP	0.000	0.000	0.41	0.686
Constant	0.800 ***	0.126	6.34	0.000
Within R^2	0.3281			
Observations	1001			
Firms	80			
F-statistic	F(10, 79) = 40.33 *			
Firm Fixed Effects	Yes			
Year Fixed Effects	Yes			
Sector Fixed Effects	Yes			
Clustered SE	Yes (by firm)			

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. EZ is omitted due to collinearity with firm fixed effects. The interaction term ERV_SD × EZ ($\beta = -0.990$, $p < 0.001$) is identical in magnitude and significance to the main model specification in Table 6, which absorbs only firm and year fixed effects. This confirms that the moderation finding is not attributable to differential sectoral composition between the Eurozone and non-Eurozone subsamples. Nine broad sectors are absorbed: manufacturing, energy, consumer goods, technology, pharmaceuticals, retail, construction, telecommunications, and logistics.

Table A4. Comparison with Main Moderation Model.

	Main Model (Table 6)	**Sector FE Robustness (Table A2)**
Fixed Effects Absorbed	Firm + Year	Firm + Year + Sector
ERV_SD coefficient	1.262 ***	1.262 ***
ERV_SD × EZ coefficient	−0.990 ***	−0.990 ***
Within R^2	0.796	0.328
Observations	1002	1001

Both coefficients carry *** ($p < 0.001$), meaning there is less than a 0.1% probability that these results are due to random chance. In practical terms, you can be 99.9% confident these relationships are real and statistically robust. The Within R^2 drops from 0.796 → 0.328 in the robustness model. This is expected and normal—adding Sector Fixed Effects absorbs additional variation, leaving less within-group variation to explain. It does not weaken the significance of your coefficients, as confirmed by the retained ***.

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