

Exchange Rate Volatility, Global Currency Fragmentation, and Supply Chain Financing: Evidence from European and African Firms

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Exchange Rate Volatility, Global Currency Fragmentation, and Supply Chain Financing: Evidence from European and African Firms

Abstract

Global supply chains increasingly depend on financial mechanisms that support liquidity and trade credit across borders, yet macro-financial instability may disrupt these arrangements. This study investigates how exchange rate volatility, cross-border credit availability, and global currency fragmentation influence supply chain financing among European and African firms, while examining the moderating role of domestic credit to the private sector. Using a balanced panel of 40 firms from 2010–2024 (600 firm-year observations), the study applies a multi-method empirical strategy combining two-way fixed effects, dynamic System-GMM estimation, and panel quantile regression to capture static, dynamic, and heterogeneous effects. Machine learning validation using Extreme Gradient Boosting (XGBoost) with SHAP analysis further assesses nonlinear relationships and predictive relevance of the explanatory variables. The econometric results indicate that exchange rate volatility and global currency fragmentation significantly reduce firms' reliance on supply chain financing, whereas cross-border credit availability enhances trade credit financing within global production networks. Domestic financial development mitigates the adverse impact of exchange rate volatility, highlighting the stabilising role of strong banking systems. Quantile regression reveals heterogeneous effects across firms with different levels of supply chain financing. The machine learning validation confirms the predictive importance of macro-financial variables. The study contributes novel evidence by integrating macro-financial risks, firm characteristics, and machine learning validation within a unified framework, offering policy insights for strengthening financial resilience in global supply chains.

Keywords: Supply Chain Financing; Exchange Rate Volatility; Cross-border Credit Availability; Global Currency Fragmentation; XGBoost Machine Learning Validation.

1 Introduction

Global supply chains have become increasingly dependent on financial mechanisms that allow firms to stabilise working capital, manage liquidity constraints, and maintain operational continuity across borders. One of the most prominent mechanisms in this regard is supply chain financing (SCFI), which enables firms to optimise trade credit arrangements and improve cash-flow management through financial intermediation and coordinated financing structures among buyers, suppliers, and financial institutions. In modern production networks characterised by dispersed manufacturing and global sourcing, SCFI has evolved into a strategic instrument that enhances firm performance and strengthens inter-firm relationships within supply chains (Ali et al., 2020; Huang et al., 2022). Empirical evidence indicates that trade credit and financial coordination within supply chains play a significant role in sustaining operational efficiency and value creation, particularly when firms face liquidity constraints or macroeconomic volatility

(Carnes et al., 2023; Wetzel & Wagner, 2025). Moreover, the COVID-19 crisis and subsequent disruptions revealed how fragile global production networks can become when financing mechanisms are weakened, highlighting the critical role of supply chain financing in preserving supply chain resilience during periods of financial or economic uncertainty (Choi et al., 2023). As firms expand their operations across multiple currency jurisdictions, macro-financial factors such as exchange-rate volatility, global financial fragmentation, and the availability of cross-border credit increasingly shape the financing conditions that support supply chain transactions.

In this evolving macroeconomic environment, fluctuations in exchange rates represent a major source of financial risk for multinational corporations operating within global supply chains. Exchange rate volatility influences firms' cost structures, trade flows, and financing strategies, often leading to adjustments in trade credit policies and liquidity management practices (Lal et al., 2023; Kamalyan & Davtyan, 2025). Empirical studies demonstrate that unpredictable currency movements can disrupt international transactions and increase uncertainty for firms engaged in cross-border supply chains, thereby affecting their access to financing and their willingness to extend or receive trade credit (Li et al., 2025; Ji et al., 2026). In parallel, global financial uncertainty and currency market instability have been shown to intensify macroeconomic stress, particularly in emerging markets where exchange rate movements can propagate financial instability through multiple channels (Glebocki & Saha, 2024; Penzin & Salisu, 2026). Another critical dimension shaping supply chain financing is cross-border credit availability, which determines the ability of firms to obtain external liquidity from international banking systems. Financial globalisation has historically facilitated trade financing through cross-border banking networks; however, recent trends toward financial fragmentation and tightening international credit conditions have constrained these flows. Empirical evidence suggests that disruptions in credit availability can significantly weaken supply chain financing arrangements, as firms rely heavily on external liquidity to sustain trade relationships and manage working capital requirements (De Lucio et al., 2023; Ersahin et al., 2024). These developments have raised concerns about the stability of supply chain financing systems in an increasingly fragmented global financial architecture.

A further emerging dimension of the global financial landscape is global currency fragmentation, which refers to the gradual diversification of reserve currency systems and the declining dominance of a single global currency regime. Changes in the composition of global reserve currencies and the rise of alternative financial blocs may influence the structure of cross-border transactions and international liquidity distribution. Currency fragmentation can introduce additional complexities in international trade settlements, affecting firms' exposure to currency risks and shaping their financing decisions within supply chains. Despite growing interest in the macroeconomic implications of exchange-rate dynamics and financial fragmentation, the intersection between these macro-financial developments and firm-level supply chain financing remains insufficiently explored in the existing literature. While prior studies have examined the role of exchange rate volatility in international trade and supply chain disruptions (Lal et al., 2023;

Li et al., 2025), as well as the importance of trade credit for supply chain stability (Ersahin et al., 2024; Wetzal & Wagner, 2025), most empirical research has focused either on macroeconomic outcomes or firm performance rather than the financing structures that sustain global supply chains. Similarly, existing studies have examined supply chain finance primarily from operational or technological perspectives, emphasising digital transformation and financial intermediation (Chen et al., 2021; Gelsomino et al., 2023), but have paid limited attention to macro-financial risks such as exchange rate instability and global currency fragmentation. Consequently, a significant research gap remains in understanding how these macroeconomic forces jointly influence supply chain financing decisions across firms operating in different financial environments.

Motivated by these gaps, the present study investigates the implications of exchange rate volatility, cross-border credit availability, and global currency fragmentation for supply chain financing among European and African firms, while also examining the moderating role of domestic financial development measured by domestic credit to the private sector. By integrating firm-level financial data with macro-financial indicators across a balanced panel of firms from two distinct economic regions between 2010 and 2024, the study offers a comparative perspective on how macroeconomic instability and financial fragmentation shape supply chain financing structures across heterogeneous institutional environments. Unlike previous studies that rely solely on conventional econometric approaches, this research adopts a multi-method framework combining panel econometrics and machine-learning validation, thereby providing more robust insights into nonlinear relationships and predictive dynamics within global supply chain financing systems. The central objective of the study is therefore to examine how macro-financial risks influence firms' trade credit financing behaviour and to evaluate the conditions under which domestic financial development mitigates or amplifies these effects. Guided by theoretical insights from Transaction Cost Theory, Trade Credit Theory, Resource Dependence Theory, the Pecking Order Theory of Capital Structure, and Financial Intermediation Theory, the study addresses the following research questions: (1) How does exchange rate volatility influence supply chain financing among European and African firms? (2) What is the effect of cross-border credit availability on supply chain financing? (3) To what extent does global currency fragmentation affect supply chain financing structures? (4) Does domestic credit to the private sector moderate the relationship between exchange rate volatility and supply chain financing? and (5) How do firm-specific characteristics, particularly firm size and leverage, influence supply chain financing decisions? By addressing these questions, the study contributes to the growing literature on global financial fragmentation and supply chain resilience while offering novel insights into the macro-financial determinants of supply chain financing across advanced and emerging economies.

2 Literature Review and Hypothesis

The theoretical foundation of supply chain financing (SCFI) and its interaction with macro-financial conditions can be explained through several complementary economic and financial theories. Transaction Cost Theory, originally proposed by Coase (1937), posits that firms structure financial and contractual relationships to minimise transaction costs associated with market

exchanges. In the context of global supply chains, exchange rate volatility and financial uncertainty increase transaction costs associated with cross-border trade, thereby influencing firms' reliance on internal liquidity or trade credit arrangements. Similarly, Trade Credit Theory, articulated by Emery (1984), suggests that firms use trade credit as an alternative financing mechanism when access to traditional external finance is constrained. This theoretical perspective explains why supply chain financing becomes particularly relevant in environments characterised by financial market imperfections or macroeconomic instability. Furthermore, Resource Dependence Theory, developed by Pfeffer and Salancik (1978), argues that firms depend on external resources controlled by other actors, including financial institutions and trading partners. Consequently, the availability of cross-border credit and domestic financial systems plays a crucial role in shaping firms' financing decisions within supply chains. Pecking Order Theory, proposed by Myers and Majluf (1984), further explains that firms prioritise internal financing sources before resorting to external funding due to information asymmetry between firms and investors. In volatile macroeconomic environments, firms may therefore rely more heavily on trade credit and supply chain financing mechanisms when external credit becomes costly or uncertain. Finally, Financial Intermediation Theory, introduced by Diamond (1984), emphasises the role of financial institutions in allocating capital efficiently and mitigating information asymmetries between borrowers and lenders. In supply chain finance ecosystems, financial intermediaries facilitate liquidity provision and credit risk management among supply chain participants. Together, these theoretical perspectives provide a comprehensive framework for understanding how macroeconomic volatility, financial market conditions, and firm-specific characteristics influence supply chain financing decisions.

Empirical research increasingly recognises the strategic importance of supply chain finance in modern production networks. Ali et al. (2020) examined how supply chain finance mechanisms influence firm performance using a moderated mediation model within logistics systems. Their study aimed to explore the interaction between financial integration and supply chain coordination using structural modelling techniques. The results revealed that supply chain financing significantly enhances firm performance through improved financial flexibility and operational efficiency. Similarly, Huang et al. (2022) conducted a comprehensive review of recent developments in supply chain finance research, emphasising the growing integration of financial services into supply chain operations. Using a systematic literature review methodology, they found that supply chain financing enhances liquidity management and strengthens inter-organisational collaboration among supply chain actors. These findings align with Trade Credit Theory (Emery, 1984), which suggests that firms utilise trade credit arrangements to mitigate financing constraints and maintain operational continuity. Additionally, Carnes et al. (2023) investigated the role of cash flows within supply chain systems using empirical firm-level analysis. Their results demonstrated that liquidity allocation within supply chains influences value distribution among supply chain participants, reinforcing the importance of financial coordination within supply networks. Collectively, these studies highlight the fundamental role of financial arrangements in sustaining supply chain resilience and performance.

Another important strand of literature focuses on the role of exchange rate volatility in shaping trade relationships and supply chain dynamics. Lal et al. (2023) investigated the relationship between exchange rate volatility and international trade flows using econometric analysis across multiple economies. Their study aimed to determine how exchange rate fluctuations affect global trade activities. The findings revealed that exchange rate volatility increases uncertainty in international transactions and can discourage cross-border trade engagement. Similarly, Kamalyan and Davtyan (2025) examined the macroeconomic implications of exchange rate volatility for business cycle fluctuations using advanced macroeconomic modelling. Their results showed that exchange rate instability significantly amplifies economic uncertainty and affects firms' financial planning strategies. Furthermore, Li et al. (2025) explored the impact of exchange rate volatility on supply chain disruptions using panel data techniques. Their study found that volatile currency movements can destabilise international supply chains by increasing financial risk and operational uncertainty. These findings are consistent with Transaction Cost Theory (Coase, 1937), which suggests that increased uncertainty raises transaction costs associated with cross-border exchanges. Based on this theoretical and empirical evidence, exchange rate volatility is expected to influence firms' supply chain financing decisions as firms adjust trade credit policies to manage financial risks. Therefore, the following hypothesis is proposed:

H1: Exchange rate volatility significantly influences supply chain financing among European and African firms.

The availability of cross-border credit represents another crucial determinant of supply chain financing, particularly in globally integrated financial systems. De Lucio et al. (2023) investigated how firms respond to supply chain disruptions using empirical evidence from international trade networks. Their analysis aimed to determine how firms adjust their trade relationships when external financing conditions change. Using econometric models based on international trade data, the authors found that firms adapt their financial arrangements to maintain supply chain stability during disruptions. Similarly, Ersahin et al. (2024) examined the role of trade credit in sustaining supply chain stability using financial and supply chain datasets. Their study found that trade credit mechanisms provide a crucial buffer against financial shocks by enabling firms to maintain supplier relationships during periods of liquidity constraints. These findings strongly support Resource Dependence Theory (Pfeffer & Salancik, 1978), which posits that firms depend on external financial resources to sustain operational activities. When cross-border credit availability declines, firms may face difficulties in financing trade transactions, thereby affecting their reliance on supply chain financing mechanisms. Consequently, international banking networks and cross-border credit flows play an essential role in facilitating supply chain financing arrangements across firms operating in different financial environments. Based on this reasoning, the following hypothesis is formulated:

H2: Cross-border credit availability significantly influences supply chain financing among European and African firms.

The concept of global currency fragmentation has recently gained prominence in international finance literature as the dominance of a single global reserve currency gradually declines. Changes in global reserve currency structures may influence international financial flows, trade settlement mechanisms, and cross-border liquidity distribution. Glebocki and Saha (2024) examined the impact of global uncertainty and exchange rate conditions on financial stability across emerging and advanced economies using empirical econometric models. Their study revealed that global financial uncertainty and currency instability significantly influence macroeconomic outcomes and financial markets. Similarly, Penzin and Salisu (2026) analysed financial stress and exchange rate volatility using predictive modelling approaches. Their findings indicated that financial stress indicators can effectively predict exchange rate volatility and broader macro-financial instability. These findings align with Financial Intermediation Theory (Diamond, 1984), which emphasises the role of financial institutions and currency systems in facilitating efficient capital allocation. In an environment characterised by global currency fragmentation, firms operating within international supply chains may face increased financial complexity and liquidity constraints. Consequently, currency fragmentation may affect firms' ability to secure stable financing arrangements for cross-border transactions. Therefore, the following hypothesis is proposed:

H3: Global currency fragmentation significantly influences supply chain financing among European and African firms.

Beyond macro-financial variables, domestic financial development plays a critical moderating role in shaping firms' financing decisions within supply chains. Chen et al. (2021) examined how digital transformation enhances supply chain finance systems by improving transparency and financial accessibility. Their findings indicated that technological advancements and financial infrastructure development improve firms' access to financing and reduce transaction costs in supply chain finance arrangements. Similarly, Gelsomino et al. (2023) analysed transparency mechanisms within supply chain finance systems using empirical and conceptual analyses. Their results showed that financial transparency and institutional support improve the effectiveness of supply chain financing mechanisms. These findings are consistent with Financial Intermediation Theory (Diamond, 1984), which emphasises the importance of financial institutions in mitigating information asymmetries and improving capital allocation. When domestic credit markets are well-developed, firms can access financing more easily, thereby reducing the adverse effects of exchange rate volatility on supply chain financing decisions. In other words, strong domestic financial systems may mitigate macro-financial shocks affecting international supply chain operations. Based on this reasoning, the following hypothesis is formulated:

H4: Domestic credit to the private sector moderates the relationship between exchange rate volatility and supply chain financing.

Finally, firm-specific characteristics play an important role in determining firms' financing strategies within global supply chains. Larger firms typically possess stronger financial capacity, diversified revenue streams, and greater bargaining power within supply chain networks.

According to Pecking Order Theory (Myers & Majluf, 1984), firms prioritise internal financing sources before resorting to external borrowing. Large firms with greater internal resources may therefore rely less on external supply chain financing compared to smaller firms. In addition, leverage influences firms' financial risk profiles and borrowing capacity. Highly leveraged firms may rely more heavily on trade credit arrangements to manage liquidity constraints within supply chains. The importance of firm-specific characteristics in shaping financing decisions has been highlighted in supply chain finance research, which emphasises the interaction between firm-level financial structure and supply chain financial arrangements (Ali et al., 2020; Carnes et al., 2023; Wetzal & Wagner, 2025). Therefore, firm size and leverage are expected to influence firms' reliance on supply chain financing within global production networks. Based on these theoretical arguments and empirical insights, the following hypothesis is proposed:

H5: Firm size and leverage significantly influence supply chain financing among European and African firms.

3 Data and Methodology

3.1 Research Design and Sample Description

This study adopts a quantitative panel research design to examine the macro-financial determinants of supply chain financing among firms operating within global production networks. A panel data framework is particularly appropriate for this analysis because it allows the study to control for both cross-sectional heterogeneity across firms and temporal variations across years, thereby improving the reliability and consistency of the estimated relationships. Panel datasets provide several econometric advantages compared with purely cross-sectional or time-series data, including improved efficiency of parameter estimates, reduced multicollinearity among explanatory variables, and enhanced ability to capture unobserved heterogeneity (Baltagi, 2021). In the context of global supply chains, panel data approaches enable researchers to analyse how macroeconomic shocks and financial conditions influence firm behaviour over time while controlling for firm-specific characteristics that remain constant across periods.

The dataset used in this study consists of a balanced panel of 40 multinational firms observed over the period 2010–2024, producing a total of 600 firm-year observations (40 firms $\times$ 15 years). The firms included in the analysis comprise 20 European firms and 20 African firms, selected based on the availability of continuous financial reporting and international operational exposure throughout the study period. The inclusion of firms from both advanced and emerging markets allows the study to capture heterogeneous financial environments and institutional contexts affecting supply chain financing decisions. The European sample includes globally recognised firms such as Nestlé, Siemens, Volkswagen, and Airbus, while the African sample includes firms such as Dangote Cement, MTN Group, Safaricom, and Standard Bank. These firms operate across diverse sectors, including manufacturing, telecommunications, financial services, and consumer goods, thereby ensuring broad representation of global supply chain activities.

The dependent variable of the study is Supply Chain Financing (SCFI), proxied by the ratio of trade payables to total assets, which captures the extent to which firms rely on trade credit arrangements to finance supply chain transactions. This proxy has been widely used in supply chain finance research to measure firms' reliance on supplier credit within production networks (Ali et al., 2020; Wetzel & Wagner, 2025). The key explanatory variables include Exchange Rate Volatility (ERV), measured as the standard deviation of monthly exchange-rate returns; Cross-Border Credit Availability (CBC), proxied by foreign bank claims as a percentage of GDP; and Global Currency Fragmentation (GCF), measured using one minus the Herfindahl–Hirschman Index (HHI) of global reserve currency shares. These variables capture macro-financial conditions influencing firms' access to liquidity within global supply chains. The moderating variable is Domestic Credit to the Private Sector by Banks (DCPSB), which measures domestic financial development and credit availability within national banking systems. Firm-level control variables include Firm Size (SIZE), measured as the logarithm of total assets, and Leverage (LEV), measured as total debt divided by total assets. These control variables are widely used in corporate finance and supply chain studies because firm size and capital structure significantly influence financing behaviour and liquidity management (Carnes et al., 2023; Huang et al., 2022).

Data for the study were obtained from multiple reputable sources to ensure data reliability and comparability across countries. Firm-level financial data were collected from corporate financial statements and annual reports, while macro-financial indicators were sourced from international databases including the International Monetary Fund (IMF), the European Central Bank (ECB), the Bank for International Settlements (BIS), and the World Bank's World Development Indicators. The integration of firm-level financial data with macroeconomic indicators allows the study to examine how macro-financial shocks influence firm financing behaviour within global supply chains. Prior research highlights the importance of integrating macroeconomic variables with firm-level data when analysing supply chain finance dynamics because macroeconomic instability can significantly affect trade credit arrangements and supply chain coordination (Choi et al., 2023; Lal et al., 2023). The selected study period of 2010–2024 is particularly relevant because it captures several major global economic events, including post-financial crisis recovery, the COVID-19 pandemic, and rising global financial fragmentation, all of which have significant implications for supply chain financing systems.

3.2 Model Adaptation from Previous Empirical Studies

The econometric framework employed in this study draws upon established empirical approaches used in the literature on supply chain finance, exchange rate volatility, and international financial systems. Previous studies examining supply chain finance relationships have employed panel econometric techniques to capture firm-level heterogeneity and dynamic financing behaviour within supply chains (Ali et al., 2020; Carnes et al., 2023). Similarly, studies investigating the effects of exchange rate volatility and financial instability on international trade and supply chain disruptions have utilised panel regression and macro-financial modelling approaches (Lal et al., 2023; Li et al., 2025). Additionally, recent studies on global financial uncertainty and exchange

rate fluctuations emphasise the importance of dynamic modelling techniques to account for persistence and endogeneity in macro-financial relationships (Glebocki & Saha, 2024; Penzin & Salisu, 2026).

Drawing on these empirical contributions, this study adopts a multi-model econometric strategy consisting of three complementary econometric models: Two-Way Fixed Effects panel regression, Dynamic System-GMM estimation, and Panel Quantile Regression. These models allow the study to capture static, dynamic, and heterogeneous effects of macro-financial variables on supply chain financing behaviour. In addition to traditional econometric models, the study incorporates machine learning validation using XGBoost regression to explore nonlinear relationships and assess predictive performance. The use of both econometric and machine learning approaches has become increasingly common in contemporary empirical finance research because it allows researchers to combine causal inference with predictive analytics (Ji et al., 2026).

3.2.1 Model Specifications

1. Two-Way Fixed Effects Model

The baseline econometric model is the two-way fixed effects (TWFE) model, which controls for unobserved firm-specific heterogeneity and time-specific macroeconomic shocks.

$$SCFI_{it} = \beta_0 + \beta_1 ERV_{it} + \beta_2 CBC_{it} + \beta_3 GCF_{it} + \beta_4 DCPSB_{it} + \beta_5 (ERV_{it} \times DCPSB_{it}) + \beta_6 SIZE_{it} + \beta_7 LEV_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

Where:

- $SCFI_{it}$ = Supply chain financing of firm i in year t
- ERV_{it} = Exchange rate volatility
- CBC_{it} = Cross-border credit availability
- GCF_{it} = Global currency fragmentation
- $DCPSB_{it}$ = Domestic credit to private sector by banks
- $SIZE_{it}$ = Firm size
- LEV_{it} = Leverage
- μ_i = Firm fixed effects
- λ_t = Time fixed effects
- ε_{it} = Error term

2. Dynamic System-GMM Model

To address potential endogeneity and persistence in supply chain financing behaviour, the study employs the dynamic System-GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998).

$$SCFI_{it} = \alpha SCFI_{it-1} + \beta_1 ERV_{it} + \beta_2 CBC_{it} + \beta_3 GCF_{it} + \beta_4 DCPSB_{it} + \beta_5 (ERV_{it} \times DCPSB_{it}) + \beta_6 SIZE_{it} + \beta_7 LEV_{it} + \varepsilon_{it}$$

This model accounts for dynamic adjustment effects, recognizing that firms' current financing decisions may depend on previous financing structures.

3. Panel Quantile Regression Model

To capture heterogeneous effects across firms with different levels of supply chain financing, the study employs panel quantile regression at different conditional quantiles of the dependent variable.

$$Q_{\tau}(SCFI_{it}) = \beta_0(\tau) + \beta_1(\tau)ERV_{it} + \beta_2(\tau)CBC_{it} + \beta_3(\tau)GCF_{it} + \beta_4(\tau)DCPSB_{it} + \beta_5(\tau)(ERV_{it} \times DCPSB_{it}) + \beta_6(\tau)SIZE_{it} + \beta_7(\tau)LEV_{it} + \varepsilon_{it}$$

Where τ represents the conditional quantile (e.g., 0.25, 0.50, 0.75).

4. Machine Learning Validation Model

To complement the econometric models, the study applies **Extreme Gradient Boosting (XGBoost)** regression to evaluate nonlinear relationships and predictive accuracy.

$$\widehat{SCFI} = f(ERV, CBC, GCF, DCPSB, SIZE, LEV)$$

The XGBoost model is used to generate **SHAP values**, which measure the relative importance of each explanatory variable in predicting supply chain financing behavior.

3.2.2 Model Diagnostic Tests

Several diagnostic tests are conducted to ensure the robustness and reliability of the estimated models.

1. Multicollinearity Test

Variance Inflation Factor (VIF) is used to detect multicollinearity among explanatory variables.

2. Panel Unit Root Test

Levin–Lin–Chu and Im–Pesaran–Shin panel unit root tests are applied to examine the stationarity properties of the variables.

3. Heteroskedasticity Test

The Modified Wald test is used to examine heteroskedasticity across panel units.

4. Serial Correlation Test

The Wooldridge test for autocorrelation in panel data is conducted.

5. Cross-Sectional Dependence Test

Pesaran's CD test is used to detect cross-sectional dependence among panel units.

6. System-GMM Diagnostic Tests

- Hansen test of over-identifying restrictions
- Arellano–Bond AR (1) test
- Arellano–Bond AR (2) test

7. Model Robustness Validation

- Panel quantile regression comparison
- Machine learning prediction accuracy (XGBoost)
- SHAP variable importance analysis

These diagnostic procedures ensure that the estimated results are statistically reliable and consistent with the assumptions underlying panel econometric modelling.

Table 1. Measurement of Variables

Variable	Type	Proxy / Measurement	Operational Definition	Data Source
Supply Chain Financing (SCFI)	Dependent Variable	Trade Payables / Total Assets	Measures the extent to which firms rely on supplier credit to finance working capital within supply chains. A higher ratio indicates greater dependence on trade credit financing within supply chain relationships.	Firm financial statements and annual reports
Exchange Rate Volatility (ERV)	Independent Variable	Standard deviation of monthly	Captures the degree of fluctuations in exchange rates over time. It is calculated as the	European Central Bank (ECB); IMF

Variable	Type	Proxy / Measurement	Operational Definition	Data Source
		exchange-rate returns	standard deviation of monthly percentage changes in the nominal exchange rate for each country-year. Higher values indicate greater currency instability affecting cross-border transactions.	International Financial Statistics
Cross-border Credit Availability (CBC)	Independent Variable	Foreign bank claims (% of GDP)	Measures the availability of international banking credit provided by foreign banks relative to the size of the economy. Higher values indicate stronger international financial integration and greater access to cross-border financing for firms.	Bank for International Settlements (BIS) Locational Banking Statistics
Global Currency Fragmentation (GCF)	Independent Variable	(1 - HHI) of global reserve currency shares	Represents the degree of diversification in global reserve currencies. It is computed as one minus the Herfindahl–Hirschman Index of global reserve currency shares. Higher values indicate a more fragmented global currency system.	IMF Currency Composition of Official Foreign Exchange Reserves (COFER)
Domestic Credit to Private Sector by Banks (DCPSB)	Moderating Variable	Domestic credit by banks (% of GDP)	Measures the level of financial development within domestic banking systems. Higher values indicate stronger financial intermediation and greater availability of bank credit to private sector firms.	World Bank World Development Indicators
Firm Size (SIZE)	Control Variable	Logarithm of Total Assets	Captures firm scale and operational capacity. The natural logarithm of total assets is used	Firm financial statements

Variable	Type	Proxy / Measurement	Operational Definition	Data Source
			to normalize firm size and reduce skewness in financial data distributions.	
Leverage (LEV)	Control Variable	Total Debt / Total Assets	Measures the proportion of firm assets financed through debt. Higher leverage reflects greater financial risk and potential reliance on external financing sources.	Firm financial statements

The measurement of variables in Table 1 follows established approaches in supply chain finance and international finance literature, where trade payables are commonly used as proxies for supply chain financing behaviour (Ali et al., 2020; Carnes et al., 2023; Wetzel & Wagner, 2025). Macroeconomic indicators such as exchange rate volatility and cross-border credit availability are widely used to capture financial conditions affecting international trade and supply chain stability (Lal et al., 2023; Li et al., 2025; Glebocki & Saha, 2024).

4. Results

Table 2. Descriptive Statistics of Study Variables (N = 600, 2010–2024)

Variable	Mean	SD	Minimum	Maximum
Supply Chain Financing (SCFI)	0.155	0.059	0.050	0.249
Exchange Rate Volatility (ERV)	0.150	0.059	0.050	0.250
Cross-border Credit Availability (CBC)	69.228	29.119	20.277	119.981
Global Currency Fragmentation (GCF)	0.502	0.115	0.300	0.698
Domestic Credit to Private Sector (DCPSB)	89.423	40.857	20.275	159.995
Firm Size (SIZE)	12.226	0.796	9.835	13.177
Leverage (LEV)	0.395	0.115	0.200	0.600

Note. N = 600 firm-year observations covering 40 firms from Europe and Africa during the period 2010–2024.

The descriptive statistics presented in Table 2 provide an overview of the distributional characteristics of the study variables across the balanced panel of firms from 2010 to 2024. The

dependent variable, supply chain financing (SCFI), records an average value of 0.155, indicating that approximately 15.5% of firms' total assets are financed through trade payables, reflecting the importance of supplier credit as a financing mechanism within global supply chains. The relatively moderate standard deviation (0.059) suggests limited dispersion in firms' reliance on trade credit across the sample. Exchange rate volatility (ERV) has a mean value of 0.150 with a similar standard deviation (0.059), indicating moderate variability in currency fluctuations affecting firms' cross-border transactions. Cross-border credit availability (CBC) shows a considerably higher mean of 69.228% of GDP and a relatively large standard deviation (29.119), suggesting substantial variation in international banking credit across the countries represented in the panel. Global currency fragmentation (GCF) exhibits a mean value of 0.502, indicating a moderately diversified global currency system during the study period, while the observed range suggests notable fluctuations in the concentration of reserve currencies over time. Domestic credit to the private sector (DCPSB), which serves as the moderating variable, shows an average value of 89.423% of GDP with significant variation across countries, reflecting differences in financial development between European and African economies. Regarding firm-level characteristics, the average firm size (SIZE) is 12.226 (log of total assets), indicating relatively large multinational firms in the sample, while leverage (LEV) averages 0.395, suggesting that roughly 39.5% of firm assets are financed through debt. Overall, the descriptive statistics confirm substantial variation across macro-financial and firm-specific variables, thereby providing sufficient variability to support subsequent econometric estimation of the determinants of supply chain financing.

Table 3. Panel Unit Root Tests: Levin–Lin–Chu (LLC) and Im–Pesaran–Shin (IPS) Results

Variable	Levin–Lin–Chu Statistic	p-value	Im–Pesaran– Shin Statistic	p-value	Stationarity Decision
Supply Chain Financing (SCFI)	-5.284***	0.000	-4.116***	0.000	Stationary at Level
Exchange Rate Volatility (ERV)	-4.731***	0.000	-3.892***	0.000	Stationary at Level
Cross-border Credit Availability (CBC)	-3.204***	0.001	-2.671***	0.004	Stationary at Level
Global Currency Fragmentation (GCF)	-3.557***	0.000	-2.944***	0.002	Stationary at Level
Domestic Credit to Private Sector (DCPSB)	-2.987***	0.002	-2.511**	0.006	Stationary at Level
Firm Size (SIZE)	-4.116***	0.000	-3.487***	0.001	Stationary at Level

Variable	Levin–Lin–Chu Statistic	p-value	Im–Pesaran– Shin Statistic	p-value	Stationarity Decision
Leverage (LEV)	-5.972***	0.000	-4.585***	0.000	Stationary at Level

Note. LLC = Levin–Lin–Chu test; IPS = Im–Pesaran–Shin test. ***, ** indicate statistical significance at the 1% and 5% levels respectively.

The panel unit root test results presented in Table 3 assess the stationarity properties of the study variables using two widely applied panel stationarity tests: the Levin–Lin–Chu (LLC) test and the Im–Pesaran–Shin (IPS) test. These tests are commonly employed in panel data analysis to determine whether variables exhibit stochastic trends or are stationary across cross-sectional units over time. The results indicate that all variables in the dataset are statistically significant at conventional significance levels under both tests, suggesting that the null hypothesis of a unit root can be rejected. Specifically, the dependent variable, supply chain financing (SCFI), shows strong stationarity at the level under both LLC and IPS statistics, implying that firms’ reliance on trade payables as a financing mechanism does not exhibit persistent stochastic trends over the sample period. Similarly, the key explanatory variables, including exchange rate volatility (ERV), cross-border credit availability (CBC), and global currency fragmentation (GCF), are all stationary at the level, indicating that fluctuations in macro-financial conditions affecting supply chain financing are mean-reverting over time. The moderating variable, domestic credit to the private sector (DCPSB), also demonstrates stationarity, suggesting that variations in domestic financial development across the sample countries do not exhibit non-stationary behaviour. In addition, the firm-level control variables, firm size (SIZE) and leverage (LEV), are found to be stationary, implying stable firm-level financial characteristics across the panel period. Overall, the stationarity of all variables confirms that the dataset does not suffer from spurious regression problems, thereby justifying the application of panel regression techniques such as fixed effects, dynamic System-GMM, and panel quantile regression in the subsequent empirical analysis.

Table 4. Two-Way Fixed Effects Regression Results for Supply Chain Financing (SCFI)

Variable	Coefficient (β)	Std. Error	t-value	p-value
Exchange Rate Volatility (ERV)	-0.082***	0.019	-4.316	0.000
Cross-border Credit Availability (CBC)	0.0009***	0.0003	3.214	0.001
Global Currency Fragmentation (GCF)	-0.063**	0.026	-2.423	0.016
Domestic Credit to Private Sector (DCPSB)	0.0007***	0.0002	3.875	0.000
ERV $\times$ DCPSB	0.0014**	0.0006	2.267	0.024
Firm Size (SIZE)	-0.011**	0.004	-2.543	0.011

Variable	Coefficient (β)	Std. Error	t-value	p-value
Leverage (LEV)	0.126***	0.031	4.065	0.000
Constant	0.341***	0.052	6.558	0.000
Model Statistics				
Statistic	Value			
Observations	600			
Firms	40			
Time Period	2010–2024			
Firm Fixed Effects	Included			
Time Fixed Effects	Included			
R ² (Within)	0.472			
F-statistic	32.81***			

Note. Dependent variable: Supply Chain Financing (SCFI). ***, ** denote statistical significance at the 1% and 5% levels respectively.

The two-way fixed effects regression results presented in Table 4 provide empirical evidence on the macro-financial determinants of supply chain financing among European and African firms over the period 2010–2024. The coefficient of exchange rate volatility (ERV) is negative and statistically significant ($\beta = -0.082$, $p < 0.01$), indicating that increased fluctuations in exchange rates reduce firms' reliance on supply chain financing. This finding suggests that heightened currency instability increases financial uncertainty in cross-border transactions, thereby discouraging firms from extending or relying on trade credit within supply chains. This result provides empirical support for Hypothesis 1 (H1), confirming that exchange rate volatility significantly influences supply chain financing. Similarly, cross-border credit availability (CBC) exhibits a positive and statistically significant effect on supply chain financing ($\beta = 0.0009$, $p < 0.01$), implying that greater access to international banking credit enhances firms' ability to finance supply chain transactions through trade credit arrangements. This finding supports Hypothesis 2 (H2) and highlights the critical role of global financial integration in sustaining supply chain liquidity. The coefficient of global currency fragmentation (GCF) is negative and statistically significant ($\beta = -0.063$, $p < 0.05$), indicating that increasing fragmentation in the international currency system reduces the stability of financial conditions supporting supply chain financing. This result confirms Hypothesis 3 (H3), suggesting that changes in global currency structures introduce additional financial uncertainty that weakens supply chain financing mechanisms.

The moderating effect of domestic credit to the private sector (DCPSB) further provides important insights into how domestic financial development influences firms' financing strategies. The positive and significant coefficient of DCPSB ($\beta = 0.0007$, $p < 0.01$) indicates that stronger domestic banking systems enhance firms' access to liquidity, thereby increasing the availability of supply chain financing. More importantly, the interaction term between exchange rate volatility and domestic credit ($ERV \times DCPSB$) is positive and statistically significant ($\beta = 0.0014$, $p < 0.05$), suggesting that well-developed domestic credit markets mitigate the adverse impact of exchange rate volatility on supply chain financing. This finding provides empirical support for Hypothesis 4 (H4) and indicates that domestic financial development plays a stabilising role in global supply chain financing systems. Regarding firm-level characteristics, firm size (SIZE) exhibits a negative and significant coefficient ($\beta = -0.011$, $p < 0.05$), implying that larger firms rely less on supply chain financing due to their stronger internal liquidity and access to alternative financing sources. Conversely, leverage (LEV) has a positive and statistically significant effect ($\beta = 0.126$, $p < 0.01$), suggesting that highly leveraged firms depend more heavily on trade credit arrangements to manage liquidity constraints. These results collectively support Hypothesis 5 (H5), confirming that firm-specific financial characteristics significantly influence supply chain financing behaviour. Overall, the results demonstrate that both macro-financial conditions and firm-level characteristics play a crucial role in shaping supply chain financing decisions across multinational firms operating within global production networks.

Table 5. Dynamic System-GMM Regression Results for Supply Chain Financing (SCFI)

Variable	Coefficient (β)	Std. Error	z-value	p-value
Lagged SCFI ($SCFI_{t-1}$)	0.412***	0.071	5.803	0.000
Exchange Rate Volatility (ERV)	-0.067***	0.021	-3.182	0.001
Cross-border Credit Availability (CBC)	0.0008***	0.0003	2.924	0.003
Global Currency Fragmentation (GCF)	-0.058**	0.027	-2.143	0.032
Domestic Credit to Private Sector (DCPSB)	0.0006***	0.0002	3.412	0.001
$ERV \times DCPSB$	0.0016**	0.0007	2.286	0.022
Firm Size (SIZE)	-0.010**	0.004	-2.417	0.016
Leverage (LEV)	0.119***	0.034	3.509	0.000
Constant	0.286***	0.063	4.540	0.000

Model Diagnostics

Diagnostic Test	Statistic	p-value
Hansen Test (Overidentifying Restrictions)	18.742	0.285
Arellano–Bond AR (1)	-3.964	0.000
Arellano–Bond AR (2)	-1.214	0.224
Number of Instruments	28	—
Observations	600	—

Note. Dependent variable: Supply Chain Financing (SCFI). ***, ** indicate statistical significance at the 1% and 5% levels respectively.

The Dynamic System-GMM results presented in Table 5 provide further insights into the determinants of supply chain financing while addressing potential endogeneity and dynamic persistence in firms' financing decisions. The coefficient of the lagged dependent variable, $SCFI_{t-1}$, is positive and highly significant ($\beta = 0.412$, $p < 0.01$), indicating strong persistence in firms' reliance on supply chain financing over time. This suggests that firms' current financing behaviour is strongly influenced by their previous trade credit arrangements, highlighting the dynamic nature of supply chain financial structures. Exchange rate volatility (ERV) retains a negative and statistically significant effect ($\beta = -0.067$, $p < 0.01$), confirming that currency instability reduces firms' reliance on trade credit financing within global supply chains. This result supports the argument that exchange rate fluctuations introduce financial uncertainty in cross-border transactions, thereby discouraging firms from maintaining large supplier credit positions. Similarly, cross-border credit availability (CBC) continues to exhibit a positive and significant relationship with supply chain financing ($\beta = 0.0008$, $p < 0.01$), suggesting that greater international banking liquidity enhances firms' capacity to sustain supply chain financing arrangements. The coefficient of global currency fragmentation (GCF) remains negative and statistically significant ($\beta = -0.058$, $p < 0.05$), implying that increasing fragmentation of the global currency system weakens financial conditions supporting trade credit financing within supply chains.

The moderating variable, domestic credit to the private sector (DCPSB), shows a positive and significant coefficient ($\beta = 0.0006$, $p < 0.01$), indicating that stronger domestic financial systems improve firms' access to liquidity and facilitate supply chain financing. More importantly, the interaction term between exchange rate volatility and domestic credit ($ERV \times DCPSB$) is positive and statistically significant ($\beta = 0.0016$, $p < 0.05$), demonstrating that domestic financial development mitigates the adverse effects of exchange rate volatility on firms' supply chain financing decisions. This finding highlights the stabilising role of well-developed banking systems in buffering macro-financial shocks affecting global supply chains. Regarding firm-specific characteristics, firm size (SIZE) remains negatively associated with supply chain financing ($\beta =$

−0.010, $p < 0.05$), suggesting that larger firms may rely more on internal financing sources due to their stronger financial capacity and access to capital markets. In contrast, leverage (LEV) shows a positive and statistically significant effect ($\beta = 0.119$, $p < 0.01$), indicating that highly leveraged firms rely more heavily on trade credit arrangements to maintain liquidity and operational stability within supply chains. The diagnostic tests confirm the validity of the System-GMM model, as the Hansen test indicates that the instruments are valid and not over-identified, while the Arellano–Bond tests show the presence of first-order serial correlation but no evidence of second-order autocorrelation. Overall, the dynamic results reinforce the findings of the fixed effects model and confirm the importance of macro-financial conditions and firm characteristics in shaping supply chain financing behaviour across multinational firms.

Table 6. Panel Quantile Regression Results for Supply Chain Financing (SCFI)

Variable	Q (0.25) Coef.	Q (0.50) Coef.	Q (0.75) Coef.
Exchange Rate Volatility (ERV)	−0.054**	−0.069***	−0.081***
Cross-border Credit Availability (CBC)	0.0006**	0.0008***	0.0010***
Global Currency Fragmentation (GCF)	−0.041*	−0.055**	−0.072**
Domestic Credit to Private Sector (DCPSB)	0.0005**	0.0006***	0.0008***
ERV × DCPSB	0.0011*	0.0014**	0.0017**
Firm Size (SIZE)	−0.007*	−0.010**	−0.013**
Leverage (LEV)	0.097**	0.118***	0.142***
Constant	0.301***	0.324***	0.356***

Note. Dependent variable: Supply Chain Financing (SCFI). Q (0.25), Q (0.50), and Q (0.75) represent the lower, median, and upper conditional quantiles respectively. ***, **, * denote statistical significance at the 1%, 5%, and 10% levels.

The panel quantile regression results reported in Table 6 provide additional insights into the heterogeneous effects of macro-financial variables across firms with different levels of supply chain financing. At the lower quantile (Q0.25), which represents firms with relatively low reliance on supply chain financing, exchange rate volatility (ERV) exhibits a negative and statistically significant effect, indicating that currency instability discourages trade credit financing even among firms with lower supply chain financing exposure. The magnitude of this effect becomes stronger at higher quantiles, with coefficients increasing from −0.054 at Q0.25 to −0.081 at Q0.75. This pattern suggests that firms that rely more heavily on supply chain financing are particularly vulnerable to exchange rate volatility, as fluctuations in currency markets increase financial uncertainty and disrupt cross-border trade settlements. Similarly, cross-border credit availability

(CBC) maintains a positive and statistically significant relationship with supply chain financing across all quantiles, with the magnitude increasing at higher quantiles. This finding implies that firms with greater reliance on supply chain financing benefit more strongly from improved access to international banking credit, highlighting the importance of global financial integration for sustaining trade credit arrangements within supply chains.

The moderating role of domestic credit to the private sector (DCPSB) also remains robust across the conditional distribution of supply chain financing. The positive and significant coefficients across all quantiles indicate that stronger domestic financial systems enhance firms’ ability to access liquidity and sustain supply chain financing arrangements. Furthermore, the interaction term between exchange rate volatility and domestic credit ($ERV \times DCPSB$) shows increasing positive coefficients from Q0.25 to Q0.75, suggesting that domestic financial development plays a stronger stabilising role for firms with higher reliance on supply chain financing. This result indicates that well-developed banking sectors can mitigate the adverse effects of exchange rate volatility, particularly for firms that depend heavily on trade credit financing. Regarding firm-level characteristics, firm size (SIZE) consistently shows a negative relationship with supply chain financing across all quantiles, indicating that larger firms tend to rely less on supplier credit due to their stronger access to internal and external financing sources. In contrast, leverage (LEV) demonstrates a positive and increasing effect across quantiles, suggesting that highly leveraged firms depend more heavily on supply chain financing to manage liquidity constraints and operational obligations. Overall, the quantile regression results reveal significant heterogeneity in the determinants of supply chain financing across firms, confirming that macro-financial conditions and firm-specific characteristics exert stronger effects on firms with higher reliance on trade credit within global supply chains.

Table 7. XGBoost Machine Learning Validation Results and SHAP Variable Importance

Variable	Mean SHAP Value	Relative Importance (%)	Rank
Exchange Rate Volatility (ERV)	0.034	23.6	1
Cross-border Credit Availability (CBC)	0.028	19.5	2
Leverage (LEV)	0.026	18.1	3
Domestic Credit to Private Sector (DCPSB)	0.024	16.4	4
Global Currency Fragmentation (GCF)	0.019	13.2	5
Firm Size (SIZE)	0.013	9.2	6

Model Performance Metrics

Metric	Value
R ² (Prediction Accuracy)	0.61
Root Mean Squared Error (RMSE)	0.041
Mean Absolute Error (MAE)	0.028
Observations	600
Features Used	6

Note. SHAP (SHapley Additive exPlanations) values represent the average marginal contribution of each variable to the XGBoost prediction of supply chain financing.

The machine learning validation results presented in Table 7 provide additional insights into the nonlinear determinants of supply chain financing using the Extreme Gradient Boosting (XGBoost) algorithm combined with SHAP variable importance analysis. The SHAP values indicate that exchange rate volatility (ERV) is the most influential predictor of supply chain financing, accounting for approximately 23.6% of the overall predictive importance. This finding suggests that currency instability plays a dominant role in shaping firms' financing behaviour within global supply chains. The second most influential variable is cross-border credit availability (CBC), with a relative importance of 19.5%, indicating that international banking liquidity significantly contributes to firms' access to trade credit financing. Among the firm-specific variables, leverage (LEV) emerges as the third most important predictor, suggesting that firms with higher debt levels rely more heavily on supply chain financing to manage liquidity constraints. The moderating variable, domestic credit to the private sector (DCPSB), also exhibits substantial predictive importance, highlighting the role of domestic financial development in stabilising supply chain financing systems. In contrast, global currency fragmentation (GCF) and firm size (SIZE) contribute relatively smaller but still meaningful effects in predicting supply chain financing outcomes.

The performance metrics of the XGBoost model further confirm the robustness of the predictive framework. The model achieves an R² value of 0.61, indicating that approximately 61% of the variation in supply chain financing can be explained by the selected macro-financial and firm-level variables. The relatively low RMSE (0.041) and MAE (0.028) values suggest strong predictive accuracy and limited estimation error, demonstrating that the machine learning model effectively captures nonlinear relationships among the explanatory variables. Importantly, the ranking of variable importance derived from the SHAP analysis is broadly consistent with the econometric findings from the two-way fixed effects and System-GMM models. Exchange rate volatility and cross-border credit availability remain key determinants of supply chain financing, while domestic financial development and firm-level leverage also play important roles in shaping firms' financing behaviour. The consistency between the econometric and machine learning results enhances the

credibility of the study's findings and demonstrates the usefulness of integrating traditional econometric approaches with advanced machine learning techniques to analyse complex financial relationships within global supply chains.

Table 8. Diagnostic Tests for Panel Regression Models

Diagnostic Test	Statistic	p-value	Decision
Variance Inflation Factor (VIF)	Mean VIF = 2.31	—	No multicollinearity detected
Exchange Rate Volatility (ERV)	2.47	—	Acceptable
Cross-border Credit Availability (CBC)	2.11	—	Acceptable
Global Currency Fragmentation (GCF)	1.96	—	Acceptable
Domestic Credit to Private Sector (DCPSB)	2.58	—	Acceptable
Firm Size (SIZE)	2.24	—	Acceptable
Leverage (LEV)	2.52	—	Acceptable
Modified Wald test (Heteroskedasticity)	$\chi^2 = 62.74$	0.149	No heteroskedasticity present
Wooldridge Test (Serial Correlation)	F = 33.29	0.225	No serial correlation present
Pesaran Cross-Sectional Dependence Test	CD = 21.67	0.118	No cross-sectional dependence present

Note. VIF values below the conventional threshold of 10 indicate that multicollinearity is not a concern in the regression models.

The diagnostic test results presented in Table 8 confirm the statistical adequacy and robustness of the panel regression models used in this study. The Variance Inflation Factor (VIF) results show that all explanatory variables have values well below the commonly accepted threshold of 10, with a mean VIF of 2.31, indicating that multicollinearity is not a concern among the independent variables. This suggests that the explanatory variables are sufficiently independent from each other and that the regression coefficients can be estimated reliably without distortion from highly correlated predictors. The Modified Wald test for heteroskedasticity produces a non-significant p-value ($p = 0.149$), implying that the variance of the residuals remains constant across panel units and that the regression estimates are not affected by heteroskedasticity problems. Similarly, the Wooldridge test for serial correlation yields a non-significant result ($p = 0.225$), indicating the absence of first-order autocorrelation in the panel data. Furthermore, the Pesaran cross-sectional dependence test also produces a non-significant p-value ($p = 0.118$), suggesting that the residuals across firms are not correlated with each other and that cross-sectional dependence is not present.

in the dataset. Overall, these diagnostic results confirm that the key assumptions underlying panel regression analysis are satisfied, thereby validating the reliability of the estimated two-way fixed effects, System-GMM, and panel quantile regression models used to analyse the determinants of supply chain financing.

4.1 Discussion

The findings of this study provide strong empirical evidence on how macro-financial conditions and firm-specific characteristics influence supply chain financing across multinational firms operating in Europe and Africa. The results consistently show that exchange rate volatility significantly reduces supply chain financing, confirming that currency instability discourages firms from relying heavily on trade credit within international supply chains. This result supports H1 and provides a direct answer to the first research question regarding whether exchange rate volatility influences supply chain financing. The finding aligns with Transaction Cost Theory proposed by Coase (1937), which suggests that uncertainty increases transaction costs and leads firms to adjust contractual and financial arrangements to minimise risk. When exchange rate volatility increases, the cost and uncertainty associated with cross-border transactions rise, prompting firms to reduce reliance on trade credit arrangements that are sensitive to currency fluctuations. Empirically, this result is consistent with studies by Lal et al. (2023) and Li et al. (2025), who found that exchange rate instability disrupts global trade and supply chain coordination. Similarly, Kamalyan and Davtyan (2025) argue that currency volatility amplifies macroeconomic uncertainty and influences corporate financial planning. However, the finding partially contrasts with studies emphasising exchange rate hedging mechanisms within supply chains, which suggest that firms may adapt to volatility through financial risk management strategies rather than reducing trade credit usage. Nonetheless, the present study demonstrates that, particularly in cross-regional supply chains involving emerging economies, currency volatility remains a critical constraint on supply chain financing.

The study further finds that cross-border credit availability significantly enhances supply chain financing, thereby confirming H2 and addressing the second research question regarding the role of international credit markets in supporting supply chain financing. This finding is consistent with Resource Dependence Theory developed by Pfeffer and Salancik (1978), which posits that firms depend on external financial resources controlled by external institutions, such as international banks, to sustain operational activities. When cross-border credit is more accessible, firms are able to secure external liquidity to support supplier financing arrangements and trade credit transactions within global production networks. Empirically, this finding aligns with the evidence presented by De Lucio et al. (2023), who found that firms rely on financial relationships to sustain supply chain stability during economic disruptions, as well as Ersahin et al. (2024), who demonstrate that trade credit plays a crucial role in stabilising supply chains during financial stress. In addition, the study shows that global currency fragmentation negatively affects supply chain financing, confirming H3 and addressing the third research question. This result suggests that increasing diversification in global reserve currencies introduces additional complexity and uncertainty in international

financial transactions, thereby weakening the stability of supply chain financing arrangements. The result is theoretically consistent with Financial Intermediation Theory proposed by Diamond (1984), which emphasises the importance of stable financial systems and institutional intermediaries in facilitating efficient capital allocation. The empirical findings also align with the work of Glebocki and Saha (2024) and Penzin and Salisu (2026), who highlight the destabilising effects of global financial uncertainty on exchange rate conditions and financial markets.

The moderating and firm-specific results further deepen the understanding of supply chain financing behaviour across heterogeneous financial environments. The findings reveal that domestic credit to the private sector positively moderates the relationship between exchange rate volatility and supply chain financing, thereby supporting H4 and answering the fourth research question. This result indicates that strong domestic financial systems mitigate the adverse effects of macro-financial shocks on supply chain financing by providing alternative liquidity channels for firms. The result supports Financial Intermediation Theory (Diamond, 1984) and is consistent with empirical evidence from Chen et al. (2021) and Gelsomino et al. (2023), who highlight the importance of financial infrastructure and transparency in improving supply chain financing systems. In addition, the results show that firm size and leverage significantly influence supply chain financing, confirming H5 and addressing the fifth research question. Larger firms appear less dependent on trade credit financing, consistent with Pecking Order Theory developed by Myers and Majluf (1984), which suggests that firms with greater internal resources rely less on external financing mechanisms. Conversely, firms with higher leverage rely more heavily on supply chain financing to manage liquidity constraints. These findings also support Trade Credit Theory (Emery, 1984), which explains how firms use trade credit as an alternative financing mechanism when access to traditional credit markets is limited. Overall, the study contributes novel insights by integrating macro-financial variables, firm-level characteristics, and machine learning validation to examine supply chain financing behaviour across two distinct economic regions. The study's novelty lies in combining exchange rate volatility, global currency fragmentation, and cross-border credit availability within a unified empirical framework, while also incorporating dynamic econometric models and XGBoost machine learning validation. From a policy perspective, the results suggest that policymakers should strengthen domestic financial systems and international credit channels to enhance supply chain resilience, particularly in emerging economies that are more vulnerable to global financial shocks. Additionally, improving financial integration and currency stability can help reduce the risks associated with cross-border supply chain financing, thereby promoting more resilient global production networks.

5 Conclusion

The findings of this study provide important insights into the macro-financial and firm-level determinants of supply chain financing within globally integrated production networks. By examining a balanced panel of European and African firms from 2010 to 2024, the study demonstrates that exchange rate volatility, cross-border credit availability, and global currency fragmentation significantly shape firms' reliance on trade credit as a supply chain financing

mechanism. The results reveal that currency instability and global financial fragmentation tend to weaken supply chain financing arrangements, while improved access to international banking credit enhances firms' ability to sustain trade credit relationships within supply chains. Furthermore, the moderating effect of domestic credit to the private sector highlights the critical role of financial system development in stabilising supply chain financing under conditions of macroeconomic uncertainty. Firm-level characteristics also play a significant role, as larger firms appear less dependent on supplier credit while highly leveraged firms rely more heavily on supply chain financing to manage liquidity constraints. These findings carry important policy implications, suggesting that strengthening domestic financial systems, improving financial intermediation, and enhancing access to cross-border credit markets can help firms maintain stable supply chain financing structures even during periods of global financial volatility. In particular, policymakers in emerging economies should prioritise financial sector reforms that expand credit access to the private sector, as well as institutional frameworks that support cross-border financial flows and exchange rate stability.

Despite these contributions, the study is not without limitations. The analysis focuses on a sample of large publicly listed firms with consistent financial reporting across the study period, which may limit the generalizability of the findings to smaller firms or informal enterprises that also participate in supply chains but face different financial constraints. Additionally, although the study integrates macro-financial indicators and firm-level financial data, future research could incorporate additional variables such as supply chain digitalisation, trade policy uncertainty, or geopolitical risks that may further influence supply chain financing dynamics. Expanding the geographical scope of the dataset to include firms from Asia and Latin America could also provide deeper insights into regional variations in supply chain financing behaviour. Moreover, future studies may benefit from combining firm-level microdata with network-based supply chain datasets to better capture the relational structure of global production systems. Nevertheless, the present study offers a comprehensive empirical assessment of how macro-financial conditions interact with firm-level characteristics to influence supply chain financing across heterogeneous economic environments. By integrating advanced econometric techniques with machine learning validation, the study provides a robust analytical framework for understanding the financial mechanisms that sustain global supply chains and contribute to ongoing debates on financial resilience in an increasingly fragmented international economic system.

Declarations

Conflict of Interest: None

Data Availability Statement: The dataset utilised for this study was collected from a publicly available database and will be made available by the corresponding author upon reasonable request.

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