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Financial Econometrics and Quantitative Economic Analysis

Edited by
Sergej Gričar, Nemanja Lojanica and Tamara Backović

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Cover image courtesy of Sergej Gričar

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About the Editors

Sergej Gričar

Dr. Sergej Gričar is an Associate Professor at the Faculty of Business and Management Sciences, University of Novo Mesto, Slovenia. He holds a Ph.D. in Economics and Business Sciences and specialises in financial econometrics, quantitative analysis, and tourism economics. Dr. Gričar has a strong academic and research background, with a particular focus on the application of econometric and time series models in macroeconomic forecasting and policy evaluation. He has authored and co-authored numerous scientific articles in peer-reviewed journals, contributing to advancing empirical economic research with a practical orientation. His recent work explores forecasting methods for tourism demand, the effects of technological innovation on service industries, and the use of big data and artificial intelligence in economic modelling. He was one of the authors who made an ex ante prediction in 2019 of the pandemic that occurred in 2020. As a reviewer and Guest Editor for several international journals, Dr. Gričar actively supports the dissemination of interdisciplinary research bridging economics, finance, and management. In addition to his academic work, he frequently collaborates on international research projects and participates in knowledge transfer between academia and industry. His commitment to academic excellence and practical impact continues to shape emerging perspectives in financial and quantitative economic analysis.

Nemanja Lojanica

Dr. Nemanja Lojanica is an Associate Professor at the Faculty of Economics, University of Kragujevac, Serbia. He earned his PhD in Economics in 2018, with a dissertation on modelling relationships between macroeconomic indicators and economic policy. His teaching and research interests include macroeconomic theory and policy, energy economics, macroeconometric forecasting, economic inequality, and green economy. Dr Lojanica teaches at all academic levels and has designed and delivered courses in macroeconomics, macroeconomic modelling, and sustainability-related topics. With over 45 published research papers, 10 of which were indexed in the SSCI, Dr. Lojanica has established himself as an active contributor to the field. He has participated in multiple international conferences across Europe and engaged in collaborative projects on economic development, European integration, and structural transformation. As a consultant, he has provided expertise in corporate carbon footprint development, sustainability reporting, and circular economy to diverse industrial sectors. He has completed advanced training in time series econometrics, macroeconomic forecasting, and econometric methods at institutions such as the IMF, University of St. Gallen, and the University of Graz. Dr. Lojanica is a core team member at the Centre for Green Economy at the University of Kragujevac and serves as Editorial Secretary of the journal *Economic Horizons*, underscoring his dedication to academic excellence and public engagement in policy-relevant economics.

Tamara Backović

Dr. Tamara Backović is an Associate Professor at the Faculty of Economics, University of Montenegro. With a Ph.D. in Economics, her academic and research expertise lies at the intersection of macroeconomics, fiscal policy, and regional economic development. She has developed a strong portfolio in teaching and applied research, guiding students across undergraduate and graduate programs while contributing to academic discourse through numerous publications and policy-oriented studies. Dr. Backović has participated in a variety of national and international

projects, focusing on economic transition, public finance, and the integration of sustainability principles into economic policy. Her scholarly work often explores how institutional and structural factors influence economic resilience and development in small and transitioning economies. She is also actively involved in initiatives that strengthen the linkage between academia and economic governance, serving as an advisor and collaborator on research aimed at improving fiscal transparency and strategic planning in the Western Balkans region. As a Guest Editor of this Special Issue, she brings a deep understanding of applied economic analysis and a commitment to fostering research that bridges theory and practice in financial and quantitative economics.

Preface

This reprint of the Special Issue entitled "Financial Econometrics and Quantitative Economic Analysis" features ten peer-reviewed articles that illustrate the increasing complexity and interdisciplinary nature of contemporary economic and financial research. We aimed to compile exceptional scientific contributions that enhance theoretical frameworks and empirical applications in financial econometrics and quantitative economics.

This reprint covers various topics, including asset pricing, the analysis of high-frequency data, risk modelling, exchange rate dynamics, and tourism forecasting—each selected for its methodological strength and real-world relevance. The impetus for this initiative was to provide a holistic perspective on how econometric tools and quantitative techniques can effectively elucidate and tackle significant economic and financial challenges.

This Special Issue is designed for academics, researchers, financial analysts, policy advisors, and graduate students involved in econometrics, financial modelling, and applied economics. It acts as a touchstone for contemporary developments and encourages future research endeavours.

We extend our gratitude to all contributing authors for their commitment and creativity. A special acknowledgement goes to the reviewers for their thoughtful assessments and to the editorial team at *JRFM* for their unwavering support throughout the publication process. This reprint would not have been possible without their contributions.

We hope that readers find the studies included here intellectually stimulating and practically insightful and that this collection will motivate further inquiry into the dynamic fields of financial econometrics and quantitative economic analysis.

Sergej Gričar, Nemanja Lojanica, and Tamara Backović
Guest Editors

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Editorial

Financial Econometrics and Quantitative Economic Analysis

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1. Behind the "Curtain"

Since the foundational contributions of Katarina Juselius and Søren Johansen on cointegration, along with earlier works by influential scholars like Clive Granger, the field has witnessed significant developments. Their groundbreaking research laid the groundwork for a deeper understanding of integrated series and their application to econometrics. Through their efforts, we continually improve and refine methodologies, ensuring that the scientific community remains on a path of progress. However, the continuous challenge is to build upon their foundational theories and explore new avenues and perspectives that push the boundaries of knowledge. The aim of this Special Issue is to foster innovation and encourage younger generations of scholars to engage with new concepts in econometrics and quantitative economics. By studying works ranging from foundational texts to contemporary journal articles, new researchers can deepen their understanding and contribute to the ongoing evolution of econometrics. By integrating historical insights with modern analytical techniques, we aim to foster continual growth and discovery, ensuring that our legacy inspires new generations and scientific journals to push the boundaries of knowledge (Mosconi & Paruolo, 2022; Juselius, 2021).

2. The Special Issue Development

As we conclude this Special Issue titled Financial Econometrics and Quantitative Economic Analysis, we extend our heartfelt gratitude to all the authors, reviewers, and Guest Editors whose exceptional contributions have made this publication a remarkable success. This hardcopy edition is a testament to the collaborative spirit and rigorous scholarship that define our field. We are honored to present diverse research that enhances our understanding of financial econometrics and quantitative economic analysis and establishes innovative methodologies and practical applications in these essential areas.

The varied studies presented in this Special Issue have showcased cutting-edge advancements, including novel asset pricing models, high-frequency financial data analysis, innovative volatility modelling, and macroeconomic forecasting approaches. Each article contributes uniquely to offering a richer, more nuanced perspective on the relationship between economic theory and financial practice. Our contributors have examined the dynamic intersections of empirical research and policy analysis, offering insights poised to influence academic inquiry and industry practices for years.

When reading this hardcopy edition, we hope you find it a record of pioneering research and a source of inspiration for future studies and collaborations. Thank you for joining us on this journey of gathering deeper insights and conducting more robust

analyses in financial econometrics and quantitative economic analysis. We look forward to witnessing the continued evolution of our discipline and the innovative research that will build upon the foundations detailed in these pages.

3. The Collection of Econometrics

With this in mind, the Journal of Risk and Financial Management presents a collection of ten peer-reviewed articles that enhance our understanding of complex financial phenomena. This edition features empirical studies and theoretical explorations of challenges in global financial markets, asset pricing dynamics, and sustainable finance. The articles examine issues like the impact of geopolitical risk, the role of anti-corruption measures, and central bank interventions on pricing. They also discuss digital transformation in tourism, corporate collaborations, and applications of real options theory in sustainability. These insights provide valuable analytical frameworks for scholars and policymakers to inform research and decision-making.

5 February 2025.

Imed Medhioub studied herding behaviour in Middle East Stock Markets (MENA) stock markets in response to geopolitical risk, using daily data from 4 January 2011 to 31 December 2023, for companies in Egypt, Jordan, Lebanon, Morocco, Saudi Arabia, and Tunisia. He found that higher geopolitical risk leads to increased dispersion in Lebanon's stock market and raises the likelihood of herding in Jordan and Tunisia's markets.

3 February 2025.

Recognising corruption as a barrier to economic growth, coauthors Recep Ali Küçükçolak, Gözde Bozkurt, Necla İlter Küçükçolak, Adnan Veysel Ertemel, and Sami Küçükoğlu examined the impact of anti-corruption efforts on financial development in G7 and E7 countries. Their findings reveal a significant cointegration relationship, indicating that anti-corruption measures positively influence financial development, especially in E7 economies. The Westerlund test confirmed the robustness of these results, emphasising the need for tailored anti-corruption policies that consider each country's unique economic context.

3 February 2025.

Recognising that the stability of the financial cycle is essential for the effective formulation and implementation of macroprudential policy in South Africa; author Khwazi Magubane proposed that proactive and aggressive measures are necessary in the years leading up to potential crises. Additionally, the study's findings highlight the importance of accounting for macroeconomic conditions when calibrating policies related to the financial cycle.

30 September 2024.

The coauthors Carlos J. Rincon and Darko B. Vukovic investigate the impact of central bank interventions on the pricing dynamics of selected stock markets. This research significantly contributes to understanding financial asset pricing, particularly by clarifying how interventions in government debt securities can create price distortions in specific equity markets.

29 September 2024.

The author Andrejs Čirjevskis, in his research, aimed to address a gap in the literature by investigating the applicability of real options theory to organisations that enhance sustainability policies while focusing on disciplined capital allocation through exit strategies. His study concludes with a review of the theoretical contributions of this paper to fundamental options theory, as well as the managerial and practical/social implications of applying real options in general. Additionally, it examines the valuation methods of abandonment options, highlighting the potential for future research.

24 July 2024.

The coauthors Maroua Zineelabidine, Fadwa Nafssi, and Hamza Ayass assessed the efficiency scores of 95 microfinance institutions in Africa from 2005 to 2018 using a data envelopment analysis approach. They then analysed these efficiency scores about various determinant variables that reflect the characteristics of the microfinance institutions. The main findings indicate that most institutions prioritise profitability over social outreach. Additionally, the panel data regression analysis reveals that factors such as profitability, equity capitalisation, types of loans, and low gross domestic product positively influence the efficiency of microfinance institutions.

24 May 2024.

The coauthors Heni Boubaker and Ben Saad Zorgati Mouna explored the complex mechanisms through which changes in currency exchange rates influence inflation rates while carefully considering each country's economic cycle. The research findings can be summarised as follows: in the early stages, especially during periods of strong economic growth, the impact of exchange rate fluctuations on inflation levels was found to be partial across all geographic areas studied.

31 March 2024.

The co-authors Enkeleda Lulaj, Mirela Tase, Conceição Gomes, and Lucília Cardoso examined the impact of the COVID-19 pandemic on the tourism economies of Kosovo and Albania. Their findings revealed that the pandemic led to economic stagnation and rising prices in both regions. The results highlighted several key points: (a) COVID-19 had a severe impact on both the population and businesses in the tourism sector, effects which are expected to persist even after the pandemic; (b) government intervention is essential to alleviate the financial crisis; (c) there is a need for innovative approaches and effective financial management by both the government and businesses to attract tourists; (d) control and management are crucial for ensuring financial sustainability.

21 February 2024.

Starting with the understanding that a key issue in the collaboration between business partners is whether the integration of their companies creates collaborative synergy and adds market value, the author, Andrejs Čirjevskis, aimed to develop a methodological framework useful for managerial practice and beneficial for academic research. This framework focused on forecasting explicit synergy and valuing tacit synergy in strategic collaborations. The paper contributed to both theoretical understanding and practical applications in corporate finance and strategic management.

21 November 2023.

In his study, Sergej Gričar explored the complex process of predicting tourism demand, particularly emphasising econometric and quantitative time series analysis. He thoroughly reviewed the existing literature to understand the various methods used for forecasting the "unpredictable" shocks in tourism demand on an ex ante basis. The study concluded that innovations such as virtual tourism, augmented reality, virtual reality, big data, and artificial intelligence can significantly improve demand forecasting in time series econometrics.

4. Guest Editors' Comments

On behalf of the Guest Editors, we express our gratitude to the authors of the contributions published in this Special Issue, titled Financial Econometrics and Quantitative Economic Analysis. Special thanks also go to the reviewers, whose constructive and critical comments and suggestions to the authors of the submitted papers have contributed to their quality.

Emerging scientific methodologies promise to have a transformative impact on Financial Econometrics and Quantitative Economic Analysis. Novel models harness machine learning, high-frequency data, and advanced computational techniques to capture complex

market dynamics. In particular, integrating the cointegration of $I(2)$ provides a robust framework for analysing integrated time series data, enhancing our understanding of long-run relationships. These innovations pave the way for precise analysis, informed policy-making, and research that will shape the future of econometrics.

Author Contributions: Conceptualization, N.L. and S.G.; methodology, S.G.; software, S.G.; validation, S.G., N.L. and T.B.; formal analysis, N.L.; investigation, N.L.; resources, S.G.; data curation, N.L.; writing—original draft preparation, N.L. and S.G.; writing—review and editing, S.G.; visualization, S.G.; supervision, T.B.; project administration, S.G.; funding acquisition, S.G. All authors have read and agreed to the published version of the manuscript.

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Review

Tourism Forecasting of "Unpredictable" Future Shocks: A Literature Review by the PRISMA Model

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Abstract: This study delves into the intricate process of predicting tourism demand, explicitly focusing on econometric and quantitative time series analysis. A meticulous review of the existing literature is carried out to comprehensively understand the various methods for forecasting "unpredictable" shocks of tourism demand on an ex-ante basis. The PRISMA method has been implemented. Drawing on scholarly research, this study pinpoints the critical challenges in accurately predicting tourism demand, making it a valuable resource for tourism professionals and researchers seeking to stay on top of the latest forecasting techniques. Moreover, the study includes an overview of published manuscripts from the current decade, with mixed results from the 32 manuscripts reviewed. The study concludes that virtual tourism, augmented reality, virtual reality, big data, and artificial intelligence all have the potential to enhance demand forecasting in time series econometrics.

Keywords: economic methods; PRISMA; time series; proactive tourism demand

1. Introduction

Planning a vacation can be an exciting but also overwhelming experience. One crucial aspect to consider is the demand for tourism in the desired destination. The utilization of economic, econometric, and time series analysis has the potential to provide significant contributions in predicting tourism demand amidst present unforeseen disruptions, thus facilitating informed travel arrangements that take into account the current situation (Zhang et al. 2022). Are we facing the new normal, as a metaphor? (Rowen 2020). A significant historical overview can offer a means for econometricians to use trends and cycles in econometric modeling for ex-ante predictions, without overlooking obstacles, minimums and maximums.

So, we can say that previous data offer us a comparison of past events and future well-being, and could be modeled in an econometric time series environment, as proposed by Gričar et al. (2021). By implementing systematic time series modeling, we can isolate unpredictable events from past events, which allows for present and future shocks to be predicted, e.g.,

$$Y_{t-1}|Y_0|Y_{t+1}, \tag{1}$$

where Y is an event, t is time, -1 is past, 0 is present and $+1$ is future. Past observations play a critical role in accurately predicting future events, and time series data are a valuable tool in this process. Supporting evidence from relevant sources or past incidents can confirm our predictions. However, we have concerns about time series forecasting, as it is often reactive rather than proactive. In this review, we focus on tourism demand forecasting and the various factors that influence it. By utilizing the correct variables and methodologies, tourism can prepare for unforeseeable events. Experience, knowledge, and intuition are essential in achieving this. Additionally, it is crucial to think outside the box and explore unconventional tools like AI. This review concludes with important implications for managers. The new tourism economy, e.g., freelancers and Non-Fungible

Tokens (NFTs), are essential, adding determinants to be used in tourism demand and forecasting (Umar et al. 2021).

Tourism has emerged as a dynamic and multifaceted industry that significantly contributes to the economy. The tourism sector has witnessed remarkable growth in recent years, accompanied by an increasing demand for accurate forecasting techniques to aid in strategic planning and resource allocation (Frechtling 2012). This study is motivated by the desire to consolidate and synthesize the most recent research articles that delve into the intersection of time series econometrics and tourism economics, explicitly focusing on forecasting issues. Time series analysis is particularly promising in this context, as it leverages historical data to project future trends, aligning with the notion that the past holds valuable insights for predicting the future (De Choudhury et al. 2013; Zeng and Khan 2019).

The primary objective of this research is to conduct a comprehensive review of the most recent scholarly works that address the challenges and advancements in tourism demand forecasting, particularly in the European context. To achieve this goal, we have undertaken an extensive search of academic manuscripts using keywords such as "time series", "tourism economics", and "tourism demand" in conjunction with the geographical filter "Europe". While numerous authors have explored the topic of tourism demand forecasting, a notable gap in the literature pertains to recent research efforts that challenge traditional assumptions about the predictability of long-term tourism demand. Additionally, there appears to be a lack of contemporary investigations into the applicability of stochastic models in light of the evolving dynamics in the tourism sector.

In the subsequent sections of this paper, we will delve into the details of our literature review, summarizing the key findings from recent studies, identifying gaps in the existing body of knowledge, and shedding light on emerging trends in the field of tourism demand forecasting. The subsequent objective is to provide valuable insights to those in the tourism industry and academia by analyzing and synthesizing the literature. We aim to offer a nuanced comprehension of the current challenges and opportunities in anticipating tourism demand, not only for the expected future but for unforeseeable events as well. This research endeavors to investigate how managers and researchers handle such situations. Though time series analysis is frequently used, predicting unexpected shocks is still challenging. Consequently, various skills are necessary, including expertize in selecting variables, comprehensive and specialized knowledge, intuition, a thorough understanding of the field, and the utilization of AI. Ultimately, our research seeks to enhance the accuracy and effectiveness of tourism forecasting methods, aligning them with the evolving dynamics of this critical sector.

The paper is structured as follows: First is a detailed explanation of the research methodology, including the selection criteria for relevant articles. Next, the third section presents the systematic review process and critical trends discovered from recent research on time series econometrics and tourism demand forecasting. The fourth section examines these results critically, offering interpretations and contextualization. Lastly, the Conclusion summarizes the main takeaways from the study, highlighting its contribution to the field, suggesting future research directions in tourism demand forecasting and considering the implications of the findings.

2. Materials and Methods

As previously noted, there is a shortage of current research on time series data in the tourism industry and forecasting (Onder and Wei 2022; Chen et al. 2019; Wu et al. 2023), particularly in Europe (Song et al. 2019; Bufalo and Orlando 2023). As such, this study plays a crucial role in offering an overview of the importance of tourism demand (Archer 1980) and how it can be effectively managed during times of recession or unforeseen shocks (Li et al. 2023) with an option of inclusive artificial intelligence models (Li et al. 2024).

Managers, policies, and tourists must understand the significance of predicting demand before times of uncertainty. This can bring in revenue and benefit all parties involved. Considering how many researchers have informed stakeholders about approaching pan-

demics, high inflation rates, recessions, and wars is essential. These situations must be analyzed and predicted beforehand, not after the fact (Gričar and Bojnec 2022), as is commonly found in the tourism literature, which is surprising (Gössling et al. 2021). The main research question in the present study is: When predicting tourism demand, what insights can be gained from analyzing time series data? For instance, it can help forecast a rise in virus infections beforehand (Gricar 2020) or an unprecedented shock evident a year prior (Zrinić Terlević 2021). Overall, understanding how scholars approach this issue is critical and will be analyzed using a systematic literature review in this study.

Conducting a comprehensive meta-analysis of tourism demand and forecasting every decade is customary. This practice has been established by experts such as Witt and Witt (1995), Song and Li (2008) and Peng et al. (2014). To assemble a robust dataset for the meta-analysis, we conducted an exhaustive search across the academic database Google Scholar. The investigation was guided by specific keywords, including "time series", "tourism economics", and "tourism demand" in conjunction with the geographical filter "Europe". Upon conducting the initial search, a significant amount of articles were found.

A systematic data extraction process was carried out for each included study using a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram. We extracted pertinent information, including the publication year, sample size, forecasting models employed, key findings, and location in Europe. This meticulous data extraction process allowed us to compile a comprehensive dataset for subsequent analysis. We established a set of inclusion and exclusion criteria to ensure the relevance and quality of the studies included in the meta-analysis. Only articles published in peer-reviewed journals and written in English were considered. Additionally, studies were included if they focused on time series forecasting techniques in the context of tourism demand, with a specific geographical focus on European destinations.

By employing this rigorous data collection and analysis approach, our meta-analysis aims to provide a comprehensive overview of the state of the art in time series forecasting for tourism demand within the European context. The results are presented in systematic tables. Overall, the investigation employs the widely recognized PRISMA method, meta-analysis, and ABC framework to systematically align the working sheet with the research objectives, and effectively address the research question. To effectively complete this task, the following steps should be taken:

1. Gain an understanding of how to properly manage tourism data;
2. Identify the type of information contained within the data and what insights can be gleaned from them;
3. Address recent unforeseen events that were deemed unpredictable and were documented in reputable scientific journals as such;
4. Use the data to derive explanations for some of these occurrences. For this, it is imperative to review a plethora of articles that have attempted to analyze time series data but failed to adequately predict future unforeseen events;
5. Conduct a literature review with this objective in mind, utilizing the Google Scholar site and confirmed by the Scopus database to assess the quality of the journals;
6. Present the findings of the review in tables for clarity, and thoroughly discuss implications. Overall, ex-ante forecasting is crucial in tourism, weather, and sciences, requiring appropriate methodology and data.

3. Results

This section explores the depths of knowledge on the subject of tourism demand in Europe through a thorough examination of the literature since the 2020s, utilizing pertinent search terms such as "tourism economics", "time series", and "tourism demand". This section delves into the outcomes of our systematic review and meta-analysis on tourism demand forecasting methods. The comprehensive examination of 68 key research papers from 2020 to 2024 comprised our literature review. To provide a clear and organized presentation of our results, we have employed several analytical tools and visual aids.

Firstly, we present the PRISMA diagram, offering a graphical representation of the study selection process, from the initial identification to the final inclusion of relevant papers. This diagram provides transparency and insight into our rigorous review methodology.

The study presents the findings in an organized and convenient manner. Tables are organized in a way that categorizes and organizes the results, making it easy for readers to explore the critical patterns, trends, and insights from the literature selected. The introduced categories and codes act as a structured framework to interpret the data systematically. These tools and organizational strategies enable a comprehensive understanding of the various dimensions of tourism demand forecasting methods and their evolution over time. The research findings are therefore presented clearly and concisely, synthesizing and interpreting the information gathered through this extensive review process.

3.1. PRISMA Diagram

The systematic review covered a vast amount of the academic literature, consisting of 5120 articles published until 2024, as shown in Figure 1 (the PRISMA diagram). The observation shows a surge in scholarly activity in recent years, with 1900 articles emerging between 2020 and 2024, indicating a growing interest in tourism demand forecasting. However, we ensured the integrity and efficiency of our analysis by implementing a meticulous screening process. In total, 3220 articles were excluded that had already been scrutinized in a seminal study by Sond et al. in 2019, and 1822 that had not undergone rigorous peer-review. This quality control mechanism narrowed our selection to a final cohort of 78 articles that formed the basis of our analysis, as presented in Figure 1.

Furthermore, ten literature records were excluded due to not concerning Europe. These 68 articles represent the culmination of our screening process and helped us uncover valuable insights, patterns, and trends that illuminate the evolution of tourism demand forecasting methods over time. Nevertheless, 29 articles have been observed and commented on in the paper at the end. Additionally, two studies were added to the fourth section and one newspaper article in the previous section. Overall, 32 relevant documents are included in the literature review matrix.

3.2. Screening Results

Google Scholar's website offers a concise overview of the processed research. Through an automated process, manuscripts that did not meet the predefined eligibility criteria based on specific keywords are meticulously filtered out. The resulting presentation in Table 1 is a concise compilation of articles that align with our research objectives, which are thoughtfully organized and sorted to prioritize for relevance.

In the comprehensive exploration of tourism demand forecasting and its evolution over time, many studies have contributed valuable insights and trends. Krajňák (2021) conducted a systematic review of the effects of terrorism on tourism demand, revealing that, with some exceptions, terrorism typically negatively impacts tourism demand. Abdou et al. (2021) analyzed 145 papers from 1979 to 2020, finding that forecasting models have diversified, merged, and improved accuracy with the emergence of AI and hybrid models in recent years. Rossello Nadal and Santana Gallego (2022) discussed the revival of gravity models in tourism demand modeling, highlighting GDP, population, and distance as crucial determinants of tourist flows. Song et al. (2023) conducted an evaluative survey of current tourism demand studies, identifying potential flaws and emerging research areas.

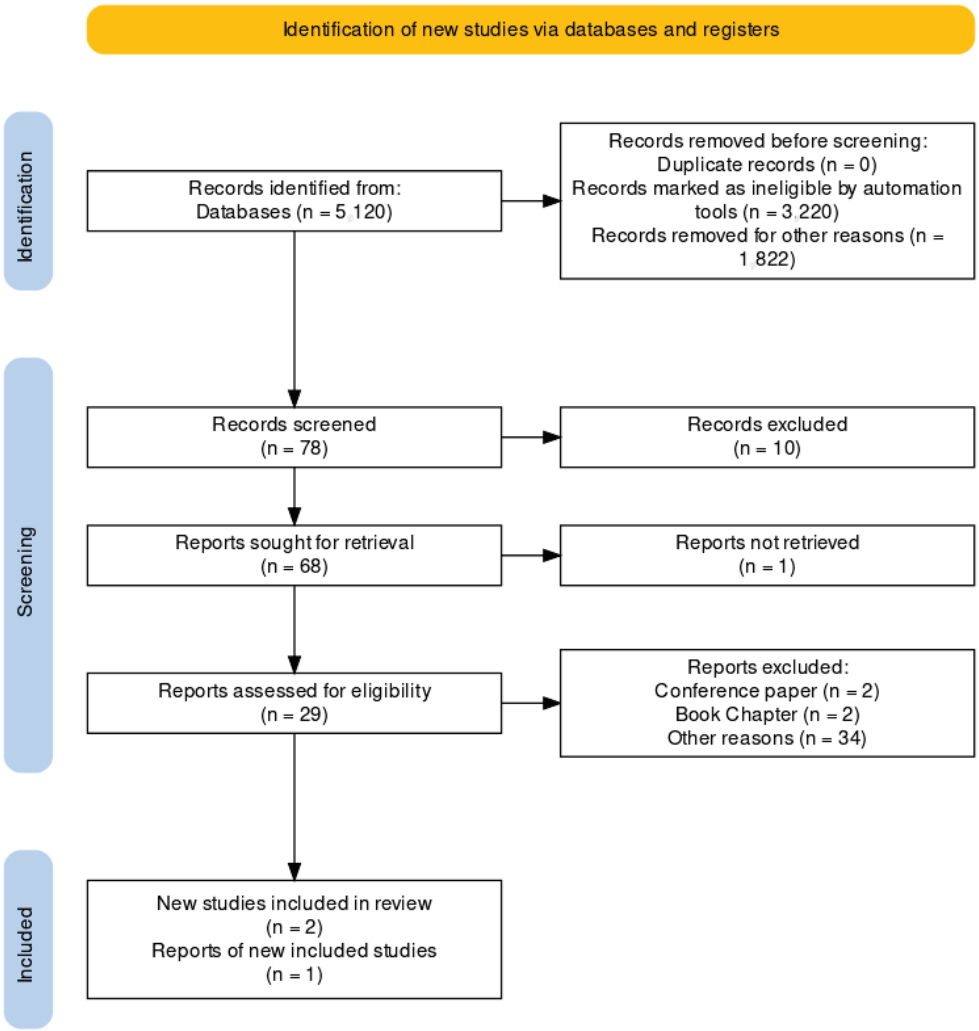

Figure 1. PRISMA diagram. Source: Authors' compilation using software designed by Haddaway et al. (2022).

Ahmad et al. (2020) conducted a citation-based systematic literature review on the tourism–growth nexus, identifying influential journals, authors, and articles, while Li et al. (2021) examined the use of internet data in tourism forecasting, revealing the dominance of time series and econometric models. Eusébio et al. (2021) conducted a systematic review of the impact of air quality on tourism demand, emphasizing the need for further empirical applications. Calero and Turner (2020) explored the role of tourism in regional development, tracing the evolution of regional tourism research. Gričar et al. (2021) employed econometric forecasting to predict shocks affecting international tourist arrivals, while Li and Jiao (2020) offered a general overview of the tourism forecasting literature and future trends. Finally, Liu et al. (2022b) conducted a systematic literature review on tourism's economic impact, emphasizing the need for cutting-edge economic methods and data in assessing its financial contributions. These studies collectively contribute to a richer understanding of tourism demand forecasting and its multifaceted dimensions, offering valuable insights and paving the way for future research in this evolving field.

Our approach aligns with the systematic review in its research methodology, explicitly employing the meta-analysis technique. Within the systematic review methodology, we first classify the articles under the A category of the PRISMA method. We have meticulously synthesized a wealth of the literature through periodic reviews and meta-analyses to provide a comprehensive and well-informed analysis. The next step, shown in Table 2, is the forecasting of the evolution of tourism demand.

Table 1. Tabular display of results that dealt with meta-analysis.

Author(s)	Data	Title	SNIP
Krajňák (2021)	45	The effects of terrorism on tourism demand: A systematic review	1.758
Abdou et al. (2021)	145	Tourism demand modelling and forecasting: A review of literature	0.375
Rossello Nadal and Santana Gallego (2022)	143	Gravity models for tourism demand modelling: Empirical review and outlook	3.267
Ahmad et al. (2020)	100	Systematic literature review of tourism growth nexus: An overview of the literature and a content analysis of 100 most influential papers	3.267
Li et al. (2021)	several	Review of tourism forecasting research with internet data	3.643
Eusébio et al. (2021)	26	The impact of air quality on tourism: a systematic literature review	0.634
Calero and Turner (2020)	several	Regional economic development and tourism: A literature review to highlight future directions for regional tourism research	1.758
Gricar et al. (2022)	1	Insight into Predicted Shocks in Tourism: Review of an Ex-Ante Forecasting	0.476
Li and Jiao (2020)	several	Tourism forecasting research: a perspective article	2.130
Liu et al. (2022b)	several	Toward an accurate assessment of tourism economic impact: A systematic literature review	0.857

Notes: SNIP—Source Normalized Impact per Paper for 2022 (Scopus 2023).

Table 2. Tabular display of results that dealt with methods.

Author(s)	Methodology	Title	SNIP
Cao (2022)	Vector autoregressive models	Econometric modelling and forecasting of tourism demand	
Al Jassim et al. (2022)	Data sources	A review of the methods and techniques used in tourism demand forecasting	
Dowlut and Gobin-Rahimbux (2023)	Deep learning techniques	Forecasting resort hotel tourism demand using deep learning techniques–A systematic literature review	1.332
Wickramasinghe and Naranpanawa (2022)	Computable general equilibrium	Systematic literature review on computable general equilibrium applications in tourism	1.758
Mulet-Forteza et al. (2021)	Intellectuality of European institutions	Research progress in tourism, leisure and hospitality in Europe (1969–2018)	
Hu et al. (2022)	Surveys	Emerging Research Trends on Residents' Quality of Life in the Context of Tourism Development	1.531
Liu et al. (2022c)	Mixed-frequency models	Ex ante tourism forecasting assessment	3.062
Verma et al. (2022)	Quantitative (science mapping) and qualitative (intellectual structure mapping)	Past, present, and future of virtual tourism-a literature review	3.087
Papavasileiou and Tzouvanas (2021)	Kuznets-curve	Tourism carbon Kuznets-curve hypothesis: A systematic literature review and a paradigm shift to a corporation-performance perspective	3.062
Zhang (2022)	Econometrics	A meta-analysis of econometrics studies of tourism and low-carbon development	2.312

Notes: SNIP—Source Normalized Impact per Paper for 2022 (Scopus 2023).

The second part of the review, encompassing a diverse set of studies utilizing methods akin to the ABC framework from the field of management focused on systematically reviewing tourism models designed to predict future events based on Equation (1).

Cao (2022) thoroughly examined vector autoregressive (VAR) models and their applications in tourism demand research, showcasing the versatility of VAR models in capturing interrelationships between tourism and economic variables. Al Jassim et al. (2022) assessed studies on forecasting tourism demand, emphasizing the importance of integrating diverse data sources and inspiring future research. Dowlut and Gobin-Rahimbux (2023) explored deep learning techniques for occupancy rate prediction in the hospitality industry, highlighting the adoption of Long Short-Term Memory (LSTM) models and underscoring the significance of hybrid models for enhanced accuracy. Wickramasinghe and Naranpanawa (2022) provided a systematic quantitative review of computable general equilibrium (CGE) applications in tourism, emphasizing the importance of addressing research gaps, especially in poverty, inequality, gender, and environmental impacts.

Additionally, Mulet-Forteza et al. (2021) presented a bibliometric overview of tourism, leisure, and hospitality articles, identifying publication trends and offering insights for future research. Hu et al. (2022) conducted a systematic review of residents' quality of life concerning tourism development, revealing patterns and suggesting future directions for research. Liu et al. (2022c) conducted a comprehensive study of mixed-frequency models for tourism forecasting, showcasing their effectiveness in improving accuracy and reducing forecast failure risk. Verma et al. (2022) bridged the knowledge gap by reviewing the integration of virtual and augmented reality in tourism, highlighting the transformation of the virtual tourism experience. Papavasileiou and Tzouvanas (2021) debated the carbon Kuznets curve hypothesis, conducting a systematic literature review on the role of tourism and introducing a novel tourism corporate/performance orientation to the thesis. Zhang (2022) employed meta-analysis to examine the effects of tourist arrivals and tourism receipts on carbon emissions and energy use, shedding light on their significant positive impacts and moderators. These studies collectively contribute to a deeper understanding of tourism forecasting models and their applications, providing insights for future research and policy development.

In the third segment of the review (Table 3), denoted as part C, the focus shifted to systematically examining the intersection of tourism with artificial intelligence (AI), economic growth and/or CO_2 emissions.

Binesh et al. (2021) conducted a comprehensive meta-analysis of hotel revenue management literature, identifying key themes, methodological approaches, and geographical trends while highlighting research gaps and avenues for future investigation. Bhuiyan et al. (2021) delved into the multifaceted consequences of disasters and pandemics, notably COVID-19, on tourism, economies, and mitigation strategies, synthesizing a wealth of research findings and providing directions for future exploration. Sun et al. (2022) scrutinized the tourism–carbon emissions nexus by reviewing environmental Kuznets curve studies, revealing conflicting results across regions and emphasizing the need for a refined understanding of the mechanisms involved.

Moreover, Steiger et al. (2022) systematically analyzed climate change's impacts on mountain tourism, identifying knowledge gaps, geographical biases, and areas requiring further research for effective climate adaptation strategies. García-Madurga and Grilló-Méndez (2023) comprehensively synthesized the existing literature on AI in tourism, highlighting key themes, strengths, limitations, and emerging research areas within this context, providing valuable insights for practitioners and academics. Han and Bai (2022) explored the evolving landscape of pricing research in marketing, hospitality, and tourism, employing sophisticated bibliometric analyses to identify trends and suggest potential research directions. Leal et al. (2020) addressed the transparency and sustainability issues in online tourism crowdsourcing platforms, proposing an accountable and responsible processing pipeline for data streams that can enhance sustainable tourism practices. Kong et al. (2023) reviewed AI research in the hospitality and tourism industry, tracing its growth

over the years, categorizing research clusters, and revealing shifts in research focus, thus serving as a valuable resource for future investigations.

Table 3. Tabular display of results that dealt with AI and economic or CO_2 growth.

Author(s)	Data/Methodology	Title	SNIP
Binesh et al. (2021)	Meta-analysis: 76	A meta-analysis of hotel revenue management	0.794
Bhuiyan et al. (2021)	Meta-analysis: 100	A review of research on tourism industry, economic crisis and mitigation process of the loss: analysis on pre, during and post pandemic situation	1.198
Sun et al. (2022)	Environmental Kuznets Curve studies: 81	Does tourism increase or decrease carbon emissions? A systematic review	2.742
Steiger et al. (2022)	Meta-analysis: 276	Impacts of climate change on mountain tourism: a review	3.148
García-Madurga and Grilló-Méndez (2023)	AI in tourism	Artificial intelligence in the tourism industry: an overview of reviews	1.018
Han and Bai (2022)	Marketing	Pricing research in hospitality and tourism and marketing literature: a systematic review and research agenda	2.074
Leal et al. (2020)	ARIMA, neural networks and hybrid models in time series	Responsible processing of crowdsourced tourism data	3.148
Kong et al. (2023)	Meta-analysis: 491	30 years of artificial intelligence (AI) research relating to the hospitality and tourism industry	2.074
Buturac (2021)	Mixed data and methodology	Measurement of economic forecast accuracy: A systematic overview of the empirical literature	0.476

Notes: SNIP—Source Normalized Impact per Paper for 2022 (Scopus 2023).

Finally, Buturac (2021) conducted a systematic literature review of measures of economic forecast accuracy, offering insights into methodological developments, limitations, and the potential for future advancements in assessing economic forecast accuracy. These studies provide valuable insights into the relationship between AI, tourism, and financial or environmental factors. They offer guidance for future research in tourism forecasting and combined econometric time series models.

Our comprehensive analysis in Tables 1–3 encompasses 29 articles strongly correlating with the primary keywords, particularly forecasting. Papers that did not meet our criteria, such as book chapters or conference papers not indexed in substantial databases aside from Google Scholar, or those that did not concentrate on the European context, were appropriately excluded. Table 4 categorizes included articles, with Category A being the most pertinent to our research field and Category C being the least relevant.

Table 4. Development of codes by categories.

Category	Code	Authors
A	Meta-analysis	Listed in Table 1
B	Forecasting methods	Listed in Table 2
C	AI and growth	Listed in Table 3

In total, Google Scholar provided us with 68 manuscripts. After careful consideration, we have narrowed our list to 29 articles relevant to our research on tourism demand forecasting. During this step, researchers incorporate time series econometrics within the context of their modeling. This is done to improve the accuracy of the model and ensure that it accounts for changes over time.

4. Discussion

The selected 29 articles obtained through Google Scholar represent a valuable foundation for studying tourism demand forecasting in the European context using time series econometrics. These articles encompass a diverse range of methodologies, approaches, and findings, offering a comprehensive overview of the research landscape in this domain. The decision to focus specifically on European tourism demand forecasting is noteworthy, as it aligns with the European continent's unique economic and environmental dynamics.

One key observation derived from the literature review is the evolution and diversification of forecasting methods employed in tourism demand studies. While time series econometrics remains a prominent approach, there is evidence of its integration with other techniques, such as AI and machine learning models (Essien and Chukwukelu 2022). This reflects the growing complexity of tourism demand dynamics and the need for more accurate and adaptable forecasting tools. The combination of various methodologies signals a broader shift toward a holistic and multidisciplinary approach in accurately addressing the challenges of predicting tourism demand.

Another notable finding relates to the variability in results and conclusions across the reviewed articles. Tourism demand forecasting is inherently sensitive to numerous factors, including economic conditions, political events, and environmental changes. Consequently, the context-specific nature of these forecasts has led to outcome variations. This variability underscores the importance of considering regional nuances and employing localized models to enhance the accuracy of predictions, especially within the diverse European landscape. Noting the previous in predicting future shock(s) is essential in time series analysis regarding stochastic linearities (Claveria and Torra 2014; Dong et al. 2023).

Furthermore, categorizing articles, with Category A representing the most relevant and Category C the least prominent, provides a clear hierarchy of the literature's alignment with the research objectives. This categorization streamlines the selection process and highlights the research gaps and areas that warrant further investigation. Focusing on Category A articles closely aligned with the core research objectives, this study aims to contribute to a refined understanding of European tourism demand forecasting and foster the development of more effective forecasting models tailored to the region's specific dynamics (Zekan et al. 2022). There appears to be a shortage of scholarly forecasts regarding the future of tourism. Additionally, very few studies on ex-ante prediction seem to exist (Liu et al. 2022a). This may be attributed to a lack of enthusiasm on the part of academic journals or a scarcity of experts in forecasting and time series analysis, which can be rather demanding when utilizing econometric techniques accompanied by machine learning (Pérez-Pons et al. 2022).

5. Conclusions

This comprehensive review examined a vast body of the academic literature, including 5120 articles published before September 2023. The analysis revealed a significant increase in scholarly activity from 2020 to 2024, indicating a growing interest in predicting tourism demand. After a thorough screening process, 3220 articles previously analyzed in seminal studies and 1822 articles lacking rigorous peer review were excluded, resulting in a final cohort of 78 papers at the core of our analysis. Additionally, ten literature records were excluded for not being about Europe. These 68 articles, representing the culmination of our screening process, provided valuable insights into the evolving landscape of tourism demand forecasting methods. Moreover, this paper has discussed 29 additional articles, including two studies in the fourth section, and cited one newspaper article. Drawing from 32 relevant documents, this comprehensive review sheds light on key trends and developments in tourism demand forecasting. Overall, after analyzing 29 relevant articles in the renowned Scopus database and 3 additional articles to support section four, this study concludes that ex-ante forecasting is of paramount importance.

In conclusion, this comprehensive review of 29 articles selected from Google Scholar and shown in the third section has shed light on the multifaceted landscape of tourism de-

mand forecasting, mainly focusing on time series econometrics within the European context. The articles examined in this study provide a valuable knowledge repository, reflecting the ongoing evolution of methodologies and approaches in tourism demand forecasting.

One central observation derived from this review is the increasing diversification of forecasting methods, which have evolved to accommodate the intricate and dynamic nature of tourism demand. While time series econometrics remains a fundamental tool, integrating artificial intelligence and machine learning models highlights the industry's readiness to embrace more sophisticated forecasting techniques.

The variability in outcomes and conclusions across the reviewed articles underscores the contextual sensitivity of tourism demand forecasting. Economic, political, and environmental factors play pivotal roles in shaping tourism trends, meaning forecasters need to consider local nuances and adapt their models accordingly. This diversity of outcomes emphasizes the need for region-specific models and data sources to enhance forecasting precision in the European tourism stochastic linearity sector.

The categorization of articles based on relevance, with Category A representing the most pertinent contributions, offers a practical framework for future research endeavors. By focusing on Category A articles, researchers can expedite their exploration of foundational concepts and theories while identifying knowledge gaps and potential avenues for further investigation. This categorization system is a valuable resource for scholars seeking to navigate the extensive literature on forecasting tourism demand.

In sum, this review provides insights into the current state of tourism demand forecasting, and highlights its continuous evolution and adaptation to contemporary challenges.

5.1. Policy and Managerial Implications

For policymakers, these findings underscore the significance of leveraging time series econometrics, coupled with AI and machine learning techniques, as essential tools for informed decision-making. The ability to anticipate fluctuations in tourism demand allows policymakers to craft targeted strategies that optimize resource allocation, enhance destination management, and stimulate economic growth.

Similarly, managers within the tourism industry can harness the predictive power of time series econometrics to optimize their operations. By leveraging these methodologies, they can prepare them for any obstacles, e.g., shocks. This enables managers to adapt swiftly to changing market conditions, improve customer experiences, and maintain competitiveness in the dynamic tourism landscape. The recommendation for managers is straightforward: relying solely on raw data is not advisable, as many may not feel comfortable with mathematical or statistical concepts. Instead, it is suggested that managers acquire the necessary skills to interpret quantitative data accurately, enabling better decision-making. While experience and intuition are valuable assets, they may not be sufficient, as numbers can offer predictive insights into the future. To anticipate a company's short-, medium-, and long-term strategies, a hybrid model combining time series data and AI would be an invaluable tool. This model can predict almost all foreseeable events in strategic documents and support them. By allowing data to speak for themselves, the past can guide the present, and the present can forecast future outcomes. Managers have access to a wealth of unique data, which they can use to make predictions with proper methodologies. For instance, they can use data to forecast total revenues for the next year or years, optimize process costs, and more. In competitive markets, successful organizations will thrive by making accurate predictions, such as estimating higher or lower demand and predicting prices for the next season, accompanied by optimized costs. Tourists can also benefit indirectly from utilizing time series econometrics and predictive modeling in the industry for an "unpredictable" future (Equation (1)). Accurate forecasting helps destinations provide tailored experiences, anticipate peak visitation periods, and manage resources more efficiently, ultimately enhancing the overall tourist experience.

In conclusion, the fusion of AI, machine learning, and time series econometrics has emerged as a reliable and robust approach to forecasting European tourism demand. This

methodology furnishes policymakers, managers, and travelers with valuable insights to facilitate prudent decision-making, promote sustainable growth, and elevate the overall quality of the tourism industry (Doborjeh et al. 2022; Sharma et al. 2022).

5.2. Limitations and Delimitations

The limitations of this study primarily revolve around the scope and methodology employed. Firstly, while a comprehensive effort was made to select relevant articles and publications related to tourism demand forecasting using time series econometrics, the study may still be subject to potential publication bias, as specific relevant articles may not have been included in the analysis.

Secondly, the focus on Europe as a delimited context for the study, while allowing for a more in-depth examination of this region, may limit the generalizability of the findings to other global contexts.

Lastly, the study's analysis was predominantly quantitative, focusing on the frequency of keywords and themes within the selected articles. While this approach provided valuable insights into research trends, it did not delve deeply into the qualitative aspects of the articles.

Despite these limitations, the study's delimitations, such as the focus on European contexts, were essential in narrowing the scope to provide a more detailed and region-specific examination of tourism demand forecasting using time series econometrics.

5.3. Proposals for Future Research

For future research, exploring alternative techniques to retrieve articles and keywords beyond the PRISMA model could be a valuable avenue. Utilizing advanced text mining, natural language processing, or machine learning algorithms to extract relevant articles and keywords could enhance the comprehensiveness of the literature review. Investigating emerging databases and sources beyond traditional academic repositories might provide a broader perspective. These alternative approaches could offer new insights, and contribute a more comprehensive understanding of tourism demand forecasting, especially when combined with existing methodologies.

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Exploring Competence-Based Synergism in Strategic Collaborations: Evidence from the Global Healthcare Industry

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Abstract: One of the most essential issues in business partners' collaboration is whether the integration of their businesses creates a collaborative synergy and adds market value to merging companies. This paper aims to develop a methodological framework that will be convenient for managerial praxis and helpful for scholars' research in forecasting explicit synergy and valuing tacit synergy in strategic collaborations. The paper theoretically and empirically contributes twofold to strategic foresight. It employs the ARCTIC framework as an extension of the VRIO model to predict an explicit synergy and real options methodology to measure tacit competence-based synergies in M&A deals. The paper makes several theoretical contributions and managerial implications to corporate finance and strategic management disciplines. Finally, the paper discusses research limitations and future work.

Keywords: foresight; resource-based view; the ARCTIC framework; core competence; explicit synergy; tacit synergy; mergers and acquisitions; real options

1. Introduction

> "*Synergy makes great business sense, but it may make lousy consumer sense for health care.*" Arthur Caplan, the New York University Grossman School of Medicine (Fowler 2022, p. 1)

A methodical and distinct focus on the future of corporations characterizes foresight (Fergnani 2022, p. 825). Corporate foresight gives a company the flexibility to reorganize its resource base by adding resources from partnerships and acquisitions. However, it can be very difficult to realize the value-creating potential of collaborative solutions (Bower 2001; Schweizer et al. 2022; King et al. 2004). According to the resource-based perspective (RBV), the foundation for adding more value than competitors is the acquisition of rare, valuable, unique, and organized (VRIO) resources (Barney and Hesterly 2015). For instance, it is now standard practice in academic and managerial strategic thinking to build up VRIO resources to increase economic rent (added value) (Lin and Wu 2014). Furthermore, there is still a lack of consensus in the literature addressing the relationship between value-added economic rent and the components of a mechanism that generates synergy through integrating collaborative partners' VRIO resources and predicting their synergistic implications.

According to Haleblian et al. (2006), King et al. (2004), and Schweizer et al. (2022), most collaborative strategic transactions do not seem to meet expectations, so scholars and practitioners alike have been calling for a deeper understanding of M&A performance. To assess collaborative synergies, Rabier (2017) suggests measuring financial synergies (such as enhancing free cash flows and optimizing the weighted average cost of capital (WACC) and operating synergies (such as revenue growth through new product offerings or cost savings through economies of scale) that are more likely to result in higher operating profit margins (EBIT/net sales). Thus, scholars and practitioners mostly examine explicit synergies between revenue growth and cost savings. But, to achieve tacit synergy, new core

competencies must be developed to leverage the VRIO resources of merging partners and generate "value in development" (Hao et al. 2020).

The adoption of this kind of tacit synergy or "value in development" calls for thought from academics and professionals. The purpose of this study is to create a conceptual framework that academics and professionals may utilize to value explicit and tacit synergies in strategic merger and acquisition endeavors. As a result, this study seeks to address two research questions: (1) How does one analyze the prerequisites of explicit competence-based synergism in M&A deals employing the ARCTIC framework? (2) How does one measure a tacit competence-based synergism of M&A deals with the application of real options?

By examining the prerequisites for explicit competence-based synergies using the ARCTIC framework, measuring tacit synergy by exploring the acquisition of One Medical by Amazom.com in 2022 and valuing their collaborative tacit synergies with real options, three real options methodologies, namely, BOPM, BSOPM, and Monte Carlo simulations, were used to empirically addresses the research questions. To answer the first research question, the paper examines explicit competence-based synergies in mergers and acquisitions within the global healthcare industry through the RBV theoretical lens in general and the ARCTIC framework in particular. To answer the second research question, the paper employs methodological quantitative triangulation (Patton 1999; Arias Valencia 2022) that refers to the application and combination of three real options valuation methods in the study of the same phenomenon, namely, "value in development" or tacit synergies.

According to Brandão et al. (2005), investments with option-like characteristics—that is, where the investment's value is dependent on events occurring over time—can be classified as real options in the widest sense. But, for a real option to be worth something, the management of the firm has to be able and willing to exercise (or actualize) the option when the circumstances are appropriate. This ability is also known as dynamic management capabilities (Helfat and Martin 2014) or (managerial) flexibility or "contingency" (Mun 2003, p. 285; Li et al. 2007). While the term "uncertainty" is used rather generically in the context of real options, it means that it is unclear what a given variable will be worth in the future (Copeland and Keenan 1998a; Triantis and Borison 2001). Uncertainty typically has been associated with potential volatility in the value of an underlying asset or the investment's cash flow stream (Mun 2002, p. 147; Damodaran 2005).

Flexibility only has a meaningful value when management can respond to uncertainty surrounding an investment (Copeland and Keenan 1998b; Mun 2002, p. 82). Thus, the overall goal of real options theory is to assess management flexibility as a monetary value. Real options have important features that make them more suitable for valuing M&A synergism in a changing environment than common static techniques like discounted free cash flows. Expansion or growth option (invest), abandon option (reject), and deferred option (postpone) are the three various types of options related to M&A deals. While the abandon option is valued as a put option, the growth and deferred options are valued as call options. Consequently, it is possible to value the tacit managerial synergies that result from a merger as a real call option (Čirjevskis 2021c).

The structure of the paper is as follows: It begins by looking at the sources of synergies as well as the importance of the core competencies for M&As' success. The ARCTIC framework is established based on a profound examination of previously published scholars' papers on M&A successes and failures. The ARCTIC model that was developed to predict explicit competence-based synergies and generalized in the previous author's publications is then empirically tested by using a deviant case study as the most intriguing Amazon acquisition in the global healthcare industry, namely, the acquisition of One Medical by Amazon.com in 2022. Next, three real options valuation models, Black–Scholes option pricing model (BSOPM), the binominal option pricing model (BOPM), and Monte-Carlo simulations (MCS), for the assessment of strategic tacit competence-based synergism in M&A are employed and explained in detail. The author addresses theoretical contributions, empirical findings, limitations, and future work at the end of the paper.

2. Key Literature Review

2.1. Foreseeing Explicit and Valuing Tacit Strategic Collaborative Synergism

The strategic compatibility, complementarities, and transferability of core competencies across collaborative partners are factors that contribute to strategic synergism in collaborative endeavors. According to recent research by Hao et al. (2020), two sorts of synergistic effects are related to a business partnership's strategic collaboration: explicit and implicit. Financial and operational synergies are straightforward to comprehend and measure. They are explicit types of synergies. Explicit synergy arises when business partners reciprocally share complementing core competencies (Zaheer et al. 2013).

Relying on multiple case studies, the ARCTIC framework expanded generalizability (Chirjevskis and Joffe 2007; Čirjevskis 2020, 2021a, 2021b, 2023a). The usefulness of the ARCTIC framework application was measured for a broader set of case studies on strategic collaborative deals, particularly for M&A deals (among them Facebook's acquisitions of Instagram in 2012 and WhatsApp in 2014, Microsoft's acquisition of LinkedIn in 2016, and others) and alliances (among them the alliance of Renault–Nissan–Mitsubishi within 1999–2016, and the alliance of Ford and Mazda in 1995). There are several case studies where the ARCTIC framework had predicted competence-based synergies (e.g., the Samsung Electronics acquisition of Harman Industry International in 2017) and where the ARCTIC model had NOT predicted one (e.g., the L'Oreal acquisition of the Body Shop in 2006 and the alliance of Tesco–Carrefour within 2018–2021). That research allowed readers to contrast case studies and grasp how the ARCTIC framework works in greater detail. Because the ARCTIC framework was broadly applicable to many different types of collaborative strategies, the current case study, therefore, is said to have good generalizability.

However, the previously published papers on the ARCTIC framework did not provide an answer to the important question: does the ARCTIC framework predict explicit or tacit types of synergies or both? Understanding the differences between explicit and tacit collaborative synergism was a critical point for the further application and development of the ARCTIC framework. In this vein, the current research argues the ARCTIC framework provides an analytical tool to explore the potential of explicit competence-based synergies. As a result, the current research addresses the question of how to analyze the prerequisites of explicit competence-based synergism in M&A deals employing the ARCTIC framework. Hao et al. (2020) argued that the exchange of core competencies between partners generate "value-in-exchange" or an explicit synergy that can be easily predicted in advance. Therefore, the ARCTIC framework explores the prerequisites and predicts explicit synergies (value-in-exchange) in the process of the exchange of collaborative partners' core competencies. For example, partnering with IBM brings traceability and transparency to Walmart's entire food supply network through blockchain (Aitken 2017). Blockchain reduces waste, spoilage, and contamination incidents (Lawrence 2018), thereby facilitating an explicit type of synergy.

However, new core competencies may emerge spontaneously through strategic collaboration and, thus, represent a tacit synergy in real business practice. Hao et al. (2020) referred to this alternating concept of tacit synergy as "value-in-development" (Hao et al. 2020, p. 434). According to Hao et al. (2020), collaborative tacit synergies known as "value in development" occur when partners' core competencies complement one another and encourage the generation of novel core competencies or ways to create value (Lasker et al. 2001; Hao et al. 2020, p. 433). For instance, Alphabet's core competencies in high tech and Carrefour's core competencies in retail grocery have been integrated into new customer value proposition development, thus updating the retailer's business model, reframing their modes of thinking, and adding tacit synergetic value (Čirjevskis 2022).

To anticipate and recognize a tacit synergy in the process of synthesizing existing core competencies to develop new competencies and, therefore, new competence-based synergies is far more difficult. Partner firms might come from unrelated industries or market areas but entail the potential to inspire each other to develop new core competencies. Tacit synergies cannot be predicted until collaboration has proceeded but can

be approximated with the application of the real options. In this vein, the acquisition of One Medical by Amazon.com is a spectacular illustration of tacit synergy. Accordingly, partner businesses' knowledge bases and their mutual learning, creativity, and managerial flexibility to integrate and build new core competencies constitute the foundation of tacit synergy and "value in development" (Baum et al. 2010; Hao et al. 2020, p. 434). Hence, it is a call for real option application because real options can be used to value managerial flexibility and, thus, tacit synergies.

A real options methodology views collaborative strategy as a set of options that are continuously exercised to produce both short- and long-term returns on co-operation. Furthermore, the author argues that the potential of a tacit competence-based synergy can be approximated by using the real options theory (ROT). The logic behind real options recognizes the importance of strategic managerial flexibility, as well as the possibility of obtaining better returns on investment or, in the case of co-operative strategies, competence-based synergies (Yeo and Qiu 2003). In this vein, real options valuation techniques can be adopted to quantify tacit competence-based synergies in collaborative strategies (Čirjevskis 2021c). Tacit synergy can be pursued when business partners' knowledge bases spur learning and inspire new core competencies that could not be predicted upfront (Baum et al. 2010) but can be valued as a real option.

Moreover, numerous researchers have recognized foresight methods—in particular, strategic (real) options techniques—as approaches that offer a competitive advantage through the real value of foresight (Fergnani 2022, p. 828). In this line, the following section is devoted to real options reasoning and application because this study is interested in employing real choices theory to quantify collaborative tacit synergies.

2.2. Application of Real Options to Measure Competence-Based Synergies

The management flexibility resulting from M&A transactions is measured by the synergy evaluation inclusion of real options (Loukianova et al. 2017). Consequently, the synergies generated by a merger or acquisition can be viewed as the market value added by the merging business or as a real option value. Additionally, Bruner (2004) emphasized that M&A professionals require real options. The present work incorporates the commonly accepted recommendations of Dunis and Klein (2005, p. 8) on the correspondence of financial options' parameters to real options as follows:

The cumulative market value of the target and acquirer, or their capitalizations before the announcement, excluding the week of an announcement (four-week average) is the share price (So) equivalent of the option. Market capitalization data are typically accessible through the following websites: https://ycharts.com/ (accessed on 20 February 2024); https://companiesmarketcap.com/ (accessed on 20 February 2024); and other websites. The hypothetical future market value of the separated entities forecast by EV-based (EV/EBITDA and EV/Revenues) multiples is the strike price (E). The volatility (σ) of a share price can be obtained through direct observation or by using the V-Lab APARCH Volatility Analysis. The synergy life cycle or duration of real options (T) is usually one year according to Dunis and Klein (2005). A long-term government bond yield is known as the risk-free rate (Rf).

Following the Black–Scholes option pricing model, the European call option on the market value added of the combined firm represents the competence-based synergies at the moment of real options expiration. Cox et al. (1979) proposed a different method for valuing real options and suggested using the binomial options pricing model (BOPM) to evaluate American options. A competence-based synergy can be valued by time steps within the projected time frame. According to Gilbert (2005), the binomial lattice approach and the American option are the most practical, adaptable, and natural methods for valuing real options. The parameters of the binomial tree can be derived once all input parameters described above have been established. As such, it permits an analyst to evaluate a synergy based on competencies as an American call option in the following manner.

First, the underlying (event tree) lattice needs to be built. The calculation starts at the initial node and moves from left to right until the real options expire. The movement of the underlying asset (S) throughout the real option is depicted by a lattice of the underlying asset. In this work, the author employs EV/EBITDA (Enterprise Value/Earnings before Interest, Taxes, Depreciation, and Amortization) for Amazon.com and EV/Revenue multiples for One Medical to determine the value of the underlying asset at time zero, also known as the PV of the underlying asset (So). Stepping time (δt, ΔT, or Δt) is the interval of time between each time step in the lattice that needs to be calculated (Brealey and Myers 2003; Nembhard and Aktan 2009, p. 24). Second, the real option valuation lattice is constructed and computed from the terminal nodes backward.

The value of the underlying asset will bifurcate at each time step in the lattice, increasing by the up factor (u) and decreasing by the down factor (d). These parameters depend on both the duration of the real option and the implied volatility of the underlying assets (Mun 2003, p. 74). Following the development of the underlying lattice, the real option valuation lattice or decision tree lattice (Copeland et al. 2000, p. 410) has to be built. Real options attain maturity at the terminal nodes, according to Kodukula and Papudesu (2006, p. 79). Therefore, terminal nodes' real options value needs to be identified by deducting the exercise price—"E" from the share price—"So".

The value of the embedded real options is then found by back-calculating (also known as "rolling back") the lattice to the initial node, using a risk-neutral probability formula for the up and down nodes of the real options lattice, as Borison (2005) notes. Hence, the real option valuation lattice is computed back to the first node (where So was initially input) via the backward induction procedure. Real options proponents view the value of the real option in the initial node as the "fair value" of any options (Mun 2003, p. 98). Nevertheless, the primary drawback of BOPM is its computational complexity, as it takes numerous time steps to yield a result that is accurate enough.

Mun (2002, p. 145) states that, when employing binomial lattices, the more time steps, the higher the level of accuracy and, thus, the higher the level of precision. Hull (2005, p. 355) argues that approximately thirty steps produce satisfactory results for financial options. However, Kodukula and Papudesu (2006, p. 96) suggest that, in real option valuation, four to six steps are typically sufficient for good approximations. The stepping time is the duration of each time step or the amount of time that elapses between consecutive nodes (Mun 2002, p. 144). Mun (2002) argued that, to obtain an extended net present value (eNPV), the option value should be added to the NPV of the project that is determined by the discounted cash flow (DCF) approach or, in the case of the current research, the EV/EBITDA and EV/Revenues multiples.

To conclude the literature review part, the net present value (NPV) of the collaborative strategies measures the "value-in-exchange" whereas the real options value approximates the "value-in-development" (Hao et al. (2020). Therefore, the analysts can employ both the NPV without real options application and the eNPV with the application of those by measuring competence-based synergies of collaborative strategies. Lastly, real option valuation is essentially a dynamic form of net present value (NPV) where the discount rate is modified in response to evolving uncertainty and the perceived risk of the deal (Lambrecht 2017, p. 168).

3. Research Design and Methodology

Using a qualitative case study methodology, researchers can investigate complex phenomena in depth within a particular setting (Rashid et al. 2019, p. 1). The research phenomena of the paper are explicit and tacit competence-based collaborative synergies in the context of M&A deals. Seawright and Gerring (2008) argued that case selection in case study research desires (a) a representative sample and (b) useful variation on the dimensions of theoretical interest. When it comes to sampling, according to Eisenhardt and Graebner (2007), it is appropriate to use a single case if a phenomenon-driven research question "how" is subject to investigation. Ultimately, each case can be viewed as a discrete

experiment that could be repeated (Yin 2009). Regarding research investigating a single case, Siggelkow (2007) notes that it can be a very powerful example.

Because the main theoretical interest of the current paper is the valuation of collaborative competence-based synergies and its valuation, Amazon.com as a high-tech giant with its ecosystem throughout the world is an appropriate object of current research. When it comes to a unit of research, namely, Amazon's acquisition of One Medical, this concrete case study is instrumental to answering research questions and reaching the research aim for the following reasons: According to cross-case methods of case selection and analysis (Seawright and Gerring 2008), the case study of the One Medical acquisition can be characterized as a deviant case study that deviates from some cross-case relationships on recent acquisitions of Amazon.com, like the acquisition of Souq.com in Dubai in 2017 and Whole Foods in the US in 2017.

The rationales behind acquiring Dubai-based start-up Souq.com were to enter a new geographic market and to acquire Souq.com's core competencies, capabilities, and logistic system to navigate a complicated region (MAGNiTT 2017, p. 1). Thus, consumers in the Middle East can buy Amazon.com products using the Souq.com platform (Banerjee 2021). Regarding the highly strategic and not-standard acquisition of Whole Foods by Amazon in 2017, having had limited knowledge and experience in the offline retail environment, Amazon needed to acquire more expertise in perishable grocery procurement and more knowledge of the retail market, improve the management of its supply chain for the offline retail store, and continue investing in R&D for the grocery retail business (Čirjevskis 2023b).

However, having announced in July 2022 Amazon's decision to acquire One Medical, Amazon has pursued a strengthening of its physical presence in the US healthcare market and an expansion of its online pharmacy business as well as diagnostic business. These acquisitions strongly deviate from previous Amazon strategic acquisitions that pursued new geographic online grocery market development with Souq.com and penetrated the offline grocery market with Whole Foods. The nature of the deviant case study of Amazon's acquisition of One Medical is exploratory, and the usage of this case study is confirmatory to justify the provided theoretical proposition. Moreover, Seawright and Gerring (2008) argued that one deviant case study can be used as a high-residual case or an outlier.

There are two phases to this study: A deviant case study constitutes the first phase. According to Sekaran and Bougie (2018), the validity of qualitative case study research is determined by how well the findings of the study reflect the data that were gathered (internal validity) and how well they can be applied to different contexts (external validity). One of the main benefits of case study research is that it allows for the investigation of a small number of selected samples, or even one case study, that can be investigated in depth (Yin 1984). The fact that the secondary researcher was not there throughout the data-gathering process and is, therefore, unaware of the precise methods used is a significant drawback of employing secondary data.

However, the clear advantages of adopting secondary data might outweigh its drawbacks (Johnston 2014). According to Smith (2008), the primary benefits of secondary analysis are its cost-effectiveness and ease. Not all the data gathered were used in the original survey study; however, the data that are not used can offer new insights or answers to unanswered questions (Smith 2008). According to Andrews et al. (2012) and Smith (2008), there is increasing evidence that using pre-existing secondary data for study is possible in an era where academics worldwide are gathering and archiving large amounts of data.

Regarding evidence presentation, Eisenhardt and Graebner (2007) assert that there is no rigid standard for findings presentation, unlike in large-scale investigations, because of the abundance of data that accumulate throughout the case study. As a result, the first phase of the current study uses the findings from deviant case studies as well as scholars' publications to demonstrate how the ARCTIC framework to assess the prerequisites of explicit synergies is applied. One tool that can be used to prepare existing data is contextual positioning.

In grounded theory research, the author used pertinent secondary documents to develop the ARCTIC framework, employing the contextual positioning approach (Ralph et al. 2014). To gain a micro-level understanding that enhances the operationalization of the ARCTIC framework, the current study relies on a thorough literature review and archival search that includes financial statements, annual reports, internal papers, industry publications, and CEO statements.

This has been accomplished by using contextual positioning to position the extant data of the inductive case study. This has allowed the author to identify the critical success factors (prerequisites) of competence-based synergy and codify them in the ARCTIC framework. As a result, contextual positioning makes the process of gathering data more interactive. In practice, the process is broken down into the following two stages. Using the VRIO framework, the target and acquirer companies' core competencies are determined in the first stage.

As a result, the VRIO framework makes it possible to pinpoint merging organizations' core competencies as the foundation of their long-term competitive advantages. Next, an analysis of the core competencies complementarity, compatibility, and transferability with the ARCTIC framework is the second stage. The purpose of the ARCTIC framework application is to assess whether the core competencies of partners can be sources of strategic explicit synergism in the M&A deal.

Furthermore, the second phase of the case study involves utilizing a real options valuation technique to value the strategic tacit synergism of the M&A deal. The tacit competence-based synergies in the M&A deal are measured as an added market value using real options application involving the Black–Scholes option pricing model (BSOPM); the binominal option pricing model (BOPM), and the Monte Carlo methodology, thereby achieving methodological triangulation (Patton 1999) to test the validity of the measurement of strategic tacit synergism in M&A deals and obtaining the convergence of valuation results from different quantitative methods (Arias Valencia 2022).

The first valuation model used for this step was based on the Black–Scholes option pricing model (Black and Scholes 1973), namely, $C\ (S, t) = S_0 \times N(d_1) - K \times e^{-rT} \times N(d_2)$, where $N(d_1)$, $N(d_2)$ are the cumulative distribution functions of the standard normal distribution; C (S, t) is call option price at time t; S_0 is the price of the underlying asset at time 0; K is the exercise price at time t; T is time in years; r is a risk-free rate; e is a mathematical constant approximately equal to 2.71828, the base of the natural logarithm; and σ is expected volatility of an underlying asset's value.

The Black–Scholes option-pricing model's variables, binomial option pricing model, and Monte Carlo's parameters to measure the strategic tacit synergism of Amazon and One Medical deal are further discussed in the case study research. The BOPM is used to quantify the value of strategic synergism and, hence, the market value added to the M&A deal.

To answer the first research question of how to analyze the prerequisites of explicit competence-based synergism in M&A deals employing the ARCTIC framework, the methodology is discussed in the next sub-chapter.

Competency-Based Explicit Synergy Testing Using the ARCTIC Research Framework in Mergers and Acquisitions: A Methodology

Employing the six criteria (questions) of the ARCTIC research framework is comparable to employing the VRIO framework. The ARCTIC framework's first three criteria address the possible complementarity and compatibility of core competencies in a recently merged firm, and they closely resemble the VRIO framework's first three criteria. Put another way, the first three criteria evaluate the extent to which consumers value core competencies (external relatedness), rare and difficult to imitate by rivals (internal advantages), and can be integrated by a target's or acquirer's businesses (absorption capacity).

According to Penrose (1959) and Rugman and Verbeke (2002), "competencies lead to sustained superior returns"; thereby, the first three criteria ("A", "R", and "C") also line up

with their statement. According to Larsson and Finkelstein (1999), employee support for the joining firms' integration and the level of organizational integration following the deal's completion were key factors in determining how much a merger or acquisition produced synergistic benefits. Consequently, the following three criteria ("T," "I", and last "C") center on the integration process of two sets of core competencies.

Furthermore, Penrose (1959) noted that businesses profit from the "services of resources"—that is, from how they use resources—rather than from having resources in and of themselves. Thus, an assessment of the processes of the transfer and integration of core competencies throughout the M&A deal can be carried out by employing the following three criteria. Therefore, the last three criteria also align with Penrose's (1959) arguments, namely, the time (duration) of integration of core competencies, the integration plan, and cultural fit. The core competencies of both collaborative partners must meet all six requirements, or the six critical success factors, to generate competence-based synergy during the M&A process. All criteria, which are presented as questions, should, of course, be thoroughly explained.

"A" stands for Internal Advantage. Is it necessary to enhance the core competencies of one company (the target company) to foster complementarity with the acquiring company and support competence-based synergies? The answer is "Yes", if competence is uncommon and challenging for many rivals to copy, and taking advantage of it would produce competence-based synergy during the merger and acquisition process (Hitt et al. 2009; Bauer and Matzler 2014).

"R" stands for External Relatedness. The answer is "No" if the core competencies do not offer a novel value proposition to the consumer, and the core competencies of the other partner are not connected to the market demand externally. If the core competencies enable the businesses to adapt to environmental challenges or threats, offer value to customers, and facilitate the creation of new customer value propositions, then the answer is "Yes" (Bauer and Matzler 2014). This is the second aspect of synergy potential in a transaction.

"C" stands for the ability to merge business and absorb core competencies. Each competency has a certain level of complexity that makes it difficult for partners and competitors to transmit, as well as each partner possessing different absorption capabilities. Although having core competencies that are relevant, beneficial, and valuable for the other business is important, it might not be enough. The answer to the complexity issue is "No", as this would hinder competence-based synergy if fundamental competencies are too complex for the other organization to readily absorb (Hitt et al. 2009; Bauer and Matzler 2014). The answer is "Yes" if the other company's appropriation of core competencies is not as costly and time-consuming and is quite fast to absorb and take advantage of. This is the third component of the M&A process's potential for synergy.

"T" stands for Integration Time. Perhaps the most important factor in determining how well acquisitions create synergy is how quickly the process of exchanging knowledge and integrating core competencies takes. Research has demonstrated that an acquisition's chances of success decrease with the length of time it takes for integration to take place and for operations to begin operating consistently (Netz et al. 2019; Spanner et al. 1993). The answer is "No" if rare and valuable core competencies transfer so slowly as to be rendered useless. Thus, the answer is "Yes" if the transfer of fundamental abilities happens quickly. This is the M&A process's fourth possible synergy component.

"I" is also known as the post-merger Integration Plan of core competencies. When senior management assesses a possible acquisition, at least a few realistic implementation stages must have been planned. Post-merger integration is a very complicated topic that requires careful planning, successful execution, and efficient management (Hitt et al. 2009; Bauer and Matzler 2014). A post-merger integration plan should include mechanisms for co-ordination, a plan for training and development, an effective communication strategy amongst M&A transaction teams, and the establishment of mutual trust. The answer is "yes" if the acquirer has a well-defined plan that both parties support. Once more, when

a business enters the M&A process without a defined plan to pursue, the probability of competence-based synergy is reduced, and the answer is "No".

"C" refers to Cultural Fit of Core Competencies. Lastly, the degree to which core competencies align with the culture of the other organization should be evaluated. The response is "Yes" if the organization's senior management teams and employees of a target and acquirer will embrace and absorb the new cultural contexts (Bijlsma-Frankema 2001; Lodorfos and Boateng 2006; Nguyen and Kleiner 2003). But the response is "No" if there is cultural misfitting or incompatibility. This makes up the sixth component of the M&A process's potential for synergy.

Rabier (2017) suggests quantifying synergies by mostly using quantitative methods to evaluate synergies in terms of income and expense, therefore, quantifying "value-in-exchange" or an explicit synergy. However, the valuation of competence-based synergies is far more difficult since certain success elements cannot be measured numerically in terms of revenues and costs. The two partners' mutual trust, interpersonal relationships, methods of communication, clear organizational structures, the absorption capacities (a willingness to learn rather than substitute) of the acquirer and the target, and managerial flexibility are hard to quantify in terms of operating or net profit margins.

The "value-in-development" or tacit competence-based synergies in M&A can be measured as market value added by employing a real options valuation technique. With an application of real options valuation, it becomes easier to assess a tacit synergy in terms of market value added, first. Second, practitioners gain a clearer strategic observation of a tacit synergism valuation of the M&A deal as a result of the application of real options. After developing theoretical reasons, the author has chosen the deviant case study to test the technique of the ARCTIC framework empirically: Amazon.com's acquisition of One Medical in 2022.

4. Case Study: Amazon.com Acquisition of One Medical, Data Analysis, and Interpretation of Results

This case study examines a phenomenon (the ARCTIC framework and real option valuation application) in the M&A deal: Amazon.com's acquisition of One Medical in 2022. Research using a single case study has the potential to shed light on hidden factors by investigating the phenomenon's underlying causes and improving our comprehension of "how" things work (Fiss 2009; Yin 2018).

4.1. Justifications for Amazon.com's Decision to Purchase One Medical and the Effect of Core Competencies on Collaborative Synergies

On 21 July 2022, Amazon (NASDAQ: AMZN) and One Medical (NASDAQ: ONEM) entered into a definitive merger agreement under which Amazon will acquire One Medical for $ 3.9 bn. Headquartered in San Francisco, CA, USA, 1Life Healthcare, Inc. is the administrative and managerial services company for the affiliated One Medical physician-owned professional corporations that deliver medical services in-office and virtually. 1Life and the One Medical entities do business under the "One Medical" brand. The rationale behind this was to gain access to One Medical's more than 200 brick-and-mortar medical offices in 26 markets, and roughly 815,000 members (Palmer 2023). Having disclosed its plan to cease the operations of Amazon Care, Amazon has acquired One Medical to deepen its presence in health care, and dramatically improve the experience of obtaining medical care.

4.2. Estimating Prerequisites of Explicit Strategic Synergism in Amazon.com's Acquisition of One Medical

Amazon has long had ambitions to expand into health care, buying online pharmacy PillPack in 2018 for $750 million, then launching its virtual clinic for chronic conditions and prescription perks for Prime members (Palmer 2023). Previous success in deals of a similar nature, such as Walgreen's acquisition of VillageMD in 2020 and Cigna's acquisition

of MDLive in 2021, further point to probable success (Lee et al. 2022). The prediction of strategic synergism is given in Table 1.

Table 1. The ARCTIC framework. Exploring complementarity, compatibility, and transferability of core competencies: Amazon.com's acquisition of One Medical.

The Core Competencies of One Medical and Amazon.com	(A?)	(R?)	(C?)	(T?)	(I?)	(C?)
One Medical serves over 815,000 members through more than 200 physical medical offices spread throughout 26 geographical locations. (Palmer 2023, p. 1)	Yes	Yes	Yes	Yes	Yes	Yes
In an increasing number of locations, One Medical offers pediatric, mental health, chronic care management, and preventive and regular health visits (One Medical 2023, p. 1).	Yes	Yes	Yes	Yes	Yes	Yes
The seamless in-office and round-the-clock virtual care services, on-site laboratories, and programs offered by One Medical for common illnesses, mental health troubles, chronic care management, and preventative care (One Medical 2023, p. 1)	Yes	Yes	Yes	Yes	Yes	Yes
Amazon's huge customer base and its big data strategy: 44% of Americans are members of Amazon Prime (Lee et al. 2022)	Yes	Yes	Yes	Yes	Yes	Yes
Amazon.com innovates in all its businesses, from the production of electronic devices to drone delivery systems (BSIC 2017).	Yes	Yes	Yes	Yes	Yes	Yes
As a major player in the technology industry, Amazon has gained vast expertise in automation and artificial intelligence (AI) (Lee et al. 2022)	Yes	Yes	Yes	Yes	Yes	Yes

Source: developed by the author.

It is now possible to provide a succinct and accurate summary of the case study data, their interpretations, and the empirical conclusions. The competence-based synergies have six conditions, as determined by the ARCTIC framework. One Medical is a human-centered, tech-driven U.S. primary care organization that makes quality healthcare more accessible, affordable, and pleasurable by combining in-person, online, and virtual care services seamlessly. Amazon is the largest online retailer in the world (Amazon 2022).

As a result, the complementarity (A and R) and compatibility (C and T) of both companies' fundamental competencies are present. Neil Lindsay, SVP of Amazon Health Services, stated that the two businesses operated in complementary ways ("A" and "R"):

> "*Together, we believe we can make the health care experience easier, faster, more personal, and more convenient for everyone . . . We believe we can and will help more people get better care, when and how they need it*" (Palmer 2023, p. 1).

Concerning the degree to which the core competencies of the two businesses may be absorbed by the other and the amount of time it takes to integrate and utilize them (first "C" and "T"), One Medical CEO Amir Dan Rubin reports the following:

> "*We look forward to innovating and expanding access to quality healthcare services, together*" (Amazon 2022, p. 1).

Moreover, Neil Lindsay, senior vice president of Amazon Health, added in November 2023 the following:

> "*We are bringing One Medical's exceptional experience to Prime members—it's health care that makes it dramatically easier to get and stay healthy*" (Palmer 2023, p. 1).

Regarding the transferability of key competencies regarding integration issues throughout their corporate cultures (the "I" and final "C"), Sanjula Jain, Ph.D., chief research officer and senior vice president of market research company Trilliant Health, stated the following:

> "*. . . Amazon's revised virtual care strategy will likely align with what the data shows: integrating virtual care within an in-person care delivery platform, which is what One*

Medical offers and one focused more on going directly to a specific segment of consumers." (Vaidya 2023, p. 1)

Moreover, Amir Dan Rubin, CEO of One Medical, argued the following:

"*The opportunity to transform health care and improve outcomes by combining One Medical's human-centered and technology-powered model and exceptional team with Amazon's customer obsession, history of invention, and willingness to invest in the long-term is so exciting*" (Lee et al. 2022, p. 1)

"*We join Amazon with its long-term orientation, history of invention, and passion for reimagining a better future. . . Together, we believe we can make the health care experience easier, faster, more personal, and more convenient for everyone*" (One Medical 2023, p. 1)

Amazon CEO Andy Jassy has added the following:

"*Health care will be a major growth area for Amazon, even as the company has reined in spending*" (O'Donovan 2023, p. 1).

The ARCTIC analysis has helped to answer the first research question: How does one analyze the prerequisites of explicit competence-based synergism in M&A deals employing the ARCTIC framework? The ARCTIC framework has justified that Amazon.com's acquisition of One Medical was a highly synergetic deal. Competence-based synergies can also be realized quickly between the care delivery side and pharmacy side with Amazon's significant assets of technology, consumer platform, and delivery network. The acquisition can foster synergies, helping the success of Amazon's medical business. (Lee et al. 2022)

Moreover, One Medical was convinced of the following:

"*Amazon and One Medical have extensive experience protecting data of all kinds appropriately across a variety of businesses and nothing about this acquisition changes Amazon or One Medical's commitment to privacy or the strong protections we have for Protected Health Information*" (One Medical 2023, p. 1)

4.3. Valuation of Strategic Synergism by Using Binominal Option Pricing Model (BOPM): Amazon.com's Acquisition of One Medical

To address "a valuation" in the subsequent part of the research question, the real options parameters have been computed following the recommendations of Dunis and Klein (2005). Furthermore, the real options parameters and data are given in detail in Tables 2 and 3.

Table 2. The parameters of real options and data in detail: Amazon.com's acquisition of One Medical.

Parameters of Financial Options	The Parameters of Real Options and Data
Stock price (So)	The cumulated market values of Amazon and One Medical as separated entities (four-week average) before the announcement of the acquisition were as follows: Amazon's market capitalization on 21 June 2022 was USD 1.106 T, and on 19 July 2022 was 1.204T; thus, the average market value of Amazon was USD 1.155T One Medical market capitalization on 18 June 2022 was USD 1.54 bn, and on 23 July 2022 was 3.33 bn; thus, the average market value of One Medical was USD 2.44 bn (CompaniesMarketcap.com 2024). Therefore, the cumulated market values of Amazon and One Medical as separated entities (four-week average) before the announcement of the acquisition was USD 1155 bn plus USD 2.44 bn, equaling 1157.44 bn
The strike price (K)	The hypothetical future market value of Amazon as a separate entity is forecast by the EV/EBITDA multiples. Amazon.com's twelve months of the 2021 year, ev/EBITDA multiple was 28.9×, (Finbox.com 2024). The Amazon 2021 annual EBITDA was $59.312 bn (Macrotrend.com 2024); thereby, the hypothetical future market value of One Medical as a separate entity is forecast at 1.417 T One Medical is not yet profitable, and it operates a low-margin business. Therefore, the hypothetical future market value of One Medical as a separate entity is forecast by the ev/Revenue multiples. One Medical ev/Revenue in 2022 was 4.08× (Lee et al. 2022). The revenues of One Medical in 2021 was $623 million (Lee et al. 2022); thereby, One Medical's EV was USD 2.541 bn. Thereby, the sum of hypothetical future market values as separated entities working independently (strike price) was USD$ 1417 bn plus USD$ 2.05 bn, equaling USD$ 1419.1 bn.

Table 2. *Cont.*

Parameters of Financial Options	The Parameters of Real Options and Data
Stock volatility of Amazon within the first week after the announcement of the acquisition of One Medical (σ)	Amazon's historical volatilities within the first week after the announcement of the acquisition of One Medical on 27 July 2022 was 51% (V-Lab 2024).
Risk-free rate (r)	In 2022, the average rate for a three-month U.S. Treasury bill was 2.02 percent (Statista.com 2024).
Time to maturity (T)	One year following Dunis and Klein's (2005) recommendations.
Time increment (δt)	For a year, two-month time intervals were used to account for variations in the binominal lattice-based real options method's up and down factors.

Source: developed by the author.

Using Excel spreadsheets, the value of the competence-based synergies of One Medical's acquisition by Amazon.com in 2022 has been determined by employing BOPM, as seen in Figure 1.

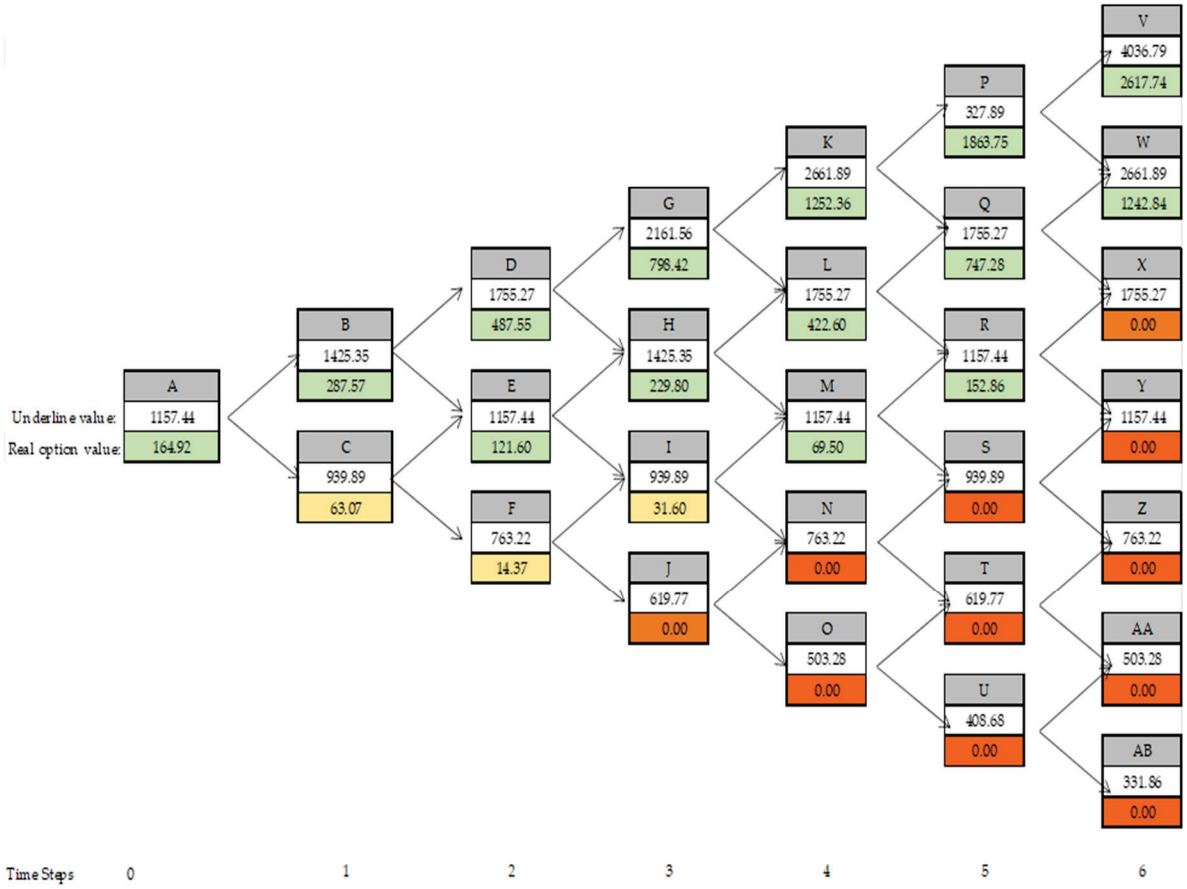

Figure 1. BOPM: underlining lattice: the value forecast of Amazon after the acquisition of One Medical (upper digits); and real options lattice: the value of Amazon strategic synergism (real options) of the acquisition of One Medical (lower digits) (in USD billion). Source: developed by the author.

Table 3. Real options binomial option pricing model parameters: Amazon.com acquisition of One Medical.

Parameters of the Binominal Tree	Numbers
Time increment (years) Δt	0.17
Up factor (u)	1.226
Down factor (d)	0.815
Risk-neutral probability (p)	0.457

Source: developed by the author.

As demonstrated in Figure 1, the binomial option pricing model (BOPM) offers a clear explanation and illustrates how M&A uncertainty, which is represented by implied volatility, affects option value over time. The acquisition of One Medical by Amazon.com has resulted in competence-based synergies valued at USD 164.92 billion.

As the next real option by following the methodological triangulation, the author employed the Black–Scholes option pricing model (BSOPM) as shown in Table 2. Parameters of BSOPM variables to value tacit competence-based synergies of Amazon and One Medical are given in Table 4.

Table 4. Parameters of the Black–Scholes option pricing model and the value of synergies: European call option value (Amazon's acquisition of One Medical, in US$ bn).

Option Variables	Data	Option Variables	Data
T=	1.0000	d_1=	−0.1050
S_0/K=	0.8156	$N(d_1)$=	0.4582
$\ln(S_0/K)$=	−0.2038	d_2=	−0.6150
variance/2=	0.1301	$N(d_2)$=	0.2693
[risk-free rate + variance/2] × T=	0.1503	−rT=	−0.0202
the square root of variance=	0.5100	e^{-rT}=	0.9800
the square root of T=	1.0000	$S_0 \times N(d_1)$=	530.31
(square root of variance) × (square root of T)=	0.5100	$K \times e^{-rT} \times N(d_2)$=	374.48
		Real option value: the value of tacit synergies, C=	155.84

Source: developed by the author.

Based on the BSOPM valuation results, Amazon.com would add market value through the acquisition of One Medical of around US$ 155.84 billion, as shown in Table 4.

Finally, the tacit synergetic result was generated by using a Monte Carlo simulation, where Excel forecasted the call option value for Amazon's acquisition of the One Medical case based on the real option parameters discussed above. The option life of one year was divided into six steps for binominal lattices, and the number of simulations was 100,000 times. The simulation results from a custom-made spreadsheet showed an average real option value of US$ 157.23 billion, which is quite close to the BSOPM result as given in Table 5.

Now, the result of the Monte Carlo pricing of the European call option can be collated with the results from a Black–Scholes option pricing model and binomial option pricing model. The call option is in the money if the market value of the merged entity exceeds the expected future market value of the two separate companies (Dunis and Klein 2005, p. 6). According to the BS-OPM, BOPM, and Monte Carlo results, Amazon.com would have added an increased market value of about $155.84–164.92 billion.

Table 5. Parameters of the Monto Carlo pricing of a European call option and data: measuring the value of a tacit synergy of Amazon.com's acquisition of One Medical, in US$ bn.

Option Variables	Data
The price of the underlying assets (So)	1157.44
The strike price (K)	1419.10
Time to maturity (T)	1
Volatility (σ)	51.00%
Risk-free rate (Rf)	2.02%
Number of steps	6
Number of simulations	100,000
Call option price (C) (the value of tacit synergy)=	157.23

Source: developed by the author.

Therefore, the expected market value of merging Amazon.com and One Medical was calculated as their market capitalizations after the announcement of the acquisition (So) of $1157.44 bn plus a tacit competence-based synergy of around $162.38 bn, equaling the theoretical market value of $1319.82 bn. As of 26 July 2023, Amazon's market capitalization

was 1322.0 billion (YChart 2022), which was approximately equal to the market value added predicted using a mean of the three real option values.

Thereby, the author has provided the answer to the second research question of how to measure a tacit competence-based synergism of M&A deal with the application of real options. Real options are incorporated into the synergy value to account for management flexibility resulting from mergers and acquisitions. In this vein, real options applications employing BSOPM, BOPM, and MCS methods can be used to quantify dynamically the tacit competence-based synergies in M&A deals.

While the binomial lattices approach is the most convenient, flexible, and intuitive in valuing real options, the BS-OPM and MCS approaches provide highly accurate and quick real options valuation results. Several scholars' studies have demonstrated that both the Monte Carlo simulation and the binomial models converge to the Black–Scholes option pricing value (Hon 2013). In this vein, the paper contributes to this conversation by justifying Hon's (2013) arguments with fresh empirical results.

Research does, however, also highlight the limitations of using real options to gauge the collaborative synergy of acquisitions of businesses. When multiple acquisitions occur in anticipation of the time of generating synergies of one concrete deal, whereas Amazon did effectively accomplish several deals in the same 2022 year, such as the acquisitions of iRobot in the UK, Cloostermans in Belgium, and Spirit.ai in the UK, it becomes challenging to justify the synergistic effect of a single isolated purchase agreement using real market capitalization. Yet, despite this limitation, the theoretical contribution and managerial implication of the paper are discussed in the next section.

5. Discussion and Contributions

Corporate foresight is a methodical and well-defined approach to a company's future (Fergnani 2022, p. 825). It guarantees chances to restructure an acquirer firm's core competencies by integrating the unique resources and dynamic capabilities of a target company (Čirjevskis 2023a), resulting in the creation of added value for the market. However, it can be highly challenging to put collaborative strategies' value-creating potential into practice (Bower 2001; King et al. 2004; Schweizer et al. 2022). In the most significant domains for future research on corporate foresight, Fergnani suggests the following path of mediation: corporate foresight > resource-based modifications > new business potential > performance (Fergnani 2022, p. 836).

This research offers a fresh theoretical and empirical contribution to the foresight of an explicit competence-based synergy in international collaborative ventures from the resource-based view and assesses a tacit competence-based synergy by using real options valuation. This is the paper's primary theoretical contribution. Additionally, the study adds several theoretical and managerial contributions to the fields of financial management and strategic management as follows:

5.1. The Theoretical Contribution

First, this paper contributed to the scientific recommendation of Fergnani (2022, p. 836) by operationalizing the following discourse on mediation paths of foresight: corporate foresight (collaborative strategies) → new business opportunities (employing VRIO analysis to explore VRIN resources and capabilities of collaborative business partners) → resource-based changes (exploring an explicit collaborative synergy with the ARCTIC framework) → performance (valuing a tacit collaborative synergy with real options). This mediation path can be useful in future quantitative research.

Second, by offering the ARCTIC framework as an expansion of the VRIO model (Barney and Hesterly 2015, this paper contributes to the field of corporate foresight research by enabling the prediction of an explicit competence-based synergy in collaborative ventures and the valuation of a tacit collaborative synergy using real options theory.

Third, by connecting financial management research on value-adding praxis with real options application and strategic management research on collaborative synergism with

the ARCTIC framework application, the paper thereby contributes to multidisciplinary research. Furthermore, by examining the case study of the One Medical acquisition by Amazon.com, this paper contributes to real options theory by examining whether the target's core competencies may impact an acquirer's core competencies in a synergistic way and by providing an example of the tacit strategic synergism measurement process with real options.

Fourth, the application of the ARCTIC framework to the deviant case study justifies that the framework fulfills its purpose and contributes to the pre-acquisition and post-acquisition examination of competence-based explicit synergies in M&A transactions, and this is the main theoretical and managerial contribution to the challenges of global M&A deals.

5.2. The Managerial Implication

The adoption of formal real option valuation models by practitioners appears to be lagging, even though the academic literature on real options has grown enormously over the past three decades (Lambrecht 2017, p. 166). The problem with most strategic decisions is that they are frequently made only based on qualitative information and strong intuition (Kyläheiko et al. 2002). At least in high-tech-based M&A transactions, it becomes possible to obtain more transparency into strategic decisions and make the results of competence-based synergies measurable with the use of pertinent quantitative information about merging companies and real options variables.

As such, this study contributes to both real options theory and the development of the ARCTIC framework by bridging them onto a new theoretical level and by providing a practical managerial example to support the theoretical proposition. The author used the real option application BSPOM, BOPM, and MCS methods as methodological triangulation, which can be easily understood by managers. While the binomial lattices approach is the most convenient, flexible, and intuitive in valuing real options, the BSOPM and Monto Carlo simulation (MCS) provide highly accurate and quick ROV results. However, BSOPM is impossible and MCS is quite hard to apply to American options (Čirjevskis 2021d).

Furthermore, the BOPM model serves as a "road map" and a tool for valuation. Thus, a clearer strategic observation of the reciprocal synergism of an M&A deal can be made by practitioners when valuing managerial tacit synergies employing real options in M&A deals and applying three real options methods. This is the current paper's main managerial implication.

When it comes to limitations, Lambrecht argues that real options valuation due to its complexity is not a particularly flexible valuation framework as managers cannot in advance identify the firm's real options but have to discover and exercise them as uncertainty unfolds (Lambrecht 2017, p. 168). In addition, Liu and Ronn argued that when the number of simulation paths is small and when the number of exercise opportunities is large, the Monte Carlo simulation will have poor performance (Liu and Ronn 2020, p. 3). The BOPM model provides a more favorable condition to be applied in strategic collaborative projects where the execution time could be at any time (Guo and Zhang 2020).

6. Conclusions

The application of the ARCTIC framework contributes to a resource-based view on strategy (Barney and Hesterly 2015) in the domestic and global contexts of collaborative ventures. This goes beyond the application of VRIO resources to the operations of an individual corporation in individual foreign countries (Kogut 1991; Ghemawat 2007). The six ARCTIC framework success factors—which allow one to anticipate explicit competence-based synergies of combined ventures—have been validated by several case studies research.

Furthermore, the ARCTIC framework assisted in anticipating the prerequisites needed for the Amazon and One Medical merger's explicit synergies, demonstrating how the collaborative partners could reciprocally forge an explicit competence-based synergy as a result of the complementarity (A, R), compatibilities (first C), and transferability (T, I,

and second C) of their core competencies. Hence, the ARCTIC framework's six success aspects facilitate an initial prediction of explicit competence-based synergies in co-operative arrangements, alliances, mergers, and acquisitions.

Moreover, the tacit competence-based synergy of this collaborative exchange was assessed through the application of different real options. Although scholarly literature on real options has expanded significantly over the past three decades, the adoption of formal real options valuation models by practitioners seems to be behind (Lambrecht 2017, p. 166). Regarding managerial contribution, practitioners can use the real options valuations to measure tacit competence-based synergies, and the first is lattices of BOPM that were presented in research as "a road map" to quantify merging firms' values and competence-based synergies in M&A transactions.

The problem with most strategic decisions is that they are frequently made only based on qualitative information and strong intuition (Kyläheiko et al. 2002). According to Kyläheiko et al. (2002), the real options method can result in a twofold improvement in strategic managerial practice: it foresees the corporate future and provides a quantified appraisal of strategic management decisions. Even though the literature on financial management has long included the "real option" viewpoint, Lambrecht (2017) argues that research on real options has only looked at a small number of strategic praxes. Lambrecht put forth the notion that perhaps more diverse industries and investment opportunities will be the focus of future real options research (Lambrecht 2017, p. 170). By offering a novel perspective on the state-of-the-art managerial practice of M&As that deals with the use of real options valuation, the author contributes to this scientific request in the current paper.

This paper also presents an avenue for future research to explore the role of dynamic capacities (Teece et al. 1997) in the strategic synergism generation in M&A deals in greater detail. Specifically, the dynamic capabilities (DC) view needs to be examined concerning the deployment of real options theory, making DC more measurable. Ultimately, real option valuation is both an art and a science since it blends business strategy and corporate finance (Lambrecht 2017).

More cross-disciplinary research on strategic foresight is needed, that can thus address and contribute to the influencing mechanisms of the synergistic impacts of M&A deals in detail and advance real options valuation perspectives to broader business and scholar societies. Several hypotheses might be developed from the provided proposition and proposed extended mediation paths (Fergnani 2022) for the novel empirical testing of an explicit and tacit collaborative synergies phenomenon with a larger sample size and quantitative research techniques.

Further research may explore and make contributions to associated issues about the prerequisites and governing mechanisms of the implicit synergistic impacts and real options application perspectives in this regard. Additionally, the paper offers a platform for future research that can further the empirical study of the tacit synergism of strategic collaboration with more complex real options applications techniques (e.g., sequential compound, with changing volatilities, and rainbow with multiple uncertainties) and deepen the scientific discussion on the issues raised.

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Navigating Financial Frontiers in the Tourism Economies of Kosovo and Albania during and beyond COVID-19

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Abstract: The problem addressed in this study is the profound impact of the COVID-19 pandemic on the tourism economies of Kosovo (KOS) and Albania (AL), which led to economic–financial stagnation and price increases. The aim was to analyze the financial frontier challenges facing the tourism industry during COVID-19 and beyond and propose effective strategies for shaping a sustainable future for countries within Europe with great potential for tourism development in the current decade. The survey was conducted in 102 locations, including cities, municipalities, regions, villages, and neighborhoods in both countries over the years 2020–2023, while data analysis was performed using a cluster analysis (K-means and hierarchical) and the multidimensional scaling method (Alscal). The results highlighted (a) the severe impact of COVID-19 on both the population and businesses in the tourism sector, which will persist beyond the pandemic, (b) the indispensable role of government intervention in alleviating the financial crisis, (c) the need for innovative approaches and accurate financial management by both the country and businesses to attract tourists, and (d) the importance of control and management for financial sustainability. This paper is of significant importance to tourism destinations as it provides insights into the severe impact of COVID-19 on both the population and businesses in the tourism economies. By highlighting the indispensable role of government intervention, the need for innovative approaches and accurate financial management, and the importance of control and management for financial sustainability, the study offers valuable guidance for tourism destinations in navigating the current crisis and attracting tourists. Furthermore, the paper emphasizes the need for future studies to explore opportunities for long-term financial resilience and growth, contributing to the development of sustainable tourism destinations.

Keywords: financial frontiers; tourism economies; COVID-19; financial econometrics; empirical studies

1. Introduction

COVID-19 brought a wide range of problems at various levels, as well as a number of challenges. Most countries' economic, financial, and social systems were disrupted, and it will be tough to assess short- and long-term consequences (Villacé-Molinero et al. 2021). The tourism and hospitality sector has been hit harder than any other industry, and the consequences will be felt well into the future (Dube et al. 2020). The fear of COVID-19 affected all industries, but the tourism industry was particularly shocked by the measures taken by all countries. The tourism industries in Albania and Kosovo, in particular, have been significantly affected by COVID-19, leading to a crisis due to their status as a significant contributor to their respective economies.

This study delves into the complex landscape of financial frontiers within the tourism sector and explores the profound impact of the pandemic on both nations. The capitals of Kosovo and Albania, as well as several other cities in the region, were under quarantine. As

a result, restaurants and non-essential retail stores were closed. This led to the suspension of flights and the closure of tourism and hospitality facilities. The tourism sector was severely impacted by COVID-19, making it one of the hardest-hit industries. In Albania and Kosovo, the 'lockdown' started on 13 March 2020, shutting tourism and hospitality businesses. The industry resulted in a loss of up to 50 billion dollars in spending and a decline in international tourist arrivals by up to 3% worldwide. The implementation of restrictions on passenger transportation to prevent close contact between travelers, including buses, trains, and airplanes, has hurt the sector (UNWTO 2020). Regarding navigating frontiers in the tourism economies of Kosovo according to Lulaj et al. (2022) it is emphasized that the lack of resources (staff, funds, infrastructure, tools, etc.) as well as the allocation of public expenditures to increase economies in the development of tourism should be right and according to priorities and funding (Lulaj 2021).

Researchers (Lin et al. 2022) have highlighted that economic and financial development leads to a change in the financial structure of countries and companies, in this case it is essential to understand that economic development involves a gradual shift from reliance on financial intermediaries to market-driven mechanisms. Meanwhile, Cagliesi and Guidi (2021) stated that the global financial crisis caused by COVID-19 has negatively impacted the level of integration of companies in the market. This transition has significant implications for the growth trajectories of tourism economies. Moreover, the findings of Agrawal et al. (2022) underscore the importance of minimizing operating costs in the context of financial frontiers. Furthermore, Zhang et al. (2015) showed that the use of dynamic models provides a better fit to empirical data compared to static models, especially concerning the financial frontiers relevant to the tourism economies of different countries.

Tang et al. (2024), on the other hand, highlighted the importance of monitoring real estate and stock market conditions to accelerate recovery from shocks during pandemic. Kohler et al. (2023) investigated external monetary vulnerability to global financial frontier uncertainty shocks from COVID-19 and their impact. However, Hsiao et al. (2023) found that the effects of financial acceleration of foreign business risk challenges on the domestic economy are insignificant. Finally, Xie et al. (2023) suggested that countries should move towards a development stage driven by innovation and governance based on accurate financial strategies after global financial frontiers.

Therefore, the novelty of this article compared to the previous literature lies in its comprehensive analysis of the financial frontiers faced by the tourism economies in the midst of the COVID-19 era and beyond. This study goes beyond mere analysis by conducting a comprehensive survey in 102 different locations, spanning various geographical areas in both countries. The objective is to assess the importance of tourism to the economies of Kosovo and Albania and its impact on their financial development. By unraveling the complex financial shocks faced by the tourism industry, this study aims to provide valuable insights and effective strategies for the recovery of tourism economies in these nations, which can be replicated in other countries with the same characteristics. The research questions addressed in this article include (1) What is the significance of tourism in the economies of Kosovo and Albania? (2) How has the tourism sector been affected by the COVID-19 pandemic? (3) What are the financial shocks and challenges faced by the tourism industry in these countries?

The research of the complex financial challenges faced by the tourism industry in Kosovo and Albania is a gap that should be reduced because understanding the financial frontiers and their impact on the tourism sector will improve the development of effective strategies and help foster a resilient and sustainable future for the industry in these countries. As this research unfolds, the primary goal is to dissect and illuminate a path towards sustainable financial frontiers for the tourism industry in Kosovo (KOS) and Albania (AL). The findings promise to provide critical insights that go beyond mere analysis and serve as a beacon for effective strategies in the recovery and future development of the tourism sector in these nations.

2. Literature Review and Developing Hypotheses

Tourism contributed approximately 8.5 percent (1.12 billion dollars) to Albania's GDP in 2017 and 9.3 percent to Kosovo's GDP in 2019, in this case Kosovo experienced a significant decline in foreign tourists, with a projected decline of 29%, much higher than the global decline of 3.99% recorded in 2009 (UNWTO 2020). The tourism industry in these countries, both of which have achieved high levels of human development, plays an important role in their GDP and enhances the well-being of their inhabitants. The pandemic disrupted Albania's positive economic trend, particularly affecting its financial statements, with 50% of revenues coming from Kosovo. The earthquake in 2019 and the subsequent impact of COVID-19 made 2020 one of the most challenging years for the economy and public finances in the last thirty years (Ministry of Finance 2023).

According to Eurostat, the tourism industry in the European Union is recovering strongly after COVID-19, with the first half of 2023 seeing the highest number of nights spent in tourist accommodation in the last decade. This is a positive indicator for the industry in many countries, with significant increases in overnight stays compared to previous years (Eurostat 2024).

Despite challenges, Albania's tourism industry is showing signs of recovery, with over 10 million tourists expected in 2023. In Kosovo, the economic situation improved in 2021 due to measures to support businesses and families, with around 5 million tourists in 2022, which had a positive impact on the country's finances (Ministry of Finance, Labour and Transfers 2024). Funding from various sources, including the Ministry of Culture, Youth and Sport (MCYS) and the Ministry of Agriculture Forestry and Rural Development (MAFRD), along with municipal support, is allocated for tourism development through cultural heritage. Funding and investment in innovative strategies are important in overcoming the impact of the COVID-19 pandemic on tourism destinations and in increasing financial stability (Lulaj et al. 2024). The relationship between tourism's financial statements and the economic development of Albania and Kosovo is significant. The impact of COVID-19 on the tourism industry in these countries poses challenges but also presents opportunities for sustainable development.

Tourism is a sector that is sensitive to local and national socio-economic development and relies heavily on energy use. Many studies have used stock price fluctuations to analyze the level of impact of different macroeconomic and non-macroeconomic forces on the tourism industry (Anguera-Torrell et al. 2021). Studies suggest that fluctuations in natural resource prices can have a negative impact on economic growth (Huang and Lei 2022). While limited prior literature directly addresses the impact of epidemics or pandemics on financial markets, lessons can be drawn from the experience of natural disasters (Goodell 2020). The main challenge lies in estimating the specific impact of COVID-19 on financial statements and its link to the tourism sector in Albania and Kosovo (Kapecki 2020). The tourism industries in these countries should position themselves as a unified destination to attract tourists and inspire new adventures (Matiza 2020).

As per Cardoso et al. (2021), the Swiss TL&HM-SR (Swiss Tourism, Leisure and Hospitality Management Scientific Research) performance indicator is a valuable tool for stakeholders looking to enhance sustainability performance through strategic destination management. In terms of financial development through tourism economies, Cardoso et al. (2020) highlight the significant role played by TLHM (Tourism, Leisure, and Hospitality Management).

According to Maehara et al. (2024), financing inclusion emerges as a pivotal and multifaceted concern that has garnered significant traction on the global stage in recent years. Regarding navigating frontiers in the tourism economies of Kosovo and Albania during and after COVID-19, according to Lulaj (2022), it is emphasized that there was a large increase in expenses, as well as to remove the consequences of the pandemic, countries (KOS and AL) must collect taxes to influence the growth of tourism, the economies, and financial development in general (Lulaj and Dragusha 2022). Ante and Saggu (2024) emphasize the strategic considerations essential for stakeholders to effectively plan, utilize,

and influence economic activities, thereby enhancing comprehension and optimization within a rapidly evolving economy.

Hence, by drawing on the literature of various authors, hypotheses can be formulated as important and valid. Then, the following hypothesis was formulated:

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H_0: *There is no significant difference between the observation groups in terms of navigating financial frontiers in the tourism economies of Kosovo and Albania during and beyond COVID-19*

$$\text{if } x^2 > x^2_{\alpha(r-1)\alpha(c-1)} - H_0 \text{ rejected}$$

$$\text{if } x^2 < x^2_{\alpha(r-1)\alpha(c-1)} - H_0 \text{ not rejected}$$

3. Materials and Methods

3.1. The Purpose of the Paper

The purpose of this paper is of particular importance, including important issues such as the impact of COVID-19 on financial frontiers and its consequences after COVID-19, and to look at the opportunities for the sustainability of the tourism industry through the indicators taken in this study. Thus, the main goal is to analyze the financial frontier shocks and challenges faced by the tourism industry during and beyond COVID-19 and to propose effective strategies. By pursuing these goals and utilizing the variables considered in the study, the formulated hypotheses will be confirmed through the analysis of the three groups (Gr1AL, Gr2KOS, and Gr3ALKOS) created using an econometric model.

3.2. Data Collection

The study was conducted in 102 locations, including cities, municipalities, regions, villages, and neighborhoods during the years 2020–2023 in Albania (AL) and Kosovo (KOS). Participants who were experts in the fields of economics, finance, and tourism willingly completed a questionnaire addressing navigating financial frontiers in the tourism economies during and beyond COVID-19 (KOS and AL). The questionnaire was conducted in two countries (AL and KOS). The questionnaire (Appendix A) was designed based on the studies referenced by the authors of this paper, utilizing Likert scales ranging from 1 (strongly disagree) to 5 (strongly agree).

Table 1 presents the description of the variables related to navigating financial frontiers in the tourism economies of Kosovo and Albania during and beyond COVID-19. The main factors F1 [(Effectiveness of inhibitory measures in preventing the spread of COVID (navigating financial frontiers in the tourism economies COVID-19 (KOS and AL)], and F2 [State support for tourism economies beyond COVID-19 in both countries] are highlighted beyond COVID-19 in both countries (KOS and AL) (the aspect of financial frontiers growth in KOS and AL beyond COVID-19)]. Ten variables (F1–10) were analyzed in the first factor (F1), while five variables were analyzed in the second factor (F2), which were explained in the introduction and literature review section, taking into account the contributions of different authors, while the contributions of other authors will be presented for each variable and research findings in the discussion section.

Table 1. Definition and description of the study variables.

Items	A. Effectiveness of Inhibitory Measures in Preventing the Spread of COVID-19 ((Navigating Financial Frontiers in the Tourism Economies during COVID-19 (KOS and AL)
F1.1	Collection of health information by tourists (ex. temperature control, COVID testing, etc.)
F1.2	International travel restrictions
F1.3	Restrictions on domestic and regional travel

Table 1. *Cont.*

F1.4	Mandatory quarantine for visitors
F1.5	Physical distance in travel and tourism
F1.6	Mandatory use of masks in travel and tourism
F1.7	Mandatory use of COVID-19 tracking applications
F1.8	Hygiene training for staff in travel and tourism
F1.9	Regular testing of workers' infection in travel and tourism
F1.10	Vaccination against COVID-19
	B. State support for tourism economies beyond COVID-19 in both countries (KOS and AL)-(the aspect of financial frontiers growth in KOS and AL beyond COVID-19)
F2.1	Financial support and stimulus packages to shape sustainability in the tourism industry
F2.2	Changes in tourism demand and consumer behavior through innovation and accurate financial management
F2.3	The impact of control and management on the financial sustainability of the tourism industry due to financial shocks and revenue loss
F2.4	Adaptation strategies for financial resilience in the tourism industry
F2.5	Investing in sustainable tourism practices for long-term financial growth and shaping sustainability

Source: Prepared by the authors.

3.3. Data Analysis

To test the hypothesis defined, two models were used: Cluster Analysis (K-means Cluster and Hierarchical Cluster) and Multidimensional Scaling Method (Multidimensional Scaling-Alscal), in conjunction with relevant tests appropriate for these analyses (e.g., Chi-Square, ANOVA, Friedman test, and Z-test).

The analysis has undergone several processes to ensure the model's validity. Using SPSS version 23.0 for Windows, certain factors were eliminated from the model. In this particular case, 15 variables (Table 1) were tested and categorized into three groups: Gr1 AL, Gr2 KOS, and Gr3ALKOS. Distances between groups and variables were measured for both countries. Group analysis, being a statistical method that involves multiple variables, classifies data based on their similarities (Hastie et al. 2009) according to the algorithms of the groups contributed by the authors (Yuan and Yang 2019), as well as according to maximum expectations (Ankerst et al. 1999). Returning to the idea of these econometric models (Steinhaus 1957). The term "K-means" was used for the first time by (MacQueen 1967). Jain, Duin, and Mao suggest trying some algorithms to gain the best possible understanding of the database (Lloyd 1982). Cluster analysis is efficient and effective if it includes as few groups as possible and should be statistically significant (Sig., 0.000). In this case, all the variables and the interviewers of Albania and the state of Kosovo were divided into three groups (k = 3). To calculate the distance between these groups, Euclidian distance was used

$$dE = \sqrt{\sum_i^k (c_i - x_i)^2} \quad (1)$$

where c_i represents the centroid (center) of the groups, x_i represents the data points of each group being compared (Gr1AL, Gr2KOS, and Gr3ALKOS), and (k) is the total number of dimensions of these groups (k = 3).

Euclidian Square distance was used for the model of financial frontiers for navigating challenges through tourism economies during and beyond COVID-19 (KOS and AL):

$$\mathrm{dE}^2 = \sum_{\mathrm{i}}^{\mathrm{k}} (\mathrm{c_i} - \mathrm{x_i})^2 \tag{2}$$

Therefore, in Equations (1) and (2), Ci represents the center of the groups, which are the variables and interviewers of Albania and Kosovo divided into three groups (Gr1AL, Gr2KOS, and Gr3ALKOS). Xi represents the comparison of these groups, and k represents the total dimensions of the groups.

Also, in K-means (Cluster analysis for shock effects), Manhattan distance was used:

$$\mathrm{dMht} = \sum_{\mathrm{i}}^{\mathrm{k}} \left| \mathrm{c_i} - \mathrm{x_i} \right| \tag{3}$$

or the maximum distance between the distribution of vectors for the shock effects on navigating financial frontiers through tourism economies in both countries (KOS and AL) during and beyond COVID-19. Therefore, Equation (3) uses the Manhattan distance, which is the maximum distance between the distribution of the vectors for the shock effects on the financial frontiers through the tourism economies in both countries (AL and KOS).

Equation (4) represents the minimization of the variance within groups (n = 3) through the K-means algorithm. $dMax_i$ represents the number of cases included in the cluster (k) for both countries AL and KOS, and the collection technique of (Gr1AL, Gr2KOS, and Gr3ALKOS) the groups is used for minimizing the variance.

$$\mathrm{dMax_i} = 1, .., \mathrm{k} = \sum\nolimits_{\mathrm{i}} |\mathrm{c_i} - \mathrm{x_i} \tag{4}$$

The algorithm (K-means) represents the minimization of quantities of variance within groups (n = 3) through the equation

$$\mathrm{E} = \sum_{\mathrm{i}}^{\mathrm{k}} \sum_{\mathrm{j}=1}^{\mathrm{ni}} \|\mathrm{X_{ij}} - \mathrm{C_i}\|^2 \tag{5}$$

ni is the number of cases included in the cluster (k AL and KOS) and $\sum_1^k ni = n$ is the collection technique of (Gr1AL, Gr2KOS, and Gr3ALKOS) groups for the minimization of variance (102R). Mathematically, the K-means analysis is a model that is estimated through maximum probabilities. The equation for shock research through tourism in financial frontiers for AL and KOS.

Equation (6) represents the equation for challenges research through tourism in financial frontiers for Albania and Kosovo. The data space has dimensions (d), and equation C helps minimize and solve the problem of challenges of the financial frontier for the three groups (Gr1AL, Gr2KOS, and Gr3ALKOS).

$$[\mathrm{x_1}, \mathrm{x_{2,}} \ldots . \mathrm{x_{n,}}] \in \mathrm{R^d} \tag{6}$$

where, (R^d) is the data space with dimensions (d). Equation

$$\mathrm{C} = [c, c_{2,} \ldots . c_{n,}] \in R^d \tag{7}$$

helps to minimize and solve the problem of shocks and challenges for the three groups (Gr1AL, Gr2KOS, and Gr3ALKOS)

$$\mathrm{E} = \sum_{\mathrm{i}=1}^{\mathrm{k}} \sum_{\mathrm{j}=1}^{\mathrm{n}} \mathrm{d}(\mathrm{C_i}, \mathrm{X_{ij}}) \tag{8}$$

is discreet distribution of financial frontiers $d\left(C_i, X_{ij}\right)$ in research,

$$E = \sum_{i=1}^{k} \int p(x) d\left(c_i X_{ij}\right) d_x \tag{9}$$

The abbreviations used in (9) are the continuous distribution in the model of financial frontiers, $p(x)$ is the function of probability density, and (d) is the function of the distance between cases of variables. While looking at the impact of the Stress test on the multidimensional measurement for navigating financial frontiers in the tourism economies during and beyond COVID-19, statistics z is used.

$$\text{Stress}_D(x_1, x_2, x_N) = \left(\sum_{i \neq j=1 \ldots N} \left(d_{ij} - \left\|x_i - x_j\right\|\right)^2 \right)^{\frac{1}{2}} \tag{10}$$

$$\text{Stress}_D(x_1, x_2, x_N) = \left(\frac{\Sigma_{ij}\left(\Sigma_{ij} - \left\|x_i - x_j\right\|\right)^2}{\Sigma_{i,j} d_{ij}^2} \right)^{\frac{1}{2}} \tag{11}$$

where, (p: d_{ij}^{0} and $-d_{ij}^{2}$) are the distance control exponents for navigating financial frontiers. The data were analyzed as highlighted above for three groups in (AL and KOS) looking at their impact on financial frontiers in both countries or denoted by (M) in which the function of distance is defined (d_{ij} = distance between cases and variables (i, y).

4. Results

In the results section of the study, the data were analyzed using two methods:

- Cluster analysis of navigating financial frontiers in the tourism economies of Kosovo and Albania during and beyond COVID-19

This analysis grouped the data based on similarities in the observed navigating financial frontiers in the context of tourism economies during and beyond COVID-19. The clusters were formed for two countries, Kosovo (KOS) and Albania (AL).

- Multidimensional measurement of navigating financial frontiers in the tourism economies of Kosovo and Albania during and beyond COVID-19

This analysis focused on measuring the navigating financial frontiers in the context of tourism economies during and beyond COVID-19 using a multidimensional approach.

4.1. Cluster Analysis of Navigating Financial Frontiers in the Tourism Economies of Kosovo and Albania during and beyond COVID-19

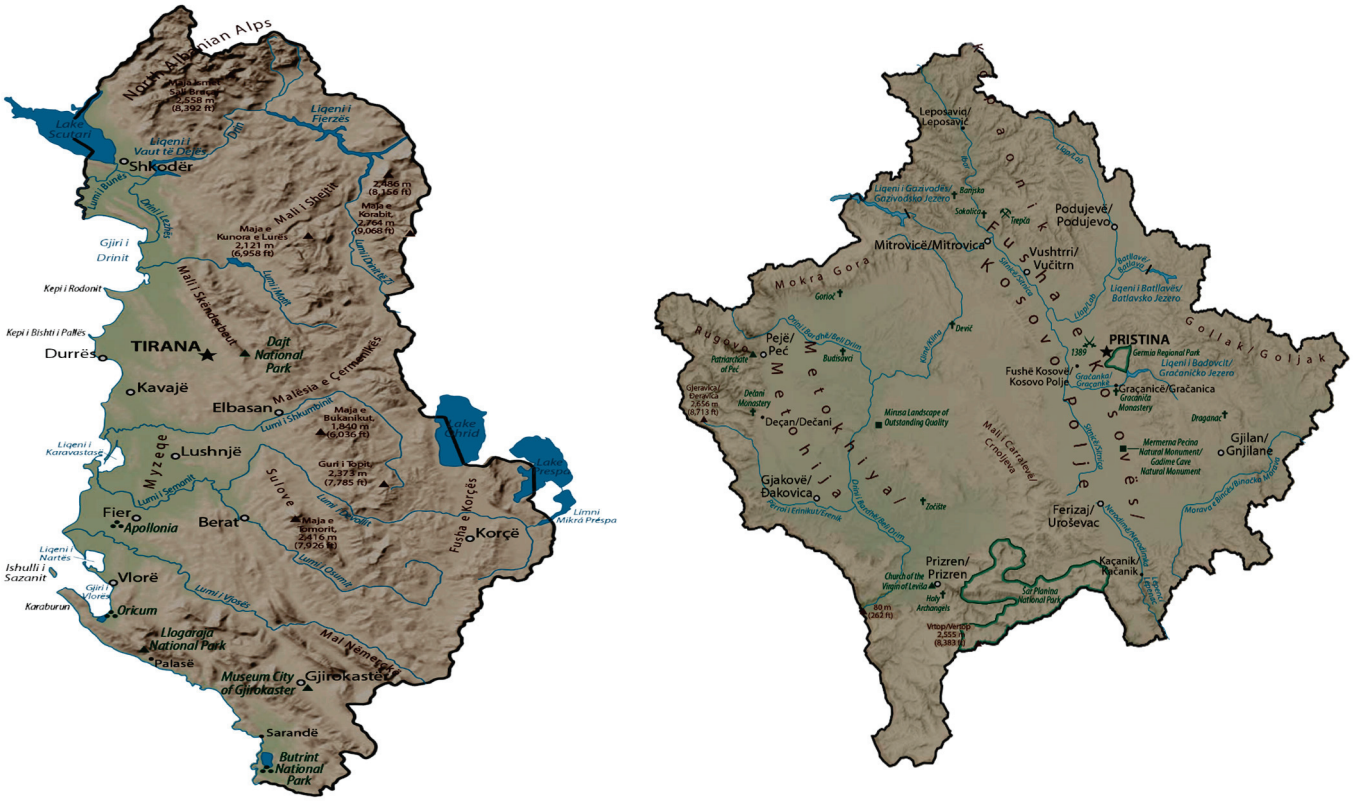
Table 2 Based on the results, the analysis was conducted in 102 locations, including cities, communes, regions, neighborhoods, municipalities, and villages, in two countries, Albania (AL) and Kosovo (KOS). The analysis aimed to examine the navigating financial frontiers of the tourism economies during and beyond COVID-19 in both countries (KOS and AL). The Euclidean squared distance and the Ward method were utilized in the analysis to assess these shocks and challenges.

Table 2. Case Processing summary of both factors (Factor I during the pandemic and Factor II—beyond the pandemic).

Case Processing Summary [a,b]					
Albanian/Kosovo					
Valid		Missing		Total	
N	Percent	N	Percent	N	Percent
102	100.0	0	0.0	102	100.0

Source: Prepared by the authors. Note: [a] Squared Euclidean Distance used, [b] Ward Linkage.

Figure 1 illustrates the maps of two countries, Albania (AL) and Kosovo (KOS), figuratively presenting the clustering of groups in 102 locations included in the research, as detailed in Table 1. Thus, Southeast European countries depend heavily on tourism, with Albania standing out due to its significant natural and cultural heritage. Blue tourism plays a pivotal role in Albania's GDP, capitalizing on diverse landscapes within a compact space, and Kosovo benefits from a favorable climate and abundant natural resources, establishing a robust foundation for tourism (Tase and Lulaj 2022). The cities as cluster groups where questionnaires were conducted encompass Tirana, Durres, Fier, Shkodra, Pristina, Peja, Prizeren, Gjakova, Klina, and Istog, covering urban centers, surrounding villages, districts, and neighborhoods.



(**a**) Albania (AL) (**b**) Kosovo (KOS)

Figure 1. Map for Cluster ((**a**) is Albania (AL) and (**b**) is Kosovo (KOS)). Source: Paper (Tase and Lulaj 2022).

Table 3 presents the final data of the groups navigating financial frontiers in the tourism economies of Kosovo and Albania during and beyond COVID-19 (KOS and AL). The analysis includes three observations across 10 variables for three groups of residents from Albania and Kosovo (AL and KOS). In variable (F1.1 = 4.40), Group 3 (Gr3) provided

the highest response, highlighting that the lack of information about tourists (e.g., COVID-19 tests) may result in financial shocks and challenges caused by an increase in COVID-19 cases among individuals who had contact, particularly within the hotel industry.

For variable (F1.2 = 4.09), Gr3 gave a higher response, emphasizing that restrictions on international travel have significantly impacted the financial development of Kosovo and Albania in terms of tourism and hospitality. Regarding variable (F1.3 = 4.14), Gr3 once again provided higher responses, emphasizing that both internal and regional restrictions have severely affected the financial frontiers during the pandemic, with lingering consequences even after its end. In relation to variable (F1.4 = 3.86), Gr3 had a higher response indicating that mandatory quarantine measures for visitors–tourists have deterred many tourists from visiting Kosovo and Albania, resulting in adverse effects on financial development and the hotel industry, with consequences extending beyond the pandemic.

As for variable (F1.5 = 4.16), Gr3 emphasizes that physical distancing measures in travel and tourism have saved lives by reducing virus transmission. However, this has also led to a decrease in the number of individuals visiting hotels, restaurants, cafes, shops, markets, etc., impacting financial development and carrying consequences even after the pandemic in both Albania and Kosovo. Regarding variable (F1.6 = 4.16), Gr3 highlights that the mandatory use of masks in travel and tourism has significantly limited people's movement except in emergencies. This has had negative implications for the economy and financial development, resulting in a reduced number of individuals affected by COVID-19 measures from both countries and carrying consequences even after the pandemic. Further, the variable (F1.7 = 4.00) emphasizes that the mandatory use of COVID-19 tracking applications has increased costs for the economies of both countries due to the procurement and provision of various materials (masks, gloves, medical and hygienic supplies) in institutions and the hotel industry.

Table 3. Final Cluster Centers for Albania (AL) and Kosovo (KOS) about Factor I during COVID-19 pandemic.

Final Cluster Centers			
Effectiveness of inhibitory measures in preventing the spread of COVID-19 (navigating financial frontiers in the tourism economies of Kosovo (KOS) and Albania (AL)			
Variables	Cluster		
	Gr1 AL	Gr2 KOS	Gr3 AL and KOS
F1.1—Collection of health information by tourists (e.g., temperature control, COVID testing, etc.)	3.62	3.27	4.40
F1.2—International travel restrictions	2.41	2.68	4.09
F1.3—Restrictions on domestic and regional travel	2.08	2.55	4.14
F1.4—Mandatory quarantine for visitors	2.32	2.50	3.86
F1.5—Physical distance in travel and tourism	3.59	2.50	4.16
F1.6—Mandatory use of masks in travel and tourism	3.68	2.41	4.16
F1.7—Mandatory use of COVID-19 tracking applications	3.22	2.09	4.00
F1.8—Hygiene training for staff in travel and tourism	4.19	3.55	4.37
F1.9—Regular testing of workers' infection in travel and tourism	4.08	3.00	4.44
F1.10—Vaccination against COVID-19	3.76	2.00	4.26

Source: Prepared by the authors.

Compliance with pandemic measures has incurred additional costs, carrying consequences even after the pandemic. For variable (F1.8 = 4.37), it is highlighted that both countries have invested in hygiene training for staff in travel and tourism to prevent COVID-19 transmission. Variable (F1.9 = 4.44) highlights that both countries have con-

ducted regular testing of workers in travel and tourism to prevent the spread of the virus. While it has prevented the virus from spreading, it has also caused shocks to the economy and financial development due to the measures implemented by governments, resulting in consequences even after the pandemic.

The variable (F1.10 = 4.26) underscores the importance of the COVID-19 vaccination in gradually reviving the economy and financial growth. The reopening of restaurants, hotels, and other tourism-related businesses has contributed to a gradual recovery of economic and financial development in both countries. During the COVID-19 period, the two variables that held significant importance were (F1.1 = Q1.9), namely collecting information on the countries most affected by COVID-19 and regular testing. Countries heavily impacted by the virus experienced extensive closures of businesses, including in the manufacturing and service sectors, leading to job losses and reduced tourist inflow. This adversely affected the countries' income and the welfare of their inhabitants and had a minor impact on economic and financial recovery due to testing costs and the provision of medical and hygiene supplies.

The hotel industry also suffered from compliance with government measures, further hindering recovery of the navigating financial frontiers in tourism economies of Kosovo (KOS) and Albania (AL) during and beyond COVID-19. Therefore, the analysis in Table 2 reveals significant findings regarding the financial frontiers for navigating financial frontiers through tourism economies during and beyond COVID-19 in both countries (KOS and AL). Group 3 (Gr3) consistently provided higher responses across various variables, indicating the profound impact of factors such as a lack of tourist information, travel restrictions, quarantine measures, physical distancing, mask usage, tracking applications, hygiene training, regular testing, and vaccination on the financial frontiers and shaping the sustainability of Albania and Kosovo. These findings highlight the complex interplay between the pandemic and the tourism sector, emphasizing the need for comprehensive strategies to address the challenges and ensure a sustainable recovery in the post-pandemic era.

In Table 4, the results of the ANOVA test reveal significant differences between the variables, indicating that the distribution of group observations during the COVID-19 pandemic is not random. The distances between the Final Cluster Centers indicate that the first group is positioned between the second and third groups. Additionally, the Friedman test statistics demonstrate a significant difference among the variables influencing financial shocks and challenges in the tourism industry of both Albania and Kosovo (AL and KOS). These findings reject the null hypothesis (H_0), confirming that there are differences between the three groups (Gr1AL, Gr2KOS, and Gr3ALKOS).

Table 4. Final Cluster Centers about Albania (AL) and Kosovo (KOS) for Factor I during the pandemic.

ANOVA Effectiveness of inhibitory measures in preventing the spread of COVID-19 (navigating financial frontier shocks through tourism during pandemic)							**Friedman**
Variables	Cluster		Error		F	Sig.	Test
	Mean Square	df	Mean Square	df			Mean ranks
F1.1	10.999	2	0.781	99	14.078	0.000	6.42
F1.2	31.752	2	0.680	99	46.694	0.000	4.57
F1.3	45.690	2	0.580	99	78.840	0.000	4.29
F1.4	27.110	2	0.836	99	32.425	0.000	4.00
F1.5	20.120	2	0.609	99	33.044	0.000	5.47
F1.6	22.513	2	0.902	99	24.963	0.000	5.83
F1.7	26.745	2	1.092	99	24.496	0.000	4.93
F1.8	5083	2	0.517	99	9833	0.000	6.98
F1.9	15.319	2	0.620	99	24.716	0.000	6.76
F1.10	37.855	2	0.939	99	40.298	0.000	5.74

Distances between Final Cluster Centers				Test Statistics–Friedman test	
Cluster	1	2	3	N	102
1		3030	3410	Chi-Square	158,065
2	3030		4998	df	9
3	3410	4998		Asymp. Sig.	0.000

Source: Prepared by the authors. if $x^2 < x^2_{\alpha(r-1)\alpha(c-1)}$—rejected H_o.

Table 5 presents the final data of the groups after the COVID-19 pandemic, focusing on the state support for tourism economies beyond COVID-19 in both countries (KOS and AL) and its effect on the aspect of financial frontiers growth. The analysis includes three observations across five variables in both Albania and Kosovo (AL and KOS) for all three groups (Gr1AL, Gr2KOS, and Gr3ALKOS). In the variable (F2.1 = 3.10), the highest response was given by Gr3, which emphasizes the importance of financial support and stimulus packages of the states (KOS and AL) to shape sustainability in the tourism industry due to the big shocks and challenges that hotels, restaurants and businesses in general in the tourism industry experienced during COVID-19, influencing the draw of tourists to tourist attractions to strengthen financial frontiers. Therefore, governments should consider measures to support financial growth through tourism. For the variable (F2.2 = 3.00), the highest response was given by Gr3, which emphasizes the importance of innovation and accurate financial management by the tourism industry and governments. This has a significant impact on economic growth and financial development through tourism because tourists want innovation to attract their attention to visit tourist attractions. In the variable (F2.3 = 4.50), Gr3 gave a higher response, emphasizing the impact of control and management on the financial stability of the tourism industry by countries and business managers due to financial shocks and loss of income. This plays a crucial role in stimulating post-pandemic economic growth and financial development while reducing the shocks experienced during the pandemic. In the variable (F2.4 = 3.00), Gr3 gave a higher response, emphasizing the importance of adaptation strategies for financial stability in the tourism industry for both countries. Therefore, the strategy of innovation in prices, technology, offers, and tourist attractions increases financial sustainability after COVID-19. In the variable (F2.5 = 4.93), Gr3 gave a higher response, emphasizing the importance of investing in valuable training practices for long-term financial growth and the formation of

compassion. Therefore, both businesses and governments in both countries should pay attention to this variable.

Table 5. Final Cluster Centers about Albania (AL) and Kosovo (KOS) for Factor II beyond COVID-19.

Final Cluster Centers State support for tourism economies beyond COVID-19 in both countries (KOS and AL)-(the aspect of financial frontiers growth in KOS and AL beyond COVID-19)			
Variables	Cluster		
	Gr1 AL	Gr2 KOS	Gr3 AL and KOS
F2.1—Financial support and stimulus packages to shape sustainability in the tourism industry	2.00	2.94	3.10
F2.2—Changes in tourism demand and consumer behavior through innovation and accurate financial management	3.00	3.86	4.00
F2.3—The impact of control and management on the financial sustainability of the tourism industry due to financial shocks and revenue loss	4.00	3.46	4.50
F2. 4—Adaptation strategies for financial resilience in the tourism industry	2.00	2.87	3.00
F2.5—Investing in sustainable tourism practices for long-term financial growth and shaping sustainability	3.30	3.72	4.93

Source: Prepared by the authors.

The analysis presented in Table 4 highlights the importance of key factors in the financial frontiers through tourism and the hotel industry after the COVID-19 pandemic. In summary, the analysis suggests that financial support, innovation, effective control and management, adaptation strategies, and investment in training practices are key factors in navigating financial frontiers through tourism economies and the hotel industry in the post-COVID-19 era.

Table 6 presents the results of the ANOVA test, demonstrating the significance of all data points and the normal differences between variables. However, the distribution of observations across groups is not random after the COVID-19 pandemic. Based on the distance between the Final Cluster Centers, the first group falls between the second and third groups. Additionally, the statistics from the Friedman test reveal a significant difference between the variables that impact financial frontiers through the tourism industry in both countries (Albania and Kosovo). These findings suggest a reduction in economic–financial shocks and challenges within tourism especially in the hotel industry. Consequently, the null hypothesis (H_0) is rejected, indicating a notable distinction among the three groups (Gr1AL, Gr2KOS, and Gr3ALKOS).

Table 6. Final Cluster Centers about Albania (AL) and Kosovo (KOS).

ANOVA State support for tourism economies beyond COVID-19 in both countries (KOS and AL)-(the aspect of financial frontiers growth in KOS and AL beyond COVID-19)							**Friedman**
Variables	Cluster		Error		F	Sig.	Test
	Mean Square	df	Mean Square	df			Mean ranks
F2.1	0.676	2	1399	99	0.483	0.000	1.61
F2.2	48.874	2	0.823	99	59.364	0.000	2.24
F2.3	8784	2	0.981	99	8956	0.000	2.15
F2.4	7164	2	0.847	99	8158	0.000	2.01
F2.5	7034	2	0.839	99	7903	0.000	1.19
Distances between Final Cluster Centers					Test Statistics–Friedman test		
N			102				
Chi-Square			38,486				
df			2				
Asymp. Sig.			0.000				

Source: Prepared by the authors. if $x^2 < x^2_{\alpha(r-1)\alpha(c-1)}$—rejected H_o.

4.2. Multidimensional Measurement of Navigating Financial Frontiers in the Tourism Economies of Kosovo and Albania during and beyond COVID-19

Table 7 shows that the repetition for k = 2 in both factors (F1 and F2) was stopped in the fourth iteration as the result reached a value of 0.001000 for both countries (Albania and Kosovo) across the three groups (Gr1AL, Gr2KOS, and Gr3ALKOS). Similarly, in the case of variables (items 1–13), the replication was stopped at 0.001000. The value of the stress matrix according to the Crucial formula was found to be 0.82108 for participants and 0.74054 for variables. These matrices explain 82% and 74% of the navigating financial frontiers in the tourism economies during and beyond COVID-19 in both countries (KOS and AL). The high percentages indicate that the data are reliable and can be used to make recommendations for Albania and Kosovo.

Table 7. MDS-Cluster analysis (F1 and F2 during and beyond COVID-19).

Iteration History for the 2-Dimensional Solution (in Squared Distances) Young's S-Stress Formula (1) Is Used (Variable-Cases)			**For Matrix**			**Interpretation**
Iteration	S-stress	Improvement	Iteration	S-stress	Improvement	Iterations stopped because S-stress improvement is less than 0.001000 Iteration history for the 2-dimensional solution (in squared distances) Young's S-stress Formula 1 is used (Variable–Variable)
1	0.34181		1	0.29545		
2	0.26762	0.07419	2	0.27490	0.02055	Iterations stopped because S-stress improvement is less than 0.001000
3	0.26109	0.00653	3	0.27008	0.00482	For matrix
4	0.26052	0.00057	4	0.26971	0.00037	Stress = 0.24086 RSQ = 0.74054

Source: Prepared by the authors.

Figure 2 illustrates the linear correspondence and coherent relationship between respondents and variables, providing a clear representation of the distances. This analysis facilitates the determination of navigating financial frontiers in the tourism economies in Albania and Kosovo during and after the COVID-19 pandemic based on the data recommendations in the respective tables for the three groups. Especially during COVID-19, there is a notable increase in the coefficients of financial frontiers in both countries (KOS

and AL). The cases (37, 79, 19, 58, 68, 96, 16, 70, 100, 49, 9, 50, 58, 24, and 21) indicate a significant impact on the population that persists beyond the pandemic. In particular, tourism enterprises (58th in Albania and 50th in Kosovo) have faced significant financial challenges that have affected economic development. The aftermath of COVID-19 shows an increase in the coefficients for financial development through tourism in both countries (cases: 18, 2, 66, 76, 28, 87, 33, 7, 1, and 41), suggesting a resurgence in the hotel industry and increased tourist demand. In particular, Albanian Tourism Enterprise No. 53 and Kosovo Tourism Enterprise No. 86 show positive economic and financial development, signaling recovery and a promising future for tourism in the region. These findings underscore the critical role of control, management, and sustainable practices in shaping financial stability, strategies, and investments. Policymakers and stakeholders can use these findings to make informed decisions and implement measures to mitigate negative impacts and improve the financial performance of the tourism industry in both countries.

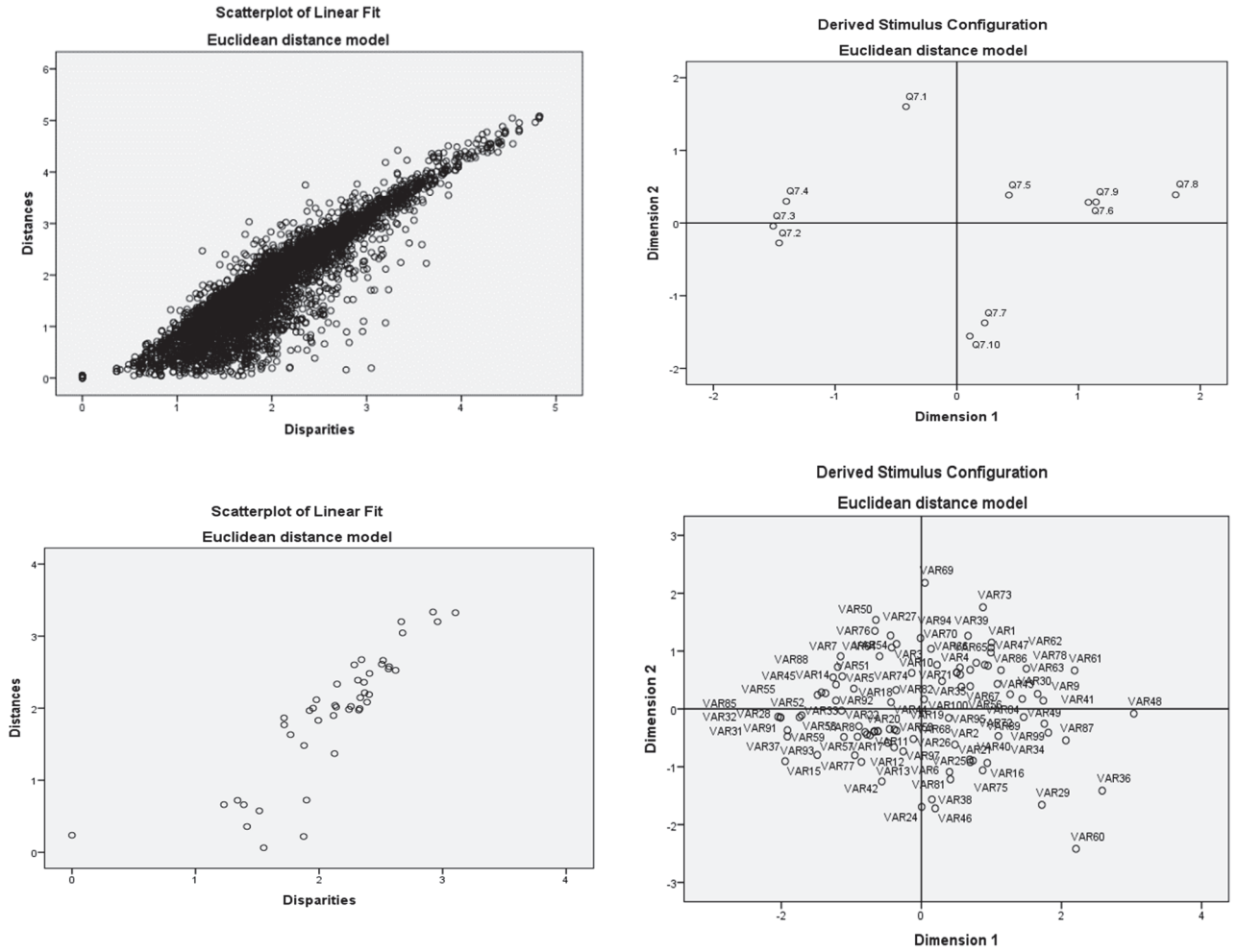


Figure 2. Euclidean distance—between respondents and variables.

5. Discussion

The discussion section aims to highlight the connection between the findings of other authors and the research conducted in this study. By examining and synthesizing the existing literature, this section provides valuable insights into the broader context of navigating financial frontiers in the tourism economies of Kosovo (KOS) and Albania (AL) during and beyond COVID-19. According to Lulaj (2023), it is emphasized that having an economic development and financial frontiers through a sustainable profit of businesses, the behavior of employees and staff, the faster handling of requests, business support before and after the purchase, the provision of informative applications (discounts, usage, term expiration date, product content, payment methods, and the delivery of business-to-consumer shipping, as well as attention should be paid to the improvement of technology, total liabilities, total assets, financial income, etc. in terms of navigating financial frontiers (Lulaj et al. 2023).

In the context of tourism (Buultjens et al. 2017), industry resilience refers to an industry's ability to overcome self-inflicted disasters and crises, effectively maintaining stability, flexibility, and diversity and promoting innovation and development. It is seen as a comprehensive program involving the participation of all sectors of society and the economy, directly or indirectly. In this case, the decrease in the number of tourists and their expenditures led to the crisis of activity of Albanian hotels. Based on the data from the Institute of Statistics (INSTAT) in Albania, there was a significant decrease of about 63% in the activity level of the tourism sector during the closure period. According to Wikipedia (2024), despite facing various challenges at different stages of development, Kosovo's tourism industry is aligning with the overall growth of the country's economy. Positioned in the heart of the Balkan Peninsula as a potential tourist hotspot, Kosovo is a crucial area that can contribute to the advancement of tourism in the region and Europe.

Drawing on the findings and perspectives of other researchers, this discussion section enriches the understanding of the financial frontiers that need to be navigated and the strategies that can shape a sustainable future for the tourism sector. Meanwhile, the findings of this research are discussed, adding value to the importance of financial frontiers for navigating financial frontiers through tourism economies during and beyond COVID-19 in both countries (KOS and AL). The analysis involved 102 participants from various locations in Albania and Kosovo, investigating financial frontiers for navigating financial frontiers through tourism economies during and beyond COVID-19. Using Euclidean squared distance and the Ward method, the final data demonstrates observations across 15 variables for three resident groups (Gr1AL, Gr2KOS, and Gr3ALKOS). Notably, Group 3 consistently provided higher responses, emphasizing the profound impact of factors like the lack of tourist information, travel restrictions, quarantine measures, and hygienic practices on the financial frontiers of Albania and Kosovo.

Specifically, Group 3 highlighted the consequences of limited information for tourists (F1.1) and referred to the negative effects of international travel restrictions (F1.2) and both internal and regional restrictions (F1.3). Quarantine measures for visitors (F1.4) and physical distancing (F1.5) were associated with reduced tourism activity and with implications for financial development. Mandatory use of masks (F1.6) was seen as restricting freedom of movement and negatively affecting the economy. The use of COVID-19 tracking apps (F1.7) resulted in additional costs, and hygiene training (F1.8) and regular testing of workers (F1.9) caused shock but were aimed at preventing the spread of the virus. Vaccination (F1.10) was highlighted as critical to economic recovery. The ANOVA test revealed significant differences between variables, rejecting the null hypothesis and supporting differences between groups (Gr1AL, Gr2KOS, and Gr3ALKOS). Friedman test statistics further confirmed differences in variables influencing financial shocks and challenges, highlighting the non-random distribution of group observations during the pandemic. Cluster analysis results showed that Group 1 was positioned between Groups 2 and 3, suggesting distinct patterns in their responses. The results showed that there was a significant increase in the coefficients representing financial shocks within the tourism economies in both

Albania and Kosovo during the COVID-19 period. The highlighted cases (37, 79, 19, 58, 68, 96, 16, 70, 100, 49, 9, 50, 58, 24, and 21) underscore the substantial impact of COVID-19 on the populations of these countries, leading to lasting post-pandemic consequences. In particular, tourism businesses in Albania (indicated by No. 58) and Kosovo (indicated by No. 50) have experienced significant financial shocks and challenges, resulting in closures or reduced operations and a decline in tourist visits. Given the economic dependence on tourism in both countries—Albania for its coastal tourism and Kosovo for its mountain tourism—these shocks have had a negative impact on the overall economy, affecting the financial sustainability of tourism.

Moving on to the results presented, this analysis focused on government support for sustainability through tourism beyond COVID-19 in both countries (KOS and AL). Group 3 (Gr3) consistently provided the highest responses across various variables (F2.1 to F2.5), emphasizing the importance of financial support, innovation, effective control and management, adaptation strategies, and investment in training practices. These factors emerged as critical elements in shaping the financial sustainability of the tourism and hospitality industry in the post-COVID-19 era. The ANOVA test and Friedman's test further supported the significance of these findings, rejecting the null hypothesis and confirming the differences between the three groups (Gr1AL, Gr2KOS, and Gr3ALKOS). Moving forward, there was a notable increase in the coefficients indicating financial development through tourism in both countries (Albania and Kosovo) in Factor II after the COVID-19 pandemic. This positive trend is observed in different phases, indicating a resumption of hotel operations and an increasing demand for tourists. In particular, specific tourism enterprises in Albania (No. 53) and Kosovo (No. 86) showed a gradual economic and financial development, characterized by an increase in the number of employees and visitors. These positive trends indicate the contribution of effective control and management, strategic initiatives, and sustainable investments in recovering from the negative effects of the COVID-19 pandemic.

The multidimensional scaling (MDS) analysis, as presented, further enhances the reliability of our findings. The high percentages explained by the stress matrix (82% for participants and 74% for variables) indicate the robustness of the data and support the reliability of our recommendations. The demonstrated linear consistency and coherent relationship provide insights into the characteristics of both countries (Albania and Kosovo) regarding financial shocks and challenges through tourism economies during and after the pandemic. These insights, derived from the data, provide valuable information for policymakers and stakeholders to make informed decisions and implement measures to mitigate the negative impacts and improve the financial resilience of the tourism industry in Albania and Kosovo.

6. Conclusions

This study conducted a comprehensive analysis of the financial frontier shocks and challenges faced by the tourism industry in Kosovo and Albania during and beyond COVID-19. Covering 102 diverse locations through a comprehensive survey, the study illuminated the significance of tourism to their economies, outlined the resulting financial shocks, and aimed to contribute effective strategies for recovery and sustainable future development. Addressing the key research questions, the findings confirmed the importance of tourism to the economies of Kosovo and Albania. The study highlighted the profound impact of the COVID-19 pandemic on the tourism economies, identified the financial shocks and challenges faced by the tourism industries, and proposed strategies for fostering resilience and sustainability.

Supported by ANOVA and Friedman tests, the hypotheses were rejected, highlighting significant differences among observation groups and underlining the importance of understanding financial frontiers through tourism economies. Analysis of the 102 locations revealed challenges such as a lack of tourist information, travel restrictions, and quarantine measures, all significantly impacting the financial frontiers. Notably, financial challenges increased during the pandemic, leading to closures and reduced operations. Government

support emerged as a crucial factor for sustainability beyond COVID-19, emphasizing financial aid, innovation, effective management, adaptation strategies, and training.

In the variable (F2.3 = 4.50), Gr3 gave a higher response, emphasizing the impact of control and management on the financial stability of the tourism economies by countries and business managers due to financial challenges and loss of income. This plays a crucial role in stimulating post-pandemic economic growth and financial development while reducing the shocks experienced during the pandemic. In the variable (F2.4 = 3.00), Gr3 gave a higher response, emphasizing the importance of adaptation strategies for financial stability in the tourism industry for both countries. Therefore, the strategy of innovation in prices, technology, offers, and tourist attractions increases financial sustainability after COVID-19.

The study also highlighted the negative impact of a lack of information about tourists and the restrictions on international travel. These factors have adversely affected the economy, financial development, and the hotel industry. Additionally, internal and regional restrictions during the pandemic have had lingering consequences, even after its end. The mandatory quarantine measures for visitors have deterred many tourists from visiting Albania and Kosovo, further impacting the economy. While measures such as physical distancing, mask usage, and tracking applications have been crucial for curbing the spread of the virus, they have had negative implications for the economy and financial development.

Recommendations for policymakers and stakeholders included improving tourist information, implementing effective control and management practices, promoting innovation and adaptation, providing financial support, encouraging sustainable investment, and strengthening cooperation between Albania and Kosovo. Continuous monitoring and evaluation of implemented measures were deemed essential for future adaptability, and future research should explore the long-term effects on financial frontiers, make targeted decisions to promote tourism and financial growth, and contribute to a deeper understanding of evolving dynamics within the tourism sector. These insights would be invaluable for informed decision-making and actions to mitigate negative impacts and enhance the financial frontiers of the tourism industry in Kosovo and Albania.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and ethical review and approval were waived for this study, for the reason that this study was conducted individually and independently by the institution where they work, respecting the anonymity of the interviewer.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data used to support and prove the findings of this study are available from the corresponding author upon request.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A. Scales Survey

Effectiveness of Inhibitory Measures in Preventing the Spread of COVID-19 ((Navigating Financial Frontiers in the Tourism Economies during COVID-19 (KOS and AL).

Items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Collection of health information by tourists (e.g., temperature control, COVID testing, etc.)					
International travel restrictions					
Restrictions on domestic and regional travel					
Mandatory quarantine for visitors					
Physical distance in travel and tourism					
Mandatory use of masks in travel and tourism					
Mandatory use of COVID-19 tracking applications					
Hygiene training for staff in travel and tourism					
Regular testing of workers' infection in travel and tourism					
Vaccination against COVID-19					

State support for tourism economies beyond COVID-19 in both countries (KOS and AL)- (the aspect of financial frontiers growth in KOS and AL beyond COVID-19)

Items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Financial support and stimulus packages to shape sustainability in the tourism industry					
Changes in tourism demand and consumer behavior through innovation and accurate financial management					
The impact of control and management on the financial sustainability of the tourism industry due to financial shocks and revenue loss					
Adaptation strategies for financial resilience in the tourism industry					
Investing in sustainable tourism practices for long-term financial growth and shaping sustainability					

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Transmission of Inflation and Exchange Rate Effects: The Markov Switching Vector Autoregressive Methodology

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Abstract: The aim of this study is to delve into the intricate the mechanism through which alterations in currency exchange rates give rise to shifts in inflation rates, while taking into careful consideration the country's economic cycle. In order to accomplish this objective, we used a dataset that spanned from 1 January 1999 to 1 July 2023, focusing our analytical lens on three specific geographic areas, namely the Eurozone, the United Kingdom, and Canada. In our pursuit of understanding this complex relationship, we employed the Markov Switching Vector Autoregressive model. Our research outcomes can be succinctly encapsulated as follows: in the initial stages, particularly during phases characterized by robust economic growth, the transmission of exchange rate effects onto inflation levels appeared to exhibit a partial impact across all geographic areas under examination. However, during periods marked by economic downturns, both the United Kingdom and Canada displayed a distinctly more comprehensive transmission of these effects. Moreover, the prevailing projections for the forthcoming time horizon, across all the countries encompassed by our study, strongly indicate the onset of an expansionary phase that is projected to extend over a span of 25 months. Lastly, concerning the implications of unexpected disturbances or shocks, it is noteworthy that the response of exchange rates to inflation induced shocks was neither immediate nor as pronounced as the corresponding reaction of inflation to sudden shifts in exchange rates.

Keywords: inflation; exchange rate; exchange rate pass-through; Markov Switching Vector Autoregressive

1. Introduction

Crafting an effective monetary policy has perpetually captivated the attention of policy makers, economists, and market participants. In essence, short-term economic policy revolves around two primary aims: the mitigation of inflation, entailing upholding price stability at a level conducive to the regular operation of the economy, or the attainment of full employment, often quantified as potential output. The selection of the most fitting monetary policy hinges on the pursued objective. In this context, an array of factors must be carefully considered when establishing the monetary policy framework, with the interest rate taking center preoccupation.

In accordance with findings by Thornton (2014), the level of control that monetary authorities possess over the interest rate is significantly overemphasized. In this research, he underscored the role of money growth in managing price levels. This sentiment was echoed by Végh (2001), who not only demonstrated the potential to achieve low inflation rates through interest rate regulations but also through adhering to monetary growth guidelines.

In addition to overseeing interest rates and money growth, policymakers must react with substantial economic uncertainty when formulating monetary policies. Consequently, comprehending the repercussions of uncertain monetary policies on economic activity and macroeconomic variables becomes paramount. Nonetheless, this issue is intricate and challenging due to the inherent complexities. Uncertainty, being an underlying factor, proves

arduous to quantify as an input within empirical models. Furthermore, the correlation between monetary policy uncertainty and the policy itself exists alongside other factors, such as the business cycle, which poses considerable estimation challenges. In the present scenario, matters of monetary policy contribute to consistent discoveries regarding the impacts of monetary policy uncertainty, which are universally recognized. This uncertainty is noted for its adverse influence on economic activity. A study by Creal and Wu (2017) delving into the relationship between monetary policy uncertainty, its transmission mechanisms, and economic volatility revealed a negative correlation between uncertainty and economic activity.

Another factor elucidating the transmission of uncertainty shocks to other nations is the exchange rate. Indeed, it assumes a pivotal role in the economy and exerts its influence through three primary channels. Firstly, in terms of production, currency appreciation tends to suppress inflation. This occurs because the cost of imported goods does not escalate as swiftly as the currency's value, thereby curbing overall price levels. Furthermore, this phenomenon diminishes real gross domestic product due to shifts in expenditure patterns. Secondly, fluctuations in the exchange rate impact investment and consumption, integral components of aggregate demand. The depreciation of the exchange rate diminishes net wealth, consequently leading to reduced consumption. Finally, currency depreciation can amplify the value of external financial obligations. In summary, variations in the exchange rate wield significant effects on prices, investments, and general economic stability, particularly in the context of expanding international trade. Hence, for the effective formulation of monetary policy, comprehending the degree to which the exchange rate influences prices is imperative, a phenomenon known as the exchange rate pass-through.

An extensive and growing body of literature has significantly contributed to enhancing comprehension of exchange rate pass-through, employing diverse methodologies. In fact, a consensus exists that pass-through diminishes along the pricing chain; in simpler terms, a currency increase in one country results in a price level increase in another country, albeit not in direct proportion. Nevertheless, the precise influence of exchange rate variations on inflation stays ambiguous. Numerous studies have acknowledged the intricate character of the exchange rate pass-through phenomenon. Early research attributed the incomplete transmission of exchange rate fluctuations to prices to microeconomic factors. In this regard, Krugman (1987) and Dornbusch (1987) emphasized the role of the pricing to market strategy in elucidating this phenomenon. Others have directed their attention towards macroeconomic factors like the extent of trade openness to expound on pass-through dynamics. However, a more recent line of inquiry, spearheaded by Shambaugh (2008) and Forbes et al. (2018), employs a structural Vector Autoregressive model (SVAR) to demonstrate that the exchange rate pass-through is contingent on the type of exogenous shock driving the exchange rate fluctuations.

In light of this backdrop, the present research aims to elucidate the connectedness amongst exchange rates and inflation from a distinctive perspective. It seeks to explore this relationship while factoring in the phases of an economic cycle. The focus is primarily on discerning the degree of exchange rate pass-through during the expansion phase, characterized by heightened production and inflation, and the recession phase, marked by low economic activity and inflation. To achieve this objective, a Markov Switching Vector Autoregressive model was employed.

In particular, the objective of this study is deeply rooted in a more nuanced understanding of the relationship between exchange rates and inflation, taking into account cyclical fluctuations in the economy. By focusing on expansionary and recessionary phases, the study aims to determine how exchange rates influence inflation in different economic contexts. During expansions, characterized by high output and high inflation, the exchange rate transmission mechanisms may differ from those observed during recessions, when economic activity is weak, and inflation is moderate or even falling. By examining these relationships across these different contexts, the study seeks to capture the nuances of the transmission of exchange rate shocks. To achieve this objective, the study adopted a

rigorous methodological approach using a Markov regime-switching vector autoregression model. This model makes it possible to capture transitions between different economic phases and to analyze how the relationship between exchange rates and inflation evolves in these different settings. The underlying ambition of this approach is to provide new and deeper insights into how exchange rate fluctuations affect the economy as a whole, by shedding light on the underlying mechanisms that modulate this complex relationship according to economic conditions. Ultimately, this deeper analysis should contribute to a better understanding of economic and monetary policies in a dynamic and ever-changing global context.

The structure of this document is as follows: It begins with a preliminary section outlining essential study components—such as inflation, the exchange rate, and shocks. This is followed by an initial theoretical section that delves into the exchange rate pass-through phenomenon, encompassing its various facets and the proposed theoretical model, alongside alternative models within the same framework. Subsequently, a practical section is presented wherein the model is applied to the selected countries: the Eurozone, the United Kingdom, and Canada. Finally, the study concludes with summarizing remarks.

2. Literature Review

An extensive body of literature has meticulously examined the pass-through phenomenon, primarily in developed nations but also in developing countries. These analyses have employed diverse methodologies and consistently revealed that the sensitivity to exchange rate fluctuations wanes along the pricing chain. In this context, Jamar and Aimon (2021) affirmed that the transmission of exchange rate movements affects price stability through various channels. This impact is direct, involving import prices for commodities such as oil and consumer goods, as well as indirect, encompassing wage formation, profit markups, foreign direct investment, and more. The pass-through mechanism unfolds across two distinct stages. Initially, exchange rate depreciation leads to an escalation in imported prices, causing imported inputs and finished products to become more costly. This phenomenon is known as the first stage pass-through. Conversely, the indirect effects, which take more time to permeate the economy, manifest through alterations in production costs and real channels. Within the production channel, the depreciation of the exchange rate amplifies production expenses due to the increased cost of imported goods. This, in turn, prompts higher producer prices, subsequently resulting in higher consumer prices. Domestic firms adjust their pricing behavior to maintain constant mark-ups and profits, thereby generating inflation on consumer prices. This sequence is referred to as the second-stage pass-through. In terms of the real channels, exchange rate depreciation elevates import prices in the local currency and reduces export prices denominated in foreign currency. This dynamic stimulates net exports and sustains gross domestic product (GDP) growth. As the real GDP growth gains momentum, it fuels heightened labor demand and increased wages, consequently exerting pressure on consumer prices.

Furthermore, Valogo et al. (2023) asserted that the persistent devaluation of Ghana's currency had sparked concerns about its potential consequences not only for inflation but also for the broader economic landscape. Their study delved deeply into the nuanced effects associated with the threshold concept of exchange rate pass-through on patterns of inflation. Their investigation delved into the critical importance of the exchange rate threshold, particularly within the context of the Taylor principle. To uncover these dynamics, they employed the approach of autoregression as their methodological framework. The outcomes revealed a noteworthy insight: a decline in the exchange rate that surpassed the monthly threshold of 0.70% manifested a conspicuously positive and momentous impact on inflationary trends. This finding strongly substantiated the significance of this particular threshold level in the analysis. The outcomes also extended to their model of the monetary policy rule, where they uncovered a significant and advantageous influence of the exchange rate on the monetary policy rate. This underscored the intricate relationship between exchange rate movements and monetary policy dynamics. In light of

these findings, they suggested that incorporating careful considerations of the exchange rate within the broader policy framework can function as a proactive measure against the exchange rate depreciation crossing the optimal threshold. By adopting this approach, the potential inflationary impacts triggered by exchange rate fluctuations can be effectively mitigated. Moreover, Anderl and Caporale (2023) embarked on an in-depth exploration into the intricate dynamics governing the transmission of exchange rates to consumer and import prices. The study focused on a comparative analysis of five countries that adhered to inflation targeting (the United Kingdom, Canada, Australia, New Zealand, and Sweden) and three countries that diverged from this approach (the United States, the Euroarea, and Switzerland). The findings pointed to a more pronounced and intricate influence of exchange rate pass-through on both consumer and import prices within the context of the nonlinear framework. In certain instances, this influence even appeared to approach full pass-through. Importantly, this effect was particularly potent during the second regime, characterized by high levels of inflation expectations within both market participants and consumers. This significant insight underscored the potential of anchoring inflation expectations as a strategy for mitigating the impacts of exchange rate pass-through. In addition, the study revealed an intriguing trend: the connection between inflation expectations and exchange rate pass-through seemed to hold greater weight in countries that had adopted measures centered around inflation targeting which underscores the potential benefits of explicit inflation targeting practices.

Adding to that, Mirza et al. (2023) explored the worldwide surge in global energy costs, which poses a significant obstacle to central banks across the globe in their pursuit of achieving stable price levels. In an effort to tackle this challenge, they assessed the viability of sustaining price stability through a focus on inflation rates, particularly when confronted with the influence of exchange rate dynamics and energy price shocks. They employed the non-linear autoregressive distributive lag (NARDL) model. The results validated that currency devaluation led to a sustained increase in domestic prices, whereas currency appreciation contributed to their alleviation. Moreover, the research established that elevated energy expenses led to heightened inflationary pressures within economies that emphasize controlling inflation.

Regarding this aspect, a study conducted by Chroufa and Chtourou (2023) engaged in a thorough exploration of the intricate and asymmetric interplay between currency exchange rates and inflation in Tunisia. They used the multi-threshold non-linear autoregressive distributed lag model (MTNARDL). Additionally, a quantile Granger causality analysis was employed to delve into the nuanced causal relationships between fluctuations in exchange rates and variations in inflation. The empirical findings unveiled a multifaceted influence of currency exchange rates on inflation, which exhibited distinct characteristics over both extended and shorter timeframes. Notably, the estimated coefficients of exchange rate changes displayed significant variations across different quantiles. They affirmed that this indicated that alterations in inflation respond in varying ways depending on the magnitude of fluctuations observed in the currency exchange rate. Moreover, the examination of causality across different quantiles offered compelling insights. It revealed a unidirectional causal link from shifts in inflation to movements in the currency exchange rate. This confirmation of a reciprocal effect at higher quantiles underscored the intricate dynamics at play, where changes in inflation can exert a notable influence on the behavior of currency exchange rates. In the work by Gereziher and Nuru (2023), the objective was to explore the imbalanced repercussions stemming from shifts in the exchange rate, impacting inflation within the context of a small open economy, specifically South Africa. The methodology adopted encompassed a threshold Vector Autoregressive model, which accommodated the alteration of parameters based on whether a designated threshold variable surpassed an established threshold value. The determination of the threshold value was intrinsically governed by the Hansen (1996) test. To scrutinize the implications of exchange rate shocks on inflation contingent upon their magnitude, direction, and synchronization with the inflation cycle, the authors made use of generalized impulse responses, as introduced by

Koop et al. (1996). Additionally, they employed a Cholesky decomposition identification scheme within the framework of the non-linear model to identify and characterize exchange rate shocks. The obtained findings underlined the existence of a nonlinear influence attributed to exchange rate shocks on inflation. Specifically, the enduring consequences of exchange rate shocks, whether positive (appreciation) or negative (depreciation), spanning one or two standard deviations, manifest as relatively minor over the long term. However, these effects were somewhat more pronounced within the sphere of elevated inflation compared to instances of low inflation.

In the context of the Southern African Development Community (SADC), Olamide et al. (2022) affirmed that the dynamics among exchange rate volatility, inflation, and economic growth have sustained their prominence in economic discourse due to historical background and the close grouping of economies within the region. Nevertheless, a significant knowledge gap exists concerning the intricate interplay, synergy, or interchangeability of exchange rate instability and inflation's impacts on the economic growth trajectory within SADC nations. To achieve their objective, Pooled Mean Group (PMG), Generalised Moments (GM), Dynamic Fixed Effect (DFE), and the Generalized AutoRegressive Conditional Heteroskedasticity (GARCH) model were employed. The research outcomes brought to light that a negative correlation exists between exchange rate instability, inflation, and the economic growth of the region. Moreover, the results affirmed that heightened levels of exchange rate instability amplified the detrimental relationship between inflation and growth in the region. This corroborated that as inflation rates escalated, the swifter the impact of exchange rate pass-through manifested. Based on these findings, it was strongly advocated that member nations prioritize policies geared towards fostering the appreciation of local currencies to better address these issues. Also, El Aboudi et al. (2023) delved into the intricate relationship between exchange rate and inflation metrics and their ramifications on overall macroeconomic performance. The objective revolved around assessing the repercussions stemming from the interplay between the exchange rate and inflation on the trajectory of economic growth within the context of Morocco. To achieve it, they adopted an autoregressive distributed lag model (ARDL). The conclusions confirmed that in the short term, the interaction between the exchange rate and inflation, commonly referred to as the pass-through effect, exerts a notable and significant influence on the trajectory of economic growth, particularly when considering the lagged impact in the realm of first differences. However, the long-term perspective presents a distinct pattern, suggesting that sustainable economic growth might not necessarily hinge upon the confluence of both exchange rate dynamics and inflationary forces.

Similarly, Citci and Kaya (2023) examined the relationship between the volatility of exchange rates and the presence of inflationary pressures. They introduced a risk premium that was passed on to consumers through amplified price levels. This pricing strategy established a conduit through which fluctuations in exchange rate uncertainty reverberate throughout the broader realm of price dynamics. The empirical estimations showed that the degree of uncertainty associated with exchange rates exerted a statistically significant and positive impact on inflationary tendencies, but this effect was characterized by nonlinearity. As the level of exchange rate uncertainty escalated, the magnitude of its influence on inflation gradually diminished. Furthermore, Sari et al. (2023) utilized the Vector Autoregressive (VAR) impulse response model to gauge the extent of. Within the framework of pandemic-induced conditions, this research employed consumer price index (CPI) and the wholesale trade price index (WPI) as the dependent variables, juxtaposed with the exchange rate serving as the independent variable. Results implied that the exchange rate pass-through's impact on both the CPI and WPI exhibited incompleteness, implying that the escalation in the price level or inflation was not as pronounced or directly proportional to fluctuations in the exchange rate.

Moreover, Gereziher and Nuru (2023) conducted a thorough investigation on the asymmetric repercussions of exchange rate shocks on inflation dynamics utilizing a threshold Vector Autoregressive model. The analysis employed generalized impulse responses

and Cholesky decomposition to examine the magnitude, direction, and temporal alignment of exchange rate shocks with the inflationary cycle. Results indicated a nuanced, nonlinear impact of exchange rate shocks on inflation, with lasting effects being relatively muted over extended periods, particularly within lower inflationary environments. Notably, Peer and Baig (2023) studied the interplay between the pursuit of inflation targeting (IT) and the transmission of fluctuations in exchange rates onto consumer prices, commonly denoted as exchange rate pass-through (ERPT). The central emphasis resided in extracting invaluable insights to illuminate the strategies of nations that are in the process of adopting IT, coupled with a concerted effort to quantify ERPT in the specific context of India. Results approved the necessity for monetary policy to shift towards future trajectories of inflation, accentuating the significance of harmonizing monetary and fiscal policy actions. The results additionally uncovered a noticeable downtrend in the magnitude of ERPT during the period characterized by the enforcement of IT measures.

In connection with this, Masoudi et al. (2023) delved into a pivotal intersection between exchange rates and inflation that exerted a dual-fold impact. The study took on the responsibility of dissecting the causal interconnection between inflation and exchange rates, delving deep into the intricacies across different frequencies and temporal scales. They employed the discrete wavelet transform. The outcomes provided thought-provoking revelations, uncovering that over the long term, the causal linkages stemmed from inflation to the exchange rate. This significant finding underscored that relying solely on exchange rate stabilization is an inadequate strategy for taming the pressures of inflation. Moreover, the study conducted by Sheferaw and Sitotaw (2023) had, as an objective, the exploration of the extent to which exchange rate pass-through (ERPT) influences local price levels. To undertake this, a structural Vector Autoregressive (SVAR) analysis was employed. The findings uncovered that a unitary alteration in the nominal effective exchange rate, indicating appreciation, corresponded to a decline of 0.059 in consumer prices within a one-year timeframe. This underscored the significance of ERPT's effect on domestic inflation in Ethiopia. Furthermore, the study delved into the intricate dynamics through the lens of impulse response and variance decomposition analyses. These explorations shed light on the fact that government expenditure plays a role, and the impact of international energy prices further amplifies the influence on domestic prices.

In addition, Jambaldorj (2023) provided tangible empirical insights into the complex interaction between inflation targeting and the pass-through mechanism stemming from fluctuations in exchange rates that influence consumer prices. The primary aim of the study was to estimate a vector-autoregressive model while examining the impulse responses related to consumer prices in response to exchange rate shocks. As a result of empirical investigation, in the pre-inflation targeting period, a distinct pass-through effect was observable, wherein changes in the exchange rate directly impacted consumer prices. However, a significant shift occurred during the post-inflation targeting era. The empirical scrutiny revealed a dampening of the pass-through effect during this phase. The author confirmed that attenuation could be attributed to the inherent mechanics of the forward-looking monetary policy framework adopted within inflation targeting regime. This framework acts as a mechanism for shaping the expectations of domestic economic agents. He explained that these agents are less prone to altering prices in response to exchange rate shocks.

In the current post-COVID-19 and geopolitical turmoil, central banks face the task of addressing heightened inflation. In this context, Alexius and Holmberg (2023) employed Bayesian VAR modeling to scrutinize pass-through effects for understanding inflation dynamics. Their analysis unveiled that those pass-through effects amplified with exchange rate volatility. The connection between pass-through and domestic price shocks followed an expected pattern, strengthening with shock scale and persistence. Results showed that exchange rate shock persistence correlates with heightened pass-through effects, particularly in low inflation scenarios. Notably, the study identified an asymmetry in the impact of inflation persistence on pass-through, with appreciations having a stronger link than de-

preciations. Equally important, Cakir and Kaya (2023) explored the evolution of exchange rate pass-through effects on consumer prices in Turkey. Using the time-varying Granger causality test, they analyzed the relationships between the U.S. dollar, Euro currency basket, and the consumer price index (CPI). The findings revealed a distinct downward trajectory in the impact of exchange rate pass-through effects on both the CPI and consumer spending categories. They explained that this shift was attributed to Turkey's economic structure, featuring a floating exchange rate and an inflation-targeting regime.

In conjunction with, Solórzano (2023) studied the exchange rate pass-through dynamics in Mexico, focusing on regional and product-specific attributes. Using CPI micro-data, the research revealed notable variations in pass-through rates across regions and industries. Specifically, low pass-through regions exhibited one-quarter of the elasticity compared to high pass-through counterparts over 12 months, persisting over extended periods. The findings attributed these differences to factors like demand dynamics, economic development, proximity to the U.S. border, import intensity, price fluctuation dispersion, and expenditure allocation. Market density emerged as a tempering factor. Additionally, Iliyasu and Sanusi's (2022) study investigated the impact of announced exchange rate policies on pass-through effects in Nigeria. Using a structural VAR model, the research revealed a significant reduction in the pass-through effect when exchange rate interventions were pre-announced and anticipated. The pass-through rate transitions indicated an incomplete and gradual nature of pass-through in Nigeria. The study suggested that well-communicated exchange rate depreciation can strategically mitigate inflationary costs compared to sudden depreciation. The authors concluded that an effective communication strategy by central banks have the potential to reduce the cascading impact of exchange rate fluctuations on consumer prices, providing nuanced insights for policy actions in Nigeria.

In addition to this, Ozdogan's (2022) investigated exchange rate pass-through (ERPT) in Turkey, focusing on the completeness of ERPT and its evolution post the 2001 flexible exchange rate regime. Utilizing Vector Auto Regression, this study unveiled two key findings: incomplete ERPT in Turkey with distinct patterns, and a notable decrease in pass through post-2001, followed by a surge after 2017 due to factors like high inflation and exchange rate volatility. Further, Nguyen Hong et al. (2022) focused on Vietnam's pursuit of price stability. They employed ARDL and NARDL methodologies to scrutinize exchange rate pass-through dynamics. Their study unveiled the substantial impact of exchange rates and money supply on the CPI, emphasizing a successful shift to a central-rate mechanism. Delving deeper, asymmetries in exchange rate dynamics were revealed through the NARDL model, adding complexity to Vietnam's economic landscape. The study concluded by offering actionable policy implications, providing policymakers with informed strategies for managing exchange rates, inflation, and economic stability in Vietnam.

Moreover, Ndou's (2022) study explored the impact of South Africa's adoption of a flexible inflation-targeting framework in 2000, accompanied by an official inflation target band of 3–6%. The analysis, conducted using a regime-dependent VAR modeling framework, revealed a transformative effect on exchange rate pass-through (ERPT) dynamics. Within the 3–6% target band, the ERPT coefficient was halved compared to scenarios exceeding the 6% threshold, emphasizing a significant structural shift induced by the inflation target band. This insight has far-reaching implications for inflation forecasting and policy decisions, offering a nuanced understanding to enhance the effectiveness of monetary policymaking. In essence, Ndou's study contributed valuable insights that resonate in the realm of policy formulation, informed by a nuanced comprehension of ERPT dynamics within the South African economic landscape. In a similar fashion, Fandamu et al. (2023) explored asymmetric exchange rate pass-through (ERPT) in Zambia, focusing on consumer price inflation. Using a structural Vector Autoregressive model, the study spanned from 1985 to 2017, revealing incomplete and asymmetric ERPT dynamics. Notably, kwacha depreciation had a more pronounced impact on consumer prices than appreciation. Temporal analyses showed that depreciation shocks persisted longer and contributed more to variance in inflation than appreciation shocks. It has confirmed that these findings hold

even when considering external factors like commodity price booms, emphasizing the robust nature of the asymmetries.

In addition, Tiamiyu (2022) investigated exchange rate pass-through and its impact on inflation in Nigeria. Using various analytical tools, including ADF and unit root tests, cointegration tests, and NARDL methodologies, the research revealed short-term relationships and incorporates asymmetric effects in the exchange rate dynamics. The findings highlighted declining but substantial estimates of exchange rate pass-through, emphasizing the nuanced impact of positive and negative changes. The study identified the industrial production index as a key factor influencing inflation, suggesting a need for government focus on productive sectors. Furthermore, Hüseyin and Kutlu's (2022) investigated the pass-through mechanism of exchange rate fluctuations onto Turkey's domestic prices. Using the SVAR model, the study explored the complex interplay between exchange rate fluctuations, producer price index, and consumer price index, focusing on cumulative exchange rate pass-through (ERPT) elasticities. The findings revealed an incomplete ERPT within Turkey, emphasizing the nuanced translation of exchange rate fluctuations into domestic prices. Importantly, the study uncovered variations in ERPT across economic variables, with a higher impact on producer prices compared to consumer prices. Additionally, the research challenged conventional notions about the role of the central bank's policy interest rate in influencing exchange rates and prices, emphasizing the multifaceted nature of these interactions. The study concluded with pragmatic policy recommendations, advocating for central bank policies characterized by stability and reliability to foster a more resilient economic environment.

Notably, Pham et al. (2022) conducted a comprehensive study on exchange rate pass-through effects (ERPT) onto consumer prices in Vietnam. Using a structural Vector Autoregressive (SVAR) approach, the research unveiled Vietnam's unique ERPT dynamics, surpassing those of both emerging and developed economies. The results affirmed that high and volatile inflation, coupled with an open economic landscape and the exchange rate regime, contributed to this heightened ERPT degree. The study delved into the interplay between ERPT, inflation levels, and volatility across different sectors, emphasizing the nuanced dynamics shaped by sectoral attributes. Namely, the focus on a single country revealed that observed differences were more likely industry-specific, enriching our understanding of ERPT dynamics and highlighting the importance of sectoral nuances.

3. Hypothesis Development

The relationship between the exchange rate and the inflation rate is essential in economic and monetary analysis. A common assumption is that exchange rate fluctuations can have a significant impact on a country's inflation rate. This assumption is based on the concept of the transmission of exchange rate variations to the prices of goods and services, often referred to as exchange rate pass-through.

When the exchange rate of a currency depreciates, imported products become more expensive in domestic currency, resulting in an increase in the price of imported goods. This increase in the price of imported goods can spread throughout the economy, in turn affecting the prices of locally produced goods and services. This first stage of exchange rate pass-through, where changes in the exchange rate translate directly into rapid adjustments in the prices of imported goods, contributes to rising inflation.

Then, there is the second stage pass-through, which occurs more indirectly. The depreciation of the exchange rate can increase the production costs of local companies, due to the higher prices of imported inputs. These higher production costs can encourage companies to increase their selling prices to maintain their profit margins, which leads to a further increase in the price of goods and services on the domestic market. This rise in prices, in turn, can contribute to inflation in the longer term.

Consequently, there is a close link between exchange rate fluctuations and changes in the inflation rate. Exchange rate movements can directly influence the prices of imported goods and indirectly influence local production costs, both of which contribute to the

evolution of inflation in a given economy. An accurate understanding of this relationship is crucial to the formulation of effective monetary policies aimed at maintaining price stability and promoting economic growth.

4. Methodology

With the aim of comprehend the intricate exchange rate pass-through (ERPH) phenomenon, researchers have engaged a diverse array of models. Among these, Özyurt (2016) and Goldberg and Campa (2010) have chosen to employ single equation time series models. Conversely, Comunale and Kunovac (2017) and Forbes et al. (2018) have embraced the vector auto regression (VAR) methodology. Ben Cheikh and Rault (2017) adopted a dynamic panel approach, utilizing the generalized method of moments estimation.

In our study, our aim was to illuminate the repercussions of exchange rate pass-through on inflation, with a specific emphasis on the fluctuations of a country's business cycle. However, to obtain a more comprehensive perspective and consider the complexity of global economic interconnections, we also wished to introduce the concept of connectedness or interconnection. To accomplish this, we opted to employ a Markov Switching Vector Autoregressive (MS-VAR) model for several compelling reasons.

Indeed, the Markov switching Vector Autoregressive (MS-VAR) model introduces a nonlinear multivariate framework wherein certain parameters are allowed to dynamically shift over time and in accordance with specific states, while other parameters remain steadfastly regime-invariant. This unique property bestows upon the model the capability to perform efficient coefficient estimation even amid periods of regime transitions. Nevertheless, traditional VAR models often grapple with challenges rooted in macroeconomic condition uncertainties. For instance, when a severe financial or debt crisis emerges while an economic system is still recovering from a prior crisis, levels of uncertainty can escalate to a degree where conventional VAR models falter in their effectiveness. Here, the Markov model emerges as a potent solution, addressing the intricacies of stochastic factors and skillfully pinpointing the probabilities associated with transitioning the system from one regime to another. Appreciating these distinctive attributes, the MS-VAR models have found versatile application across a spectrum of domains. In this context, Bessac et al. (2016) leveraged the MS-VAR model to characterize wind regimes within meteorological time series, while Monbet and Ailliot (2017) employed it to delineate fluctuations in daily mean temperature patterns.

Moreover, these models have assumed significant roles within econometric time series analyses. For example, Papadamou and Markopoulos (2018) harnessed the MS-VAR to unveil the intricate transmission mechanism of a positive shock within the EONIA index to Greek banks' retail rates, a process that necessitated an evaluation of its stochastic factors. In a different context, Aimer and Lusta (2021) utilized the MS-VAR model to dissect the repercussions of the U.S. economic policy uncertainty index and oil price fluctuations on the dollar exchange rate, utilizing monthly data from January 2006 to August 2020. Adding to that, Shahrestani and Rafei (2020) adopted the MS-VAR model with dual regimes to explore the influence of global oil price shocks on the Tehran Stock Exchange. His investigation revealed varying intercepts, coefficients, and variances within each regime. The matrices that depict transition probabilities offer insight into the persistence of both states, indicating that shocks evoke both positive and negative effects on the Tehran Stock Exchange within the respective first and second regimes.

In this context, the Markov Switching Vector Autoregressive (MS-VAR) model can be elucidated as an amalgamation of concepts. Essentially, it is a type of Hidden Markov model where the structure is composed of two distinct components: the observable variables modeled through Vector Auto Regressive (VAR) processes, and the hidden component representing the number of states, which conforms to a first-order Markov chain. In this context, Hamilton (2010) introduced the concept of the Markov switching method. This theory posits that economic systems display diverse characteristics across different

states, and these distinctions are often reflected in the parameters of economic models. Consequently, the relationships between variables may alter in response to various shocks.

Therefore, Krolzig (1998) combined the traditional Vector Autoregressive (VAR) model with the Markov switching approach, giving rise to the Markov Switching-Vector Autoregressive model. Unlike the conventional VAR model, this novel iteration effectively captures the repercussions of changes in macroeconomic factors induced by distinct shocks. The fundamental premise based on the notion that the vector of observable time series relies on an unobservable state. To simplify, within each regime denoted as S_t, the time series vector Y_t is engendered by a VAR process involving a certain number of lags (p).

Consequently, the MS-VAR model enables the inclusion of dynamic shifts within an economy's behavior by acknowledging multiple states, each marked by a different set of parameters in the VAR process. This innovation affords the model the capability to accurately capture the intricate interplay between variables even as the underlying economic conditions undergo shifts. This is especially relevant in cases where economic systems experience changes in response to exogenous shocks, which can start a transition between different states characterized by distinct relationships between variables. The MS-VAR model, with its Hidden Markov structure, empowers researchers to distinguish the complex interdependencies that unfold within dynamic economic systems, making it a powerful tool for unraveling the multifaceted dynamics of economic phenomena.

The MS-VAR model is a Hidden Markov model where the observable variables' model is the vector auto regressive per sate. We distinguish the two components of the MS-VAR model: The first component Y_t describes the evaluation of the observable variables. The second component S_t describes the number of states. It is a hidden component that takes a value between {1, ..., M} and models a first-order Markov chain. The model is given as follows:

$$Y_t = \begin{cases} \beta_{01} + \beta_{11} Y_{t-1} + \cdots + \beta_{p1} Y_{t-p} + A_1 \varepsilon_t & \text{if } S_t = 1 \\ \vdots & \\ \beta_{0M} + \beta_{1M} Y_{t-1} + \cdots + \beta_{pM} Y_{t-p} + A_M \varepsilon_t & \text{if } S_t = M \end{cases} \quad (1)$$

where A is a regime dependent matrix.

As mentioned earlier, a defining attribute of the MS-VAR framework lies in its adaptability across variables. This flexibility arises from the fact that certain parameters are subject to regime-specific variations while others remain consistent. Specifically, within the VAR framework, which encompasses three key parameters—the intercept (or mean), the variance, and the autoregressive coefficient—we discern several notable extensions within the MS-VAR model.

Introduced by Krolzig (1998), this concept involves a distinct approach. The essentials of this idea reside in the fact that solely the intercept of each regression undergoes alterations across the various states, while the autoregressive coefficients and variance remain constant across all states. To elucidate further, the intercept, representing the starting point or baseline level of the relationship between variables, can exhibit shifts in response to changes in economic regimes. This acknowledges that different states or economic conditions might yield different starting points for the relationships between variables. However, the autoregressive coefficients, which capture the relationship between a variable's current value and its past values, as well as the variance, reflecting the dispersion of data points around the mean, remain stable and unaffected by changes in states. In particular, for this idea, only the intercept of each regression varies across the M sates, while the autoregressive coefficients and the variance are constant above all states.

As a matter of fact, this structure offers a nuanced understanding of how different facets of economic relationships are influenced by shifts in regimes. By permitting regime specific intercept adjustments while keeping the autoregressive coefficients and variance constant, the MS-VAR model effectively captures the intricate dynamics of variables under changing economic circumstances. This concept finds resonance in economic reality, where certain relationships between variables might be more sensitive to regime shifts, while

others remain relatively stable. Ultimately, this adaptability within the MS-VAR structure enhances its capacity to unravel the complex interplay of variables across diverse economic states. The model is described as follows:

$$Y_t = \begin{cases} \beta_{01} + \sum_{i=1}^{p} \beta_i Y_{t-i} + A\varepsilon_t & \text{if } S_t = 1 \\ \vdots \\ \beta_{0M} + \sum_{i=1}^{p} \beta_i Y_{t-i} + A\varepsilon_t & \text{if } S_t = M \end{cases} \tag{2}$$

Illustrating the applicability of the Markov Switching Intercept Vector Autoregressive model (MSI-VAR) framework, Wai et al. (2013) employed it to discern the seamless progression of stock index fluctuations, shifting from recessionary phases to periods of growth. Using the MSI-VAR model, they delved into the dynamic shifts within stock indices, capturing the underlying mechanisms that facilitate the transition between economic states marked by downturns and those characterized by expansion.

In a more contemporary context, Lebari and Didi (2021) embarked on a study that delved into the intricate nexus between international trade and macroeconomic stability in Nigeria, adopting the MSI-VAR model as a robust analytical tool. He endeavored to unravel the interplay between international trade dynamics and the overall macroeconomic equilibrium of Nigeria. Through the application of the MSI-VAR models, Lebari and Didi (2021) scrutinized the transitions between various states of economic stability and trade interdependence, offering insights into the nuanced relationship between these two critical elements.

Fundamentally, the MSI-VAR model's distinctive feature lies in its capacity to accommodate regime-specific fluctuations in the variance-covariance matrix, while maintaining other parameters as constants across all regimes. In essence, this means that while the magnitudes and relationships between variables might change under different economic states, certain structural aspects remain unaltered. This mechanism ensures that the model can effectively capture shifts in the dispersion of data points around the mean, reflecting changes in the underlying volatility of the system.

By allowing the variance-covariance matrix to vary according to different regimes, the MSI-VAR model incorporates the changing nature of data distributions and relationships under varying economic conditions. This modeling approach acknowledges that the dynamics of certain variables might display distinct patterns during economic transitions, necessitating a nuanced treatment of the underlying covariance structure. Such flexibility enhances the MSI-VAR's capability to uncover the complex interactions and transitional dynamics within economic systems, shedding light on how variables respond to shifts from one state to another. The model is described as follows:

$$Y_t = \begin{cases} \beta_0 + \sum_{i=1}^{p} \beta_i Y_{t-i} + A_1\varepsilon_t & \text{if } S_t = 1 \\ \vdots \\ \beta_0 + \sum_{i=1}^{p} \beta_i Y_{t-i} + A_M\varepsilon_t & \text{if } S_t = M \end{cases} \tag{3}$$
$$\varepsilon_t \sim N(0, \sigma^2)$$

Within the framework of the model, a distinctive feature emerges: the variance within each state exhibits differentiation from the variances present in other states. Each state's variance, denoted as ${\sigma_i}^2$, is capable of undergoing variations across different economic regimes. However, two key parameters, namely the intercept β_0 and the autoregressive coefficient β_i, remain consistent across all these regimes. This characteristic maintains the structural foundation of the model while allowing for dynamic changes that are reflective of real-world economic transitions.

Lanne et al. (2010) illustrated the model's utility. By leveraging this modeling approach, they endeavored to uncover and identify the sources of structural shocks within the economy. In essence, the model functions as a powerful tool for untangling the intricate web of underlying factors that lead to shifts in economic conditions, offering insights into the fundamental drivers behind fluctuations and transitions.

A unique variant of this model is one where all parameters are permitted to undergo changes across states. In simpler terms, each state is characterized by distinct autoregressive coefficients, resulting in differing means and variances. This parameter variation across states captures the dynamic nature of economic transitions, where different states are associated with varying relationships between variables and fluctuations in magnitudes. This adaptable modeling structure enables researchers to delve into the intricate details of economic shifts, effectively painting a comprehensive picture of how different facets of an economy evolve across changing conditions. The model is described as follows:

$$Y_t = \begin{cases} \beta_{01} + \sum_{i=1}^{p} \beta_i Y_{t-i} + A\varepsilon_t & \text{if } S_t = 1 \\ \vdots & \\ \beta_{0M} + \sum_{i=1}^{p} \beta_i Y_{t-i} + A\varepsilon_t & \text{if } S_t = M \end{cases} \tag{4}$$

Commencing our analysis, we started by introducing the vector Y_t. This vector covers the observed variables up to time t, providing a comprehensive overview of the empirical data at that point in time. Essentially, it serves as a composite representation of the various metrics and indicators that have been monitored and recorded up until the specified moment. In conjunction with, we introduced the vector θ, a pivotal element in our procedure. This vector serves as a repository for the parameters that are subject to estimation. These parameters collectively encompass a spectrum of vital components within our modeling framework. Specifically, they include the intercept, which represents the baseline or starting point of relationships between variables. The autoregressive variables are also integral, capturing the lagged influence of a variable on its own future values, thereby incorporating the temporal dependencies present in the data. Additionally, the variance parameter is a crucial piece of the puzzle, signifying the extent of dispersion of data points around the mean and providing insights into the overall data distribution. Lastly, the vector θ incorporates the transition probabilities, which play a pivotal role in delineating the likelihood of transitions between different states within the model.

By regrouping these parameters within the vector θ, we aimed to effectively capture and quantify the underlying dynamics and relationships present within the data. The process of estimating these parameters was at the core of our analytical journey, allowing us to unlock insights, uncover patterns, and model the intricate interplay between variables and states. Through rigorous estimation, we tried to discover the hidden mechanisms that govern the observed phenomena, thereby enriching our understanding of the complex interactions that drive economic and statistical processes. $\theta = \left(\beta_0^{S_t}, \sum \beta_i^{S_t}, \sigma^2, P_{ij}\right)$. It is important to recognize that the MS-VAR model can be estimated using two methods, which are the expectation-maximization (EM) algorithm and the Bayesian method.

According to Krolzig (1998), for a given regime S_t and lagged endogenous variables $Y_{t-1} = \left(Y_{t-1}, Y_{t-2}, \ldots, Y_{t-p}\right)'$, the conditional probability density function is given by $f(y_t|S_t; Y_{t-1})$. Where ε_t is assumed to be Gaussian $\varepsilon_t \sim N\left(0, \sigma^2\right)$. Then, the error term ε_t is presupposed to follow a Gaussian distribution $\varepsilon_t \sim N\left(0, \sigma^2\right)$. In such a case,

$$f(y_t|S_t; Y_{t-1}) = (2\pi)^{-\left(\frac{1}{2}\right)} \sigma^{-1} \exp\left\{ -\frac{1}{2}\left(y_t - \overline{y_s}\right)^2 \sigma^{-2} \right\} \tag{5}$$

In which case $\overline{y_s}$ signifies the conditional mean of y_t within the context of regime S_t; $\overline{y_s} = E(y_t|S_t, Y_{t-1})$.

We made the presumption that the data accessible as of time $t-1$ encompass the recorded instances from the dataset gathered at Y_{t-1} derived from the states of the Markov chain up to S_{t-1}; the conditional distribution of y_t takes the form of a combination of Gaussian distributions.

$$f(y_t|S_{t-1}=i;Y_{t-1}) = \sum_{m}^{M} f(y_t|S_{t-1},Y_{t-1})P(S_t=m|S_{(t-1)}=i) \tag{6}$$

$$f(y_t|S_{t-1}=i;Y_{t-1}) = \sum_{m=1}^{M}\sum_{i=1}^{M}\left((2\pi)^{-(\frac{1}{2})}\sigma^{-1}\exp\left\{\frac{1}{2}\left(y_t-\overline{y_s}\right)^2\sigma^{-2}\right\}\right)P_{im} \tag{7}$$

Two factors hinder the application of the maximum likelihood (ML) function for estimating the MS-VAR model. These factors involve the latent variables such as the regime S_t and the conditional distribution of y_t. Hence, we resorted to employing the EM (expectation-maximization) algorithm. This algorithm was introduced by Dempster et al. (1977) and is an iterative procedure. It serves as a parametric estimation technique that enables the identification of the maximum likelihood parameters of a probabilistic model in scenarios where unobservable variables are present. The EM algorithm derives its name from the fact that each iteration encompasses two separate stages, namely:

→ The expectation step (E step): During this stage, we compute the anticipated value relying on the observed variables and the parameter values established in the preceding iteration. This computation can be expressed as follows:

$$\varphi\left(\theta\middle|\theta^{(0)}\right) = E_{(s|y,\theta^{(0)})}[\ln P(y,s|\theta)] \tag{8}$$

- The maximization step (M step): This phase employs the approximation of the unfamiliar information derived from the earlier stage to optimize the likelihood function and revise the parameters for the forthcoming iteration. Consequently, the shift from one iteration (m) to the subsequent iteration (m + 1) of the algorithm involves ascertaining:

$$\widehat{\theta^{(m+1)}} = \text{argmax}_\theta\{E_{(s|y,\theta^{(0)})}[\ln P(y,s|\theta)]\} \tag{9}$$

These two steps are repeated until the difference between the likelihood function of the iteration (m + 1) and that of the iteration (m) does not change.

The EM algorithm stands as the conventional method for deducing the optimal MS-VAR. Nevertheless, an alternative statistical approach is available, known as Bayesian statistics. It encompasses the domain of statistics through a perspective grounded in Bayesian interpretation, where probability incorporates the level of confidence in an occurrence. To elaborate further, consider the following instance: When presented with two events, A and B, there exists an initial belief in the occurrence of event A, denoted as P(A). Given the occurrence of event A, the impact on event B is comprehended, represented as $P(B|A)$. The initial probability $P(A)$ can be modified by taking event B into account, utilizing Bayes' theorem:

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)} \tag{10}$$

$P(A|B)$ is referred to as the posterior probability, whereas $P(A)$ is denoted as the prior probability, incorporating anticipations concerning event A prior to the unfolding of event B. $P(B|A)$ serves as the likelihood function, signifying the probability of event B being true given that event A is already true. $P(B)$ embodies the likelihood of event B being true; its calculation is as follows:

$$P(B) = \sum_{i} P(B|A_i)P(A_i) \tag{11}$$

This statistical principle concerning causality centers on the concept of anticipation. In fact, if a variable y_1 "Granger-causes" another variable y_2, it signifies that the historical val-

ues of y_1 should encompass information that contribute to the prediction of y_2, augmenting the knowledge already embedded within the past values of y_2. The testing procedure is outlined as follows. The null hypothesis postulates the absence of causality in the context of, namely, the conveyed values of the variable y_1 do not trigger the presence of y_2 in the current context. In simpler terms, y_1 is not the cause of y_2 according to the Granger causality criterion. In mathematical terms, the test can be formulated as:

$$C_{y_1 \to y_2} = \log \frac{\det V_\varepsilon [y_2 | y_{2,t-1}]}{\det V_\varepsilon [y_2 | y_{2t-1}, y_{1t-1}]} \tag{12}$$

And the test statistic is as follows: $\delta = TC_{y_1 \to y_2}$; if $\delta < p_{value}$, we accept the null hypothesis.

The reaction to an external alteration, often referred to as an exogenous shock, can be elucidated through the impulse response function (IRF). This concerns to the array of equations interconnecting multivariate autoregressive variables. Essentially, IRFs provide insights into the dynamic patterns exhibited by the assorted variables within the system when confronted with brusque changes. In simpler terms, IRFs facilitate comprehension of how the system's various variables evolve over time due to unexpected influences.

5. Empirical Analysis

5.1. Data Description

In this segment, we provide an overview of the datasets employed in our empirical examination. The nations under consideration for this study encompass the Eurozone, Canada, and the United Kingdom. These specific selections were guided by a triad of principal rationales. Firstly, we considered the accessibility and availability of comprehensive data. Secondly, we considered the robust political stability within these nations, which, in turn, minimizes the likelihood of inflation stemming from governance issues. Lastly, we considered the distinctive aspect of these geographic areas operating with their own distinct currencies: the euro (EUR), Canadian dollars (CAD), and the pound (GBP). These currencies are processed in alignment with the U.S. dollar as the base currency, all within the context of their well-established histories characterized by floating market-driven exchange rate frameworks. Our analytical framework hinges on the utilization of monthly data spanning the contiguous period, specifically commencing from 1 January 1999 to 1 July 2023.

The primary aim of this research was to gain comprehensive insights into the intricate interactions between inflation dynamics and the inherent fluctuations witnessed within the exchange rate arena. In this vein, the pivotal variables under scrutiny encompassed inflation and the exchange rate. We sought to unravel the nuanced ways in which variations in the exchange rate can influence and shape the trajectory of inflation trends.

In order to assess the stationarity characteristics of the time series data under investigation, we employed two distinct testing methodologies: the augmented Dickey–Fuller test (ADF test) and the Kwiatkowski–Phillips–Schmidt–Shin test (KPSS test) (see Table 1).

Table 1. Basic statistics of monthly log returns.

	R-EAI	R-UKI	R-CAI	R-EUR	R-GBP	R-CAD
Mean	0.0081	0.0052	0.0084	0.0004	0.0011	−0.0005
Minimum	−6.9077	−0.8782	−2.1972	−0.0618	−0.0598	−0.0600
Maximum	8.0063	0.6951	2.3025	0.0779	0.0954	0.1129
Student	0.1430	0.5030	0.3424	0.3490	0.9112	−0.5148
ADF	−6.2521	−5.0730	−6.2835	6.0782	−6.6741	−6.3452
KPSS	0.0394	0.1351	0.0411	0.1361	0.0989	0.2309

According to the Table 1, we can affirm that the series of the returns were quite stationary. We note that log returns European Annual Inflation (R-EAI), log returns United

Kingdom Inflation (R-UKI), log returns Canadian Inflation (R-CAI), log returns euro (R-EUR), log returns Great Britain pound (R-GBP), and log returns Canadian dollar (R-CAD).

The initial data density graph, as depicted in Figure 1, and the subsequent examination of Quantile-Quantile plots (QQ plots), as presented in Figure 2, collectively serve to offer a comprehensive and global understanding of the underlying distributions inherent within the dataset.

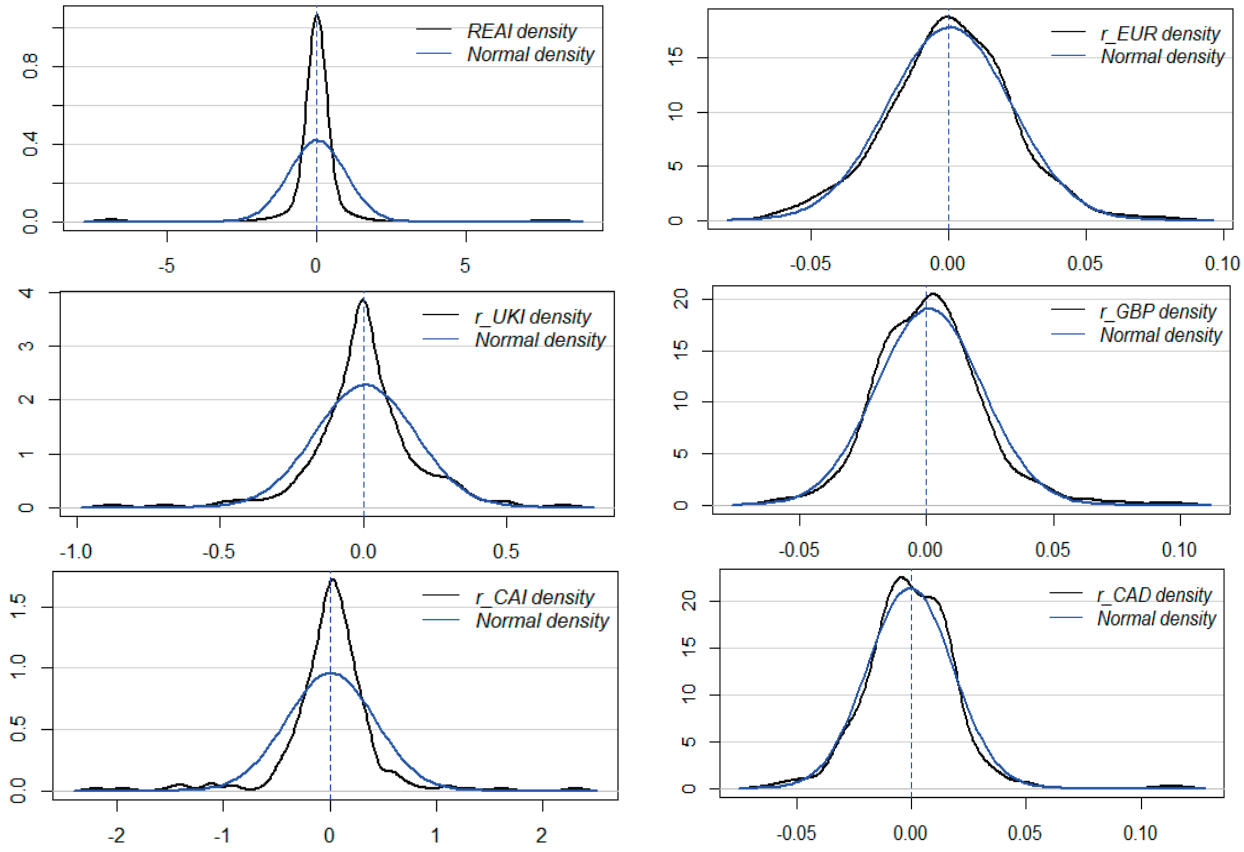

Figure 1. Unconditional density estimation.

Upon careful analysis of these representations, it became evident that the distribution exhibited by the inflation dataset deviated from the typical normal distribution. Indeed, the distribution displayed characteristics that were notably more acute and peaked in comparison to the conventional normal distribution. Similarly, the distribution observed within the exchange rate dataset approximated a normal distribution to a certain extent. However, distinct asymmetrical traits were clearly observable.

By examining the QQ plots, we embark on a comparative exploration of two probability distributions by juxtaposing their respective quantiles. This enabled us to discern how the dataset's distribution contrasts with that of a normal distribution. Evidently, these QQ plots affirm that the data's distribution, both within the context of inflation rates and exchange rates, significantly deviated from the norm. Notably, the quantiles of the samples deviated distinctly from the quantiles characterizing a standard normal distribution. This empirical evidence highlights the non-normal nature of the datasets under scrutiny and further illuminates the distinctive distribution characteristics that set them apart.

In order to examine the normality characteristics inherent within the series, our focus turned towards a set of pertinent statistical measures. Specifically, we considered and assessed the skewness and the kurtosis and applied the Jarque–Bera test (see Table 2). These indicators collectively serve as valuable tools in lighting on the distributional properties of the series under scrutiny.

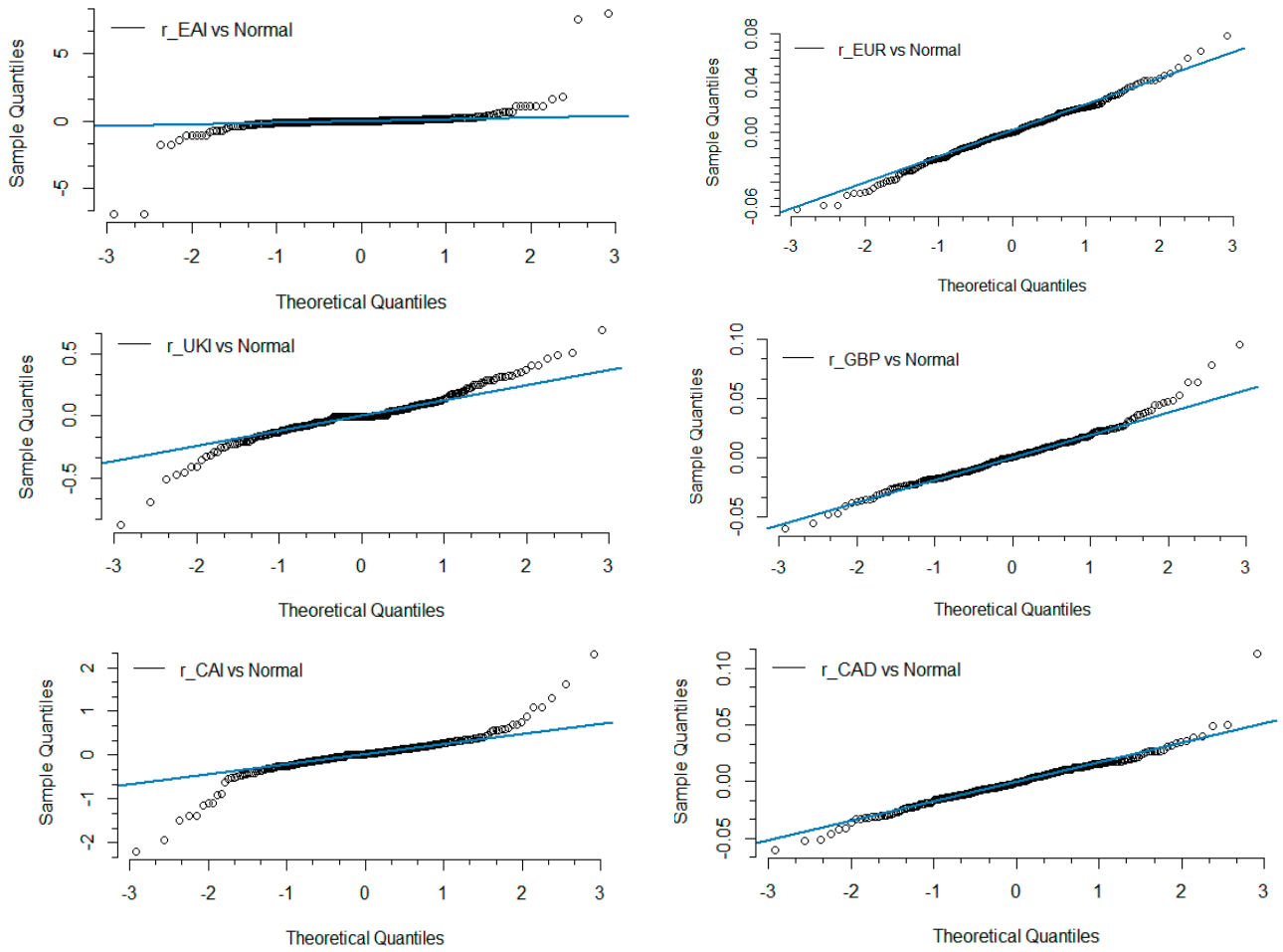

Figure 2. QQ-plots for the returns.

Table 2. Normality tests for the return series.

	R-EAI	R-UKI	R-CAI	R-EUR	R-GBP	R-CAD
skewness	1.1646	−0.3301	−0.4926	0.0065	0.5788	0.5849
kurtosis	51.9555	6.8660	12.1508	3.4763	4.9235	7.6080
J.B test (P_{value})	$<2.2 \times 10^{-16}$	$<2.2 \times 10^{-16}$	$<2.2 \times 10^{-16}$	0.2633	1.38×10^{-13}	$<2.2 \times 10^{-16}$

To analyze the autocorrelation patterns inherent within the series, a valuable tool at our disposal is the Ljung–Box test (see Table 3). This statistical test is specifically designed to assess the presence of serial autocorrelation within the observed data. The null hypothesis posits the absence of any significant autocorrelations within the errors of the model, while the alternative hypothesis operates under the assumption of the contrary—a scenario where autocorrelations do indeed exist.

Table 3. Ljung–Box test for the return series.

	R-EAI	R-UKI	R-CAI	R-EUR	R-GBP	R-CAD
Q(20)	132.04	44.925	43.732	48.776	37.966	43.732
P_{value}	$<2.2 \times 10^{-16}$	0.0011	0.0016	0.0003	0.0089	0.0016

As we observe the contents of the table, the *p*-values associated with all variables were notably lower than the conventional significance threshold of 5%. This signifies a significant departure from the null hypothesis, ultimately leading to its rejection. In essence, these

findings underscore the presence of autocorrelation within the residuals of the series under consideration. This empirical evidence points towards a temporal dependence within the dataset's residual elements.

In order to assess the presence of heteroscedasticity within the dataset, we employed a dual-pronged testing approach. Specifically, we applied two distinct tests to shed light on this crucial aspect: the Ljung–Box test, focusing on the squared returns (see Table 4), and the Lagrange multiplier test (see Table 5). These tests collectively enabled us to comprehensively explore the variance patterns within the data, and by extension, gauge the presence of heteroscedastic tendencies.

Table 4. Ljung–Box test.

	REAI	RUKI	RCAI	REUR	RGBP	RCAD
$Q^2(20)$	174.96	154.85	88.77	49.723	42.362	88.77
P_{value}	$<2.2 \times 10^{-16}$	$<2.2 \times 10^{-16}$	1.215×10^{-10}	0.0002	0.0024	1.215×10^{-10}

The results derived from the application of the Ljung–Box test reveal that the *p*-values corresponding to all the series were consistently below the established significance level of 5%. This collective outcome strongly indicates the presence of an Autoregressive Conditional Heteroskedasticity (ARCH) effect within the data. In essence, the Ljung–Box test outcomes substantiate the notion that the variances of the series are not uniformly distributed, signifying the presence of conditional heteroscedasticity. This empirical insight offers a clear indication that the level of variability within the data is not constant, which has important implications for understanding the potential patterns of volatility inherent within the series.

Table 5. Lagrange multiplier test.

	REAI	RUKI	RCAI	REUR	RGBP	RCAD
LM statistic	88.4793	14.9185	44.0564	3.8587	16.1984	0.9107
P_{value}	0	0.0001	1.6577×10^{-10}	0.0502	7.3536×10^{-5}	0.3407

The outcomes of the Lagrange test yielded nuanced insights. Specifically, by examining the *p*-values associated with the returns of the EUR and CAD series, it was evident that they surpassed the conventional threshold of 5%. This validation aligns with the acceptance of hypothesis H_0, indicating that the data for these series do not manifest an ARCH effect. This divergence becomes especially pronounced when compared to the remaining series, where the *p*-values registered below 5%. This observation signifies the presence of an ARCH effect within these series, underlining the presence of conditional heteroscedasticity.

To address the variance-autocorrelation within these series, we turned to the application of an ARCH (p) model. The selection of the appropriate model was based on the selection criteria, namely the Akaike information criterion (AIC) and the Bayesian information criterion (BIC). This methodology lies in opting for the model that displays the weakest information criterion, thereby providing a robust foundation for model selection. The determination of the lag parameter p draws on the squared returns series. This process involves identifying the number of lags that extend beyond the bounds of the confidence interval.

5.2. Empirical Results and Interpretations

Within this section, we undertook the estimation of distinct models for each of geographic areas, namely the Eurozone, the United Kingdom, and Canada. For each individual estimation, we progressed through a sequence of methodological phases. In the first phase, we determined of the optimal number of lags. This process was guided by the application of two criteria, namely AIC and BIC. In the second phase, with the optimal lag count, we pivoted towards the presentation of the appropriate model that aligns with the distinctive regimes evident within the data. This strategic alignment ensures that the models

accurately capture the complex dynamics unfolding within each regime, fostering a more accurate depiction of the real-world intricacies. The subsequent step concerns the transition matrix, which effectively outlines the transitions between the different identified regimes. This matrix offers valuable insights into the pathways through which economic conditions shifted from one regime to another. In the fourth phase, we proceeded to apply the Granger causality test, a pivotal analytical tool that enabled us to probe the causal interplays within the data. This examination allowed us to unveil the temporal cause-and-effect relationships between variables, unraveling hidden dynamics that might be otherwise obscured. In the fifth phase and following the completion of these methodological steps, we engaged in a comprehensive interpretation of the results. To conclude, in the final step, we delved into the discussion of impulse response functions. This allowed us to explore the dynamics of how the system responds to external shocks, uncovering the trajectories of adjustments and reactions that ripple through the data.

Model 1: Eurozone inflation and exchange rate EUR/USD

We began by delimiting two distinct regimes that incorporate the divergent states of the economic landscape. The initial regime pertained to the phase of economic expansion, characterized by growth and vigor. The subsequent regime, in contrast, corresponded to the phase of economic recession, marked by contraction and retrenchment. By segmenting the data into these two pivotal regimes, we laid the foundation for a comprehensive exploration of the differential behaviors and interactions that manifested across these contrasting economic states.

Our analysis identified that the optimal lag count is precisely 2 (see Table 6). With this critical insight in hand, we proceeded to the estimation of a Vector Autoregressive (VAR) model that impeccably aligns with the two identified regimes, each encompassing its unique dynamics and behaviors. This model configuration, denoted as MS (2) VAR (2), effectively captures the intricate interplay within the dataset under the lens of both two regimes and two delays. This approach ensures a robust depiction of the underlying relationships and dependencies, allowing us to comprehensively analyze the data within the context of the identified economic phases and time lags.

Table 6. Information criteria for estimated model—EAI.

	AIC	BIC
P = 1	−7.9382	−7.8595
P = 2	−8.2331	−8.1019
P = 3	−8.2254	−8.0417
P = 4	−8.2191	−7.9829
P = 5	−8.2327	−7.9451
P = 6	−8.2118	−7.8707

Covariance matrix:

$$\begin{pmatrix} 0.03626 & 0.000 \\ 0.000 & 0.00044 \end{pmatrix}$$

Covariance matrix:

$$\begin{pmatrix} 0.91951 & 0.000 \\ 0.000 & 0.00050 \end{pmatrix}$$

Transition matrix:

Subsequent to the estimation of the model for each distinct regime, we computed the Markov matrix probability. It summarizes the transition probabilities between the different identified economic regimes. Its calculation and interpretation serve as a crucial bridge that connects the observed data to the nuanced dynamics of economic shifts. By quantifying the likelihood of transitioning between these regimes, we enhance our ability to comprehend the underlying patterns that govern economic behavior across different states.

$$A = \begin{matrix} \text{expansion} \\ \text{recession} \end{matrix} \begin{bmatrix} P_{1,1} & P_{1,2} \\ P_{2,1} & P_{2,2} \end{bmatrix}$$

$$A = \begin{bmatrix} 0.96 & 0.04 \\ 0.09 & 0.91 \end{bmatrix} \text{ where } P_{1,1} + P_{1,2} = 1 \text{ and } P_{2,1} + P_{2,2} = 1$$

Beginning with the inflation equation, our analytical findings unveil noteworthy insights. During a phase of economic expansion, the observed variations in the inflation rate demonstrated a robust negative dependency on its historical values, specifically those two periods prior (at time -2). However, this linkage became relatively subdued, oscillating within the range from 0.07 to 0.1 within the context of a recessionary period (see Tables 7 and 8).

Table 7. Estimation results for regime 1: expansion—Eurozone.

	$DL(EAI_t)$ (P_{Value})	$DL(EUR_t)$ (P_{Value})
Const	0.02 (0.00)	0.0007 (0.62)
$DL(EAI_{t-1})$	-0.96 (0.00)	-0.0005 (0.5)
$DL(EAI_{t-2})$	-0.96 (0.00)	-0.0006 (0.7)
$DL(EUR_{t-1})$	0.47 (0.4)	0.34 (0.00)
$DL(EUR_{t-2})$	0.41 (0.5)	-0.11 (0.1)

Table 8. Estimation results for regime 2: recession—Eurozone.

	$DL(EAI_t)$ (P_{Value})	$DL(EUR_t)$ (P_{Value})
Const	0.02 (0.8)	0.00 (0.8)
$DL(EAI_{t-1})$	0.07 (0.57)	-0.004 (0.7)
$DL(EAI_{t-2})$	0.10 (0.33)	-0.002 (0.9)
$DL(EUR_{t-1})$	-0.35 (0.9)	0.26 (0.03)
$DL(EUR_{t-2})$	-0.66 (0.8)	0.14 (0.2)

The outcomes show that the transmission of exchange rate variations, whether in an expansive or recessionary regime, is characterized by a partial influence. Specifically, in times of expansion, the degree of transmission registered at approximately 0.47, whereas in a recessionary phase, it took a negative stance of around -0.35, both corresponding to time -1. This implies that a 1% fluctuation in the exchange rate yields a proportional effect of approximately 0.47% on the inflation rate during expansion and an inverse influence of around -0.35% during recession. This confirms the interaction between exchange rates and inflation within the two regimes. Notably, the observed outcomes reflect that the transmission of exchange rate dynamics into inflation trends remained incomplete across both expansive and recessionary phases. This pivotal insight underscores the intricate nature of these relationships and sheds light on the nuanced dynamics governing economic shifts across these distinct states.

Analyzing the equation governing exchange rate changes reveals intriguing insights, suggesting that the dynamics of exchange rate fluctuations were influenced by their his-

torical values and, to a lesser extent, by the levels of inflation within both expansion and recession states for the Eurozone. This underscores the intricate web of interactions that contributed to the shifts in exchange rates within these economic phases.

The examination of the transition matrix indicates that when the current economic state is characterized by expansion, there exists a 96% probability of transitioning into another expansion phase in the subsequent period, and a 4% probability of transitioning into a recession phase. Conversely, in the context of a current recession state, there is a 9% likelihood of transitioning into expansion and a dominant 91% probability of moving into another recession phase. Utilizing the transition matrix, the expected duration of a state can be calculated as d = 1/(1 − P_1,1). This calculation provides insights into the anticipated duration of a given state, further enhancing our comprehension of regime dynamics. Drawing upon the transition matrix and the context of the Eurozone's current state being expansionary due to ongoing geopolitical factors, such as the Russian War, it can be inferred that there is a 96% likelihood of remaining in this regime, with an expected duration of 25 months (1/0.04).

Lastly, examining the Granger causality table, we observe that the *p*-values associated with the variables exceeded the conventional threshold of 5%. Consequently, we reject the null hypothesis that posits the absence of Granger causality between the Eurozone Inflation and the exchange rate. Instead, we conclude that Granger causality indeed exists between these two variables (see Table 9).

Table 9. Granger causality test—Eurozone.

	$F_{Statistic}$	P_{Value}
REUR → REAI	0.1496	0.8611
REAI → REUR	0.8042	0.4484

As depicted in Figure 3, within the first regime, there was a distinct observation: the smoothing process assumed a prominent and sustained stature. This high level of smoothing persisted resolutely until it reached a pivotal juncture at period 120 (equivalent to the year 2009). At this juncture, a noteworthy shift occurred as the smoothing process began to experience fluctuations in a downward trajectory, indicative of an impending period of recession. Notably, this pivotal phase aligns with the aftermath of the subprime crisis—a period marked by economic turbulence and contraction.

Subsequently, a second notable recessionary phase emerged in 2015, further underscoring the inherent volatility within economic cycles. Despite these fluctuations, the graph unequivocally depicts a decisive trajectory: the prevailing regime within the Eurozone was unmistakably characterized by economic expansion.

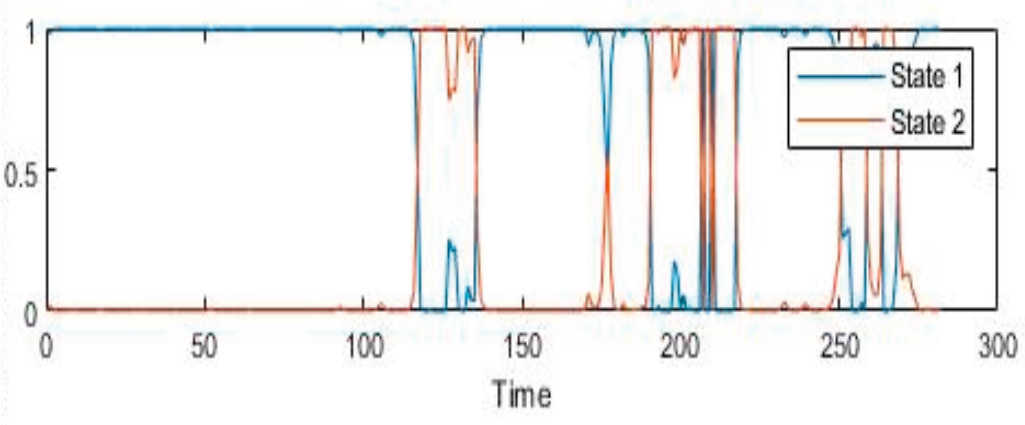

Figure 3. Smoothed states' probabilities for the Eurozone.

Model 2: United Kingdom inflation and exchange rate GBP/USD

Upon evaluation of the Information Criteria AIC, the optimal count of delays was unequivocally established as 2 (see Table 10). Our analytical pursuit leads us to the estimation of a Vector Autoregressive (VAR) model that impeccably aligns with the identified dual regimes. Each of these regimes signifies a distinctive phase in the economic landscape, contributing to a comprehensive understanding of the inherent dynamics. This specialized model configuration, denoted as MS (2) VAR (3), encompasses the interplay of these economic states, harmonizing seamlessly with the three delays integral to the analytical framework. This approach ensures that the model captures the temporal dependencies and interactions within the data.

Table 10. Information criteria for estimated model—UKI.

	AIC	BIC
P = 1	−11.2228	−11.1441
P = 2	−11.2199	−11.0887
P = 3	−11.2450	−11.0614
P = 4	−11.2282	−10.9921
P = 5	−11.2285	−10.9399
P = 6	−11.2152	−10.8742

Covariance matrix:

$$\begin{pmatrix} 0.00760 & 0.000 \\ 0.000 & 0.00042 \end{pmatrix}$$

Covariance matrix:

$$\begin{pmatrix} 0.07301 & 0.000 \\ 0.000 & 0.00030 \end{pmatrix}$$

Transition matrix:

$$\mathrm{A} = \begin{bmatrix} 0.96 & 0.4 \\ 0.7 & 0.93 \end{bmatrix}$$

The estimation tables furnish information regarding the transmission dynamics of exchange rate fluctuations in distinct economic contexts. In the expansion regime, the observed degree of transmission registers at −0.61 (see Table 11). This signifies that within this phase, the relationship between exchange rate variations and UK inflation was characterized by a partial transmission mechanism. In more concrete terms, a 1% exchange rate fluctuation induced a corresponding −0.61% change in UK inflation. Conversely, within a recession regime, the transmission phenomenon took on a different facet, showcasing a complete transmission degree of 1.09 (see Table 12). This implies that a 1% exchange rate variation generated a corresponding 1.09% inflation change in the UK within a recessionary context. This dichotomy underscores the nuanced nature of exchange rate pass-through (ERPT) in the United Kingdom, reflecting a partial ERPT within expansion states and a complete ERPT within recession states.

Shifting our focus to the exchange rate equation, an insightful pattern emerges. The findings indicate that the variation in exchange rates is influenced by their historical values and, to a lesser extent, the inflation levels of the country within both economic states. Further delving into the transition matrix, its estimations closely parallel those of the Eurozone, thereby revealing comparable regime transition patterns. When the current state is expansionary, the probability of transitioning into another expansion phase is 96%, with an expected duration of 25 months (1/0.04). Conversely, when the current state is recessionary, there is a notable likelihood of transitioning into another recession phase (93%), with an anticipated duration of 14 months. In light of these insights and given the prevailing geopolitical context such as the Russian war, it is reasonable to infer a high probability of 96% for the United Kingdom to persist in an expansionary state for a duration of 25 months. Finally, the Granger causality table lends compelling evidence. The *p*-value, significantly exceeding the threshold of 5%, leads us to reject the null hypothesis

of no Granger causality between UK inflation and its exchange rate. This discernment reinforces the presence of Granger causality, affirming a significant interaction between the two variables in a manner that aligns coherently with both empirical reality and the results derived from the model estimation (see Table 13).

Table 11. Estimation results for regime 1: expansion—United Kingdom.

	$DL(UKI_t)$ (P_{Value})	$DL(GBP_t)$ (P_{Value})
Const	0.0045 (0.5)	0.0011 (0.5)
$DL(UKI_{t-1})$	−0.03 (0.7)	0.0031 (0.8)
$DL(UKI_{t-2})$	0.15 (0.06)	0.002 (0.8)
$DL(UKI_{t-3})$	0.24 (0.0)	0.01 (0.7)
$DL(GBP_{t\_1})$	−0.61 (0.07)	0.26 (0.0)
$DL(GBP_{t\_2})$	0.50 (0.17)	−0.01 (0.8)
$DL(GBP_{t\_3})$	−0.61 (0.08)	0.2 (0.02)

Table 12. Estimation results for regime 2: recession—United Kingdom.

	$DL(UKI_t)$ (P_{Value})	$DL(GBP_t)$ (P_{Value})
Const	−0.01 (0.6)	−0.002 (0.4)
$DL(UKI_{t-1})$	0.08 (0.4)	−0.0016 (0.8)
$DL(UKI_{t-2})$	−0.10 (0.3)	0.02 (0.01)
$DL(UKI_{t-3})$	0.15 (0.19)	0.01 (0.3)
$DL(GBP_{t\_1})$	1.09 (0.5)	0.27 (0.03)
$DL(GBP_{t\_2})$	−0.25 (0.8)	−0.03 (0.7)
$DL(GBP_{t\_3})$	0.51 (0.7)	−0.17 (0.1)

Table 13. Granger causality test—United Kingdom.

	F-Statistic	*p*-Value
RGBP → RUKI	0.521	0.594
RUKI → RGBP	2.455	0.088

The smoothed probabilities provide us with a representation that incorporates the alternation between periods of expansion and recession within the country's economic landscape. Figure 4 illustrates cyclic nature of economic states as they varied between phases of growth and contraction.

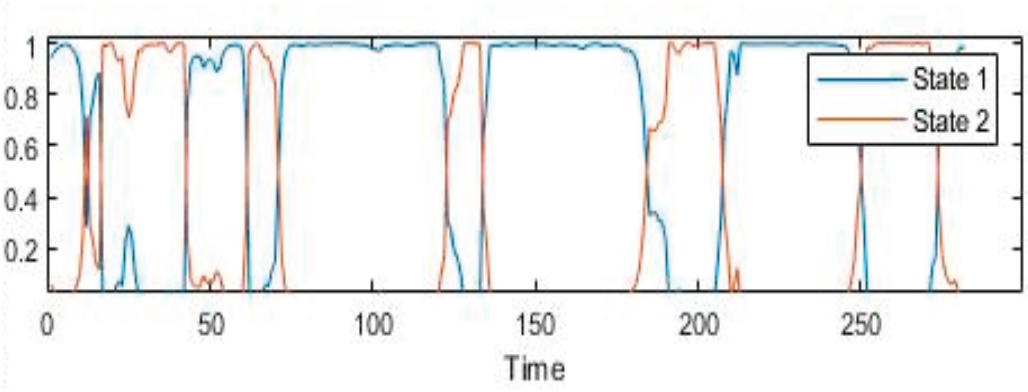

Figure 4. Smoothed states' probabilities for the United Kingdom.

Model 3: Canada inflation and exchange rate CAD/USD

Utilizing the Information Criteria, the ideal number of delays was unequivocally identified as 2 (see Table 14). Our analytical pursuit led us to the estimation of a Vector Autoregressive model that aligns with the two discerned economic regimes. Each of these regimes encapsulates a distinctive economic phase, contributing to a comprehensive understanding of the intricate dynamics at play. This model denoted as MS (2) VAR (2) captures the interplay of these economic states while accommodating the two delays inherent to the analytical framework.

Table 14. Information criteria for estimated model (CAI).

	AIC	BIC
P = 1	−9.7956	−9.7159
P = 2	−9.8467	−9.7166
P = 3	−9.8378	−9.6542
P = 4	−9.8280	−9.5919
P = 5	−9.8256	−9.5371
P = 6	−9.8076	−9.4665

Covariance matrix:

$$\begin{pmatrix} 0.04190 & 0.000 \\ 0.000 & 0.00025 \end{pmatrix}$$

Covariance matrix:

$$\begin{pmatrix} 0.67048 & 0.000 \\ 0.000 & 0.00057 \end{pmatrix}$$

Transition matrix:

$$A = \begin{bmatrix} 0.96 & 0.04 \\ 0.18 & 0.82 \end{bmatrix}$$

For the expansionary regime, the observed degree of transmission was recorded at −0.29 (see Table 15). This points to a partial degree of exchange rate pass-through where a 1% variation in the exchange rate induced a corresponding −0.29% change in Canadian inflation within an expansion phase. However, the dynamics took on a distinct nature during recession periods. The degree of exchange rate pass-through became complete and notably elevated, reaching a value of 3.9. This signifies that in times of recession, a 1% exchange rate fluctuation led to a substantial 3.9% alteration in Canadian inflation. This duality of exchange rate pass-through degrees accentuates the nuanced interplay between exchange rate variations and inflation trends, underscored by the contrasting dynamics observed within these two economic states. Moving on to the equation governing exchange rate changes, the findings indicate that these fluctuations were influenced by their historical

values and, to a lesser extent, the levels of inflation within Canada during both expansion and recession states (see Table 15).

Table 15. Estimation results for regime 1 (expansion): Canada.

	$DL(CAI_t)$ (P_{Value})	$DL(CAD_t)$ (P_{Value})
Const	0.02 (0.1)	−0.0009 (0.4)
$DL(CAI_{t-1})$	−0.11 (0.1)	0.00086 (0.8)
$DL(CAI_{t-2})$	−0.17 (0.01)	−0.0036 (0.3)
$DL(CAD_{t-1})$	−0.29 (0.7)	0.34 (0.00)
$DL(CAD_{t-2})$	0.82 (0.3)	−0.2 (0.0)

By examining the transition matrix and when the current regime is expansionary, there is a robust 96% likelihood of transitioning into another expansion phase, while the probability of transitioning to a recessionary phase is notably lower at 4%. Conversely, when the current state is recessionary, the probability of transitioning into another recessionary phase is registered at 82%. The consistent agreement across the three geographic areas in the sample regarding the anticipated expansionary state in the subsequent period, extending for 25 months, reinforces the robustness and reliability of the analytical approach (see Table 16).

Table 16. Estimation results for regime 2 (recession): Canada.

	$DL(CAI_t)$ (P_{Value})	$DL(CAD_t)$ (P_{Value})
Const	0.0014 (−)	0.0001 (0.9)
$DL(CAI_{t-1})$	−0.23 (0.13)	−0.0002 (−)
$DL(CAI_{t-2})$	−0.33 (0.03)	0.002 (0.6)
$DL(CAD_{t-1})$	−3.90 (0.4)	0.27 (0.06)
$DL(CAD_{t-2})$	−5.37 (0.3)	0.18 (0.13)

Lastly, the Granger causality table offers compelling evidence. The *p*-value, exceeding the 5% threshold, leads us to reject the null hypothesis of no Granger causality between Canadian inflation (CAI) and its exchange rate (see Table 17).

Table 17. Granger causality test (Canada).

	F-Statistic	*p*-Value
RCAD → RCAI	1.7544	0.1749
RCAI → RCAD	0.2551	0.7750

The smoothed probabilities provide us with a representation that takes into account the alternation between periods of expansion and periods of recession within the economic landscape of the country. Figure 5 illustrates the cyclical nature of economic conditions as they fluctuated between periods of growth and contraction.

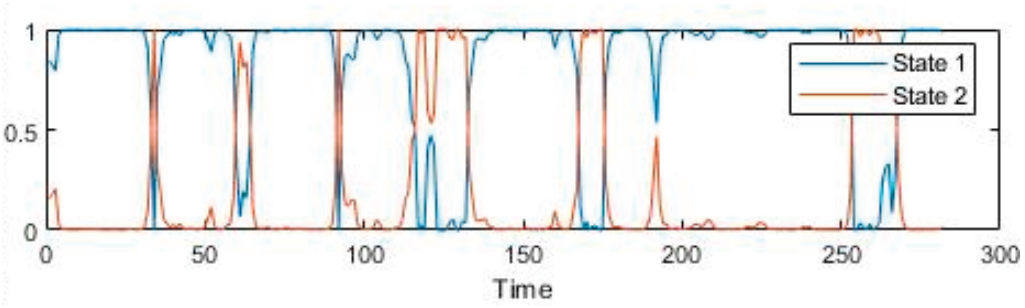

Figure 5. Smoothed states' probabilities for Canada.

Given our primary focus on understanding the impact of shocks in this study, our analytical naturally steers us towards a comprehensive examination of how our variables responded to these disturbances. To this end, we employed impulse response functions. Through their application, we gained valuable insights into the behavior of our variables when subjected to shocks. These enabled us to decipher the intricate patterns that unfolded as our variables reacted to these disruptive forces. By delving into this analysis, we unearthed a wealth of information that shed light on the nuanced dynamics that govern the interplay between variables and shocks. The culmination of this analytical exploration is succinctly encapsulated within the subsequent findings.

The representations provided above offer a comprehensive illustration of the impulse response functions (IRFs) across various lag intervals. The blue line denotes inflation, while the red line signifies the exchange rate. The graphics in the initial column elucidate the reactions of both variables to shocks in inflation, whereas the second column articulates the responses to shocks in the exchange rate.

Upon an examination of the first column, a notable convergence in responses becomes apparent. At the onset of the shock in inflation, an instantaneous and perceptibly substantial surge in inflation was witnessed across all the three geographic areas in the sample. This initial reaction was swiftly succeeded by a decline in the second period, followed by a subsequent, though milder, increase. Notably, the impact of the shock on inflation gradually dissipated, signifying the presence of a decay in its effects.

Shifting our focus to the exchange rate's response, a distinct pattern emerged. The reaction of the exchange rate to an inflation shock was not immediate, manifesting as a minor dip in exchange rates, particularly evident in GBP/USD and CAD/USD. Over time, the influence of the inflation shock waved, consistent with the observed decay effect. Transitioning to the second column of images, which depict the response of variables to a shock in the exchange rate, the response of exchange rates following an exchange rate shock was immediate and robust in the initial period. However, this sharp response rapidly diminished in the subsequent period, effectively nullifying the impact by the third period.

Turning to the inflation response the immediate inflation response is nearly negligible. This is succeeded by a modest fluctuation that attenuates and converges to baseline levels. This pattern is evident within different timeframes, with the attenuation occurring in the third period for Canada, the fourth period for the Eurozone, and the fifth period for the United Kingdom.

In sum, the IRFs illustrated unveil the intricate interplay between variables and shocks, showcasing the dynamics of immediate and subsequent responses. The contrast in behavior between inflation and exchange rate shocks offers valuable insights into the complex interactions that underlie these economic dynamics across different timeframes and regions (see Figure 6).

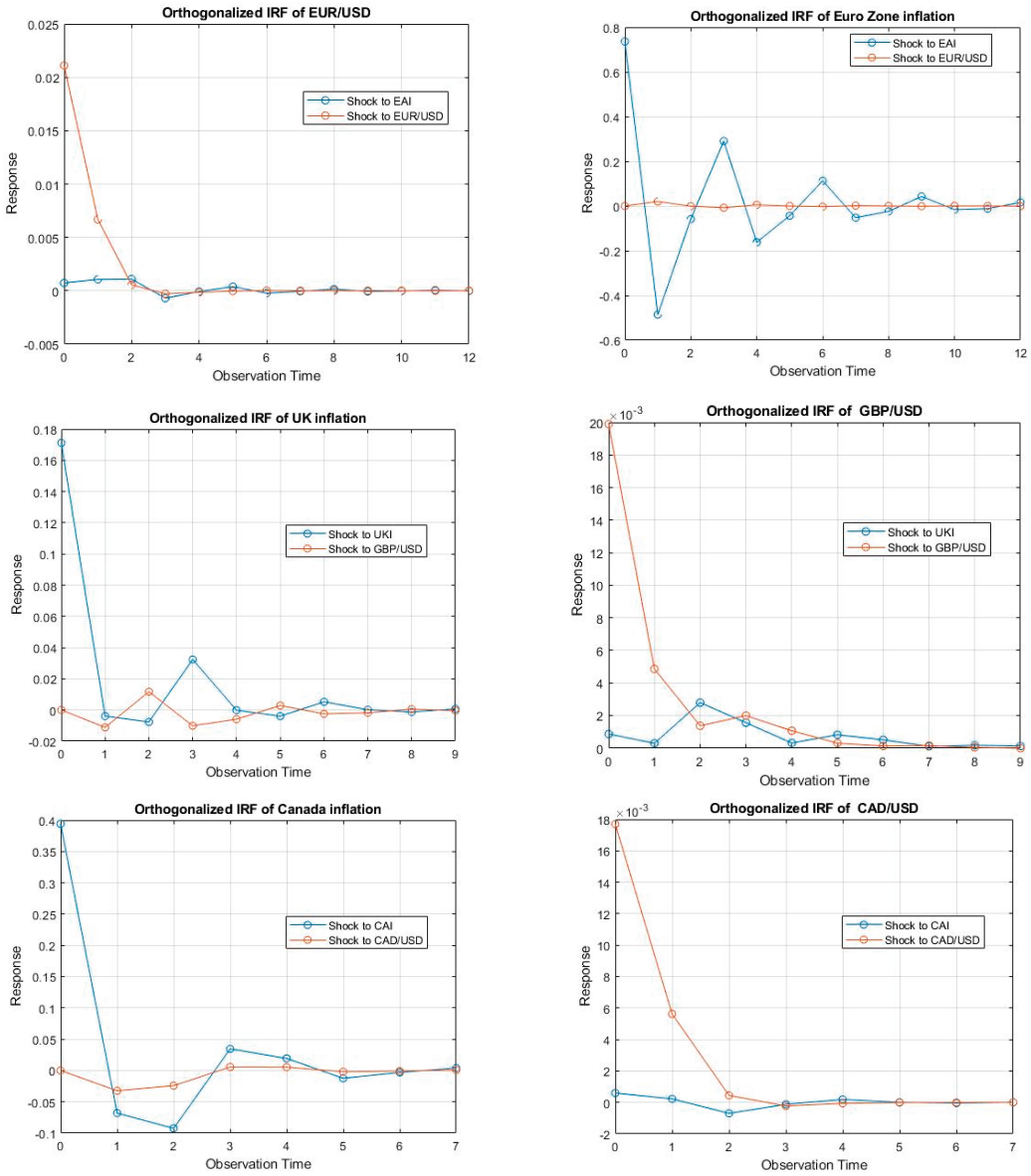

Figure 6. Orthogonalized IRF to inflation rates and exchange rates.

By analyzing the link between the hypotheses described in Section 3 and the results obtained, we can say that the initial hypotheses suggested that exchange rate fluctuations could have a significant impact on a country's inflation rate, due to the concept of transmission of exchange rate variations to the prices of goods and services, also known as exchange rate pass-through. The econometric results seem to confirm these hypotheses, in particular by showing significant relationships between the exchange rate and the inflation rate in the various countries examined.

In this context, the hypotheses initially formulated suggest that exchange rate fluctuations exert a significant influence on inflation, operating through mechanisms such as pass-through and the transmission of the exchange rate to prices. The results obtained from various econometric methods, including impulse response functions, smoothed state probabilities, and Granger causality tests, enrich our understanding of these hypotheses. Firstly, impulse response functions provide insights into the reaction of variables to shocks. They confirm that fluctuations in the exchange rate can induce variations in inflation, thus supporting the idea of a dynamic relationship between these two variables. Secondly, smoothed state probabilities, representing transitions between economic regimes, provide indications of the persistence of different economic states. Their analysis shows that ex-

pansionary regimes are characterized by distinct dynamics from recessionary ones, which supports the idea that exchange rate fluctuations can have different implications depending on the economic context.

The results of the Granger causality tests confirm the existence of causality between the inflation rate and the exchange rate for the Eurozone, the United Kingdom, and Canada. The fact that the results of these tests confirm the existence of causal relationships between the exchange rate and inflation reinforces the validity of the initial hypotheses.

6. Conclusions

The exchange rate pass-through holds a central position within the models that central banks rely upon when shaping their monetary policy decisions. Understanding the scope of ERPT's influence on final consumer prices stands as a pivotal endeavor for comprehending the interplay between exchange rates and inflation. This insight not only aids in inflation prediction and the formulation of monetary policy but also casts light on the consequential expenditure shifts prompted by fluctuations in exchange rates, thereby impacting real economic activity.

In this study, our interest laid in discerning the extent of ERPT during both expansionary and recessionary phases. We used the Markov Switching Vector Autoregressive model. Contrary to prevailing scholarly literature, our findings depart from convention. We unveiled a nuanced reality where the degree of exchange rate transmission exhibited partial characteristics during economic expansion. However, when the lens shifted to periods of recession, both the United Kingdom and Canada demonstrated a complete transmission of the exchange rate's influence. An observation emerged; all sampled geographic areas are poised for an upcoming expansion regime, forecasted to endure for a span of 25 months.

Employing impulse response functions, we traced the ripple effects of these shocks on both inflation and exchange rates. Results showed that an inflationary shock triggered an immediate and pronounced response, gradually tapering off over time until equilibrium was regained. The response of exchange rates to inflation shocks, on the other hand, unfurled differently. It was not instantaneous but rather subtle, fading over time. Similarly, for the exchange rate shocks, the initial effect was rapid but diminished over time. However, the impact on inflation was not immediate, and its magnitude was comparatively modest.

To enhance our findings, we propose delving into the causes behind complete transmission during recessions. Adding additional variables, such as uncertainty metrics, to the model could offer a more nuanced understanding. Moreover, extending the analysis to annual data could offer insights into the duration of ERPT, bolstering the depth of comprehension in this intricate economic relationship.

This study has shed light on the significant transmission of exchange rate movements to inflation across the diverse set of three geographic areas studied. However, it is important to note that while our findings provide valuable insights, they are subject to inherent limitations. One critical aspect to consider is the potential omission of crucial variables from our analysis. For example, fiscal policy plays a key role in influencing inflationary pressures within an economy. Government spending, tax policy, and the level of public debt can all affect inflation dynamics. Failure to include these variables can lead to an incomplete understanding of the relationship between exchange rates and inflation. In addition, external shocks, such as geopolitical events or changes in global commodity prices, can exert significant pressure on inflation rates. Ignoring these external factors may obscure the true nature of the relationship between exchange rate movements and inflation. Moreover, the implications of our study underscore the need for central banks to tailor monetary policy to national specificities. Economic conditions, institutional frameworks, and policy preferences differ across countries, affecting the effectiveness of monetary policy measures.

Continuous monitoring of the impact of exchange rate movements on inflation is crucial for effective policymaking. Exchange rate movements can have both direct and indirect effects on inflationary pressures. For example, a depreciation of the domestic

currency may lead to higher import prices, thereby fuelling inflation. However, the extent to which exchange rate movements translate into inflationary pressures may vary depending on factors such as the degree of import penetration. Therefore, central banks need to remain vigilant in assessing the evolving relationship between exchange rates and inflation and adjust their policy stance accordingly.

Moreover, diversification of monetary policy instruments is essential to mitigate the impact of exchange rate volatility on inflation. While interest rate adjustments remain a primary tool for influencing inflation trends, central banks should explore alternative measures, such as foreign exchange interventions or macroprudential policies, to complement traditional monetary policy instruments. By diversifying their toolkit, central banks can enhance their ability to manage exchange rate fluctuations and maintain price stability in the face of evolving economic conditions.

To sum up, while our study provides valuable insights into the transmission of exchange rate movements to inflation, it is important to acknowledge its limitations and consider the broader economic context. By addressing these limitations and adopting a nuanced approach to policymaking, central banks can effectively navigate the complexities of the exchange rate–inflation relationship and promote macroeconomic stability.

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Conflicts of Interest: The authors declare no conflict of interest.

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The Determinants of the Efficiency of Microfinance Institutions in Africa

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Abstract: Over the past few decades, microfinance institutions have attracted the interest of governments and academics alike, given their unique nature of being financial institutions with a dual mission of promoting social development and reducing poverty. However, concerns have been raised about their effectiveness in achieving these goals while remaining financially sustainable. In this study, we attempt to examine the factors that have the greatest impact on the social, financial, and overall efficiency of microfinance institutions in African regions. We adopt a two-step approach: First, we assess the efficiency scores of 95 microfinance institutions in Africa between 2005 and 2018 using a data envelopment analysis (DEA) approach. We then regress their efficiency scores on a set of determinant variables, capturing the microfinance institutions' characteristics. Our findings suggest that a majority of institutions prioritize profitability over social outreach. Furthermore, the panel data regression indicates that factors such as profitability, equity capitalization, types of loans, and low gross domestic product (GDP) have a positive influence on microfinance institutions' efficiency. Conversely, variables including their risk portfolio, grants, microfinance institution status (Non-Governmental Organization (NGO), cooperative, etc.), operational area, political environment, and size exert a negative impact on efficiency. Through this study, we seek to enhance our understanding of microfinance institutions and to identify the factors that impact their operational efficiency, thereby reinforcing their crucial role in advancing financial inclusion, empowering marginalized communities, and fostering inclusive economic growth.

Keywords: microfinance institution; social efficiency; financial efficiency; DEA; panel data

1. Introduction

A microfinance institution (MFI) is an organization that offers multiple financial services (loans, savings, grants, etc.) to individuals who are normally excluded from traditional financial channels, specifically in communities with low incomes, with the idea of achieving financial profit while promoting social development. From this point of view, microfinance plays a complementary role to the classic banking system by developing innovative lending initiatives and, in particular, solidarity loans, flexible loans, small loans with a dynamic incentive, progressive loans, and frequent repayments. Despite their perceived risks and costs, these techniques have the potential to enhance financial inclusion and reduce poverty by empowering individuals to participate more actively in the economy.

The idea of microfinance can be traced back to the works of Dr. Yunus (Noble Prize winner in 2006), whose contributions have firmly established that even a small amount of funds can have a profound impact on the lives of the underprivileged and those in need by helping them to launch new initiatives or expand their enterprises to generate more income.

Over the last few decades, the success of microfinance, particularly in developing countries, has sparked the interest of governments and academics alike due to the unique

idea that a financial institution can simultaneously pursue profit and social development. Cull et al. (2007) estimate that microfinance covers 180 million borrowers, mainly concentrated in the global South, and that the amount of assets managed by microfinance institutions is approximately USD 190 billion. This fast growth of microfinance institutions all over the world has raised many questions about how to assess their performance (Lapenu et al. 2004; Hudon and Balkenhol 2011) and their efficiency in fulfilling their dual mission: being financially viable while helping individuals with low incomes. These interrogations are mainly led by public and private funders and donors, as well as other stakeholders who want to ensure their funds and donations to these institutions are effectively utilized for their intended purpose and have a meaningful impact. As a result of being a hybrid organization that combines two different objectives (Sommeno et al. (2024)), assessing an MFI's performance can prove to be very challenging, since only a few MFIs are financially self-sufficient and their share of non-market resources is generally very significant. Therefore, evaluating the performance of MFIs simply through the lens of financial indicators such as profitability and neglecting social factors proves to be of little relevance. Alternatively, Balkenhol (2007) suggests that this analysis can be more fruitful by shifting our focus to efficiency.

This article evaluates the efficiency of 95 microfinance institutions in Africa and explores the factors influencing these efficiency levels to provide a comprehensive understanding of the dynamics of MFIs. We adopt a two-step approach following Coelli (1998), which involves regressing data envelopment analysis' efficiency scores on explanatory factors using linear regression.

While most studies on MFI efficiency use data from multiple continents, each with unique contexts, we focus specifically on Africa to enhance the applicability of the DEA approach. And, similar to Gutiérrez-Nieto et al. (2009), we examine three forms of efficiency—financial, social, and overall—to accommodate the hybrid nature of microfinance institutions in Africa.

The following sections of the article are organized into five main parts. We begin by exploring the concept of efficiency in the microfinance sector and proposing hypotheses on variables that could significantly impact efficiency scores. The second and third sections outline our two-step approach and describe the data collection process. The fourth section presents the results obtained. Finally, we conclude with a discussion and interpretation of our findings.

2. Literature Review

2.1. The Microfinance Institutions' Efficiency

An organization's efficiency is determined by its ability to achieve maximum outputs with minimum inputs. This means effectively utilizing resources such as funds, manpower, and time to generate the best possible results. In the case of microfinance institutions, their efficiency is closely tied to balancing two operating logics—private and collective—due to their hybrid nature and dual orientation (financial and social) (Mumi et al. (2020). Being efficient, for these institutions, involves minimizing costs, maximizing profit, and extending social outreach to fulfill their dual mission of providing sustainable financial services to excluded communities. The question of an MFI's efficiency has sparked debate between two opposing positions, shifting from a social welfare-focused vision of microfinance in the 1980s to a more commercially oriented one (Woller et al. 1999; Morduch 2000).

This institutionalist vision is based on the belief that financial sustainability, high returns, and reaching the poorest are compatible. This view favors the elimination of grants to microfinance to fit better with the logic of the financial markets (Rhyne 1998). On the other hand, the institutionalist vision has the advantage of denouncing the failures of certain programs, which have been forced to end because of rigorous management. However, the arguments developed by its followers conflict with reality, as only 5% or less of MFIs are financially autonomous (UNCF 2005; Deutsche Bank 2007), and grants still play a major role in the MFI operating structure (Costello 2024; Hudon and Traca 2011).

Moreover, the optimal strategy, which holds that microfinance should be profitable while reaching poor individuals, is strongly questioned.

Solely relying on financial ratios to assess efficiency provides limited insights for microfinance institutions managers, as noted Lam et al. (2020). Reciprocity between financial and social performance in microfinance institutions, as detailed in *Public Performance & Management Review* 43: 206–31, has led to the development of two approaches to applying DEA to evaluate the efficiency of West African MFIs. The results of these studies showed that the majority of the institutions observed were inefficient in both their social and financial aspects, mainly attributed to poor resource management.

Bassem (2014) conducted a study on the efficiency of 33 MFIs in North Africa using the DEA method for the period 2006 to 2011. The study found that the observed institutions experienced an annual increase of 4.9%, primarily attributed to changes in technical efficiency. Technical efficiency refers to how MFIs allocate their resources to enhance their performance. Essentially, the right combination of inputs can improve overall MFI performance.

In a similar vein, Kipesha (2012) evaluated the efficiency of MFIs from five East African countries (Tanzania, Kenya, Uganda, Rwanda, and Burundi) using the DEA approach with constant and variable return assumptions. The sample included 35 MFIs, comprising 5 banks, 17 non-bank financial institutions (NBFIs), 9 Non-Governmental Organizations (NGOs), and 4 cooperatives for the period 2009 to 2011. In our study, we have examined three forms of efficiency, financial, social, and overall, utilizing a production approach with three input variables (total assets, staff, and operating costs) and two output variables (Gross Loan Portfolio and Financial Revenue).

2.2. Determinants of Microfinance Institutions' Efficiency

The empirical literature has explored several factors impacting the efficiency of microfinance institutions. We have considered a set of key determinants frequently discussed, which can be reviewed as follows:

- The experience or the age of the MFI: The relationship between the MFI's experience level and its efficiency is not simple. According to life cycle theory, efficiency may improve with institutional maturity. Older MFIs tend to have lower operational ratios than newer ones, as they have honed their management practices through trial and error. González et al. (2007) found that older MFIs benefit from refined management techniques. On the other hand, younger MFIs can leverage new technologies and innovations, potentially making them more efficient in adopting new management information systems and developing mobile banking platforms (Cornée and Thenet 2016; Wijesiri et al. 2017). However, mature organizations may become entrenched in outdated processes, hindering their efficiency. In light of the existing literature, we hypothesize that the experience of an MFI has a positive effect on its social, financial, and overall efficiency.
- The legal status of MFIs (or Jurisdictional form (JF)): The legal status of MFIs can also significantly impact their efficiency. The works of Gutiérrez-Nieto et al. (2007), Haq et al. (2010), and Abdelkader (2023) indicate that NGOs tend to focus on social efficiency, whereas bank-oriented MFIs prioritize financial profitability (Morduch 2000; Adair and Berguiga 2010; Mersland and Strøm 2009; Lafourcade 2005; Hassan and Sanchez 2009). Consequently, we hypothesize that NGO status is related positively to social efficiency and negatively to financial efficiency.
- Impact of grants (SUB): MFIs prioritizing social missions over profitability often rely on government and donor grants. According to Cull et al. (2007), subsidized MFIs have an advantage in reaching extremely poor clients. However, other studies show a negative relationship between subsidies and financial results. Bogan (2012) found that the increased use of subsidies in large MFIs decreased their operational self-sufficiency. Our hypothesis suggests that grants improve social efficiency but decrease financial efficiency.

- Lending type (individual/group lending) (LT): Individual lending models, while less costly and labor-intensive than group lending, are more common in urban areas where borrowers are less poor and seek loans for productivity purposes (Ledgerwood 1999). However, individual loans serve self-employed individuals rather than the poorest. Conversely, group loans are more likely to be repaid, as borrowers can use group members' pressure as a substitute guarantee to ensure loan repayment (De Aghion and Morduch 2005). We postulate that both loan types ensure loan repayment. Thus, the type of loan would have a positive impact on social efficiency and financial efficiency.
- Portfolio at risk (PAR): According to Sa-Dhan (2003), the portfolio at risk provides a pessimistic estimate of the default risk in MFI loan portfolios. Institutions with high PARs experience significantly lower net interest income and profitability rates. Sambili and Ngeno (2018) indicate that high-risk portfolios substantially reduce income from credit operations and negatively impact financial efficiency (Singh 2024). Moreover, this affects MFIs negatively, as it hinders access to debt financing from investors and donors. We hypothesize that high-risk portfolios significantly reduce income from credit operations and impair MFIs' ability to fulfill their social mission, negatively affecting both social and financial efficiency.
- Return on assets or profitability (RA): Return on assets is a ratio obtained by dividing net income by total assets. During the last few years, many microfinance institutions have prioritized financial goals over social objectives (Tang et al. 2020). This focus on financial outcomes has mostly guaranteed the survival of MFIs due to the radical slowdown of the funds contributed by governments and donors (Nourani et al. 2021); thus, we assume that profitability positively affects financial and social efficiency.
- Equity capitalization (EC): The ratio of equity to total assets indicates the financial health of MFIs. Bogan (2012, cited by Sambili and Ngeno (2018)) shows that well-capitalized MFIs are the most efficient financially and socially as they can attract commercial capital easily. We hypothesize that well-capitalized MFIs achieve both social and financial efficiency; therefore, there exists a positive relationship between equity capitalization and MFIs' efficiency.
- Gross domestic product (GDP): This serves as a proxy for the socio-economic environment in which MFIs operate (Chasmar 2009; Ahlin et al. 2011; González et al. 2007; Hartarska and Nadolnyak 2007). The relationship between GDP and MFI efficiency is complex. According to (Kablan 2012; Solhi and Rigar 2014) there is a significant positive relationship, suggesting that a higher GDP correlates with increased borrower incomes, facilitating larger loan amounts and ensuring repayment. However, other studies show no significant relationship and are rather resilient to economic shocks. We hypothesize that a lower GDP has a negative relationship between GDP and financial and social efficiency.
- Operational area (ZONE): According to the study of (Solhi and Rigar 2014; Cornée and Thenet 2016), MFIs targeting rural populations and underserved urban areas achieve higher financial and social efficiency. Serving populations without access to banking services enhances their operational effectiveness. Thus, there is a positive relationship between the operational area and both financial and social efficiency.
- Political environment (EP): Political stability enhances trust in the financial market, allowing MFIs to secure better financing and improve their financial efficiency. However, several studies indicate that a stable environment often results in MFIs being less effective in targeting the ones in need. We can assume that political stability positively affects financial efficiency, while it negatively impacts social efficiency.
- Several studies on the efficiency of MFIs have focused on the potential trade-off between financial efficiency (EF) and social efficiency (SE). Some research suggests a negative relationship between social outreach and financial viability (Louis et al. 2013; Pedrini and Ferri 2016). Conversely, other studies found no evidence of compromise, while some even identified a positive relationship between financial and social efficiency (Gakhar 2016; El Azzazy 2024). While the relationship between the social and

financial objectives of MFIs is still a topic of debate, most studies suggest a negative correlation between social and financial efficiency.

3. Methodology

The main focus of the study is to comprehend the MFIs' efficiency dynamic and its determinants in the African region. The use of Data Envelopment Analysis scores in linear modeling is a common approach. Academic examples[1] illustrate how DEA scores can be effectively used in regression models as they can provide valuable insights for difficult-to-measure variables like social outreach, organizational impact, and qualitative performance indicators. To this end, we follow a two-step approach: first, we measure the efficiency scores of MFIs using the specification of different DEA models, we then examine the main key factors of efficiency via panel data modeling by regressing the obtained scores on a series of explanatory variables.

3.1. An Overview of Data Envelopment Analysis (DEA)

In this work, we used a "Data Envelopment Analysis" (DEA), a "non-parametric" approach for relatively estimating the efficiency scores of decision-making units (DMUs) based on linear programming modeling. It has the advantage of benchmarking multi-dimensional inputs and outputs with no need to specify a mathematical form for the production function.

Moreover, the DEA estimation can be applied under two main hypotheses: Constant Returns to Scale (CRS), assuming all institutions (DMUs) operate at their optimal size, and the Variable Returns to Scale model, also referred to as the Variable Returns to Scale (VRS), assuming all organizations do not operate at their optimal size. The VRS estimation allows for variations in the scale of production or operation, better reflecting real-world characteristics, where increasing inputs may not always lead to proportional increases in outputs, which proves to be a more practical setting to adapt for this study.

Mathematically, the Variable Returns to Scale for a for a single DMU can be represented by the formula

$$Max_{\{\lambda,\theta)}\ \theta$$

subject to

$$\sum_{\{j=1\}}^{m} \lambda_j x_{\{ij\}} \ \leq \theta\ x_{\{is\}} \qquad \forall i$$

$$\sum_{\{s=1\}}^{s} y_{is} = \sum_{\{j=1\}}^{m} \lambda_j x_{\{ij\}} \qquad \forall j\ x_{\{ij\}}$$

$$\lambda_j\ \geq 0, \theta \geq 0$$

where

- λ_j: non-negative weight or multiplier for input j of *DMUi.*
- θ: efficiency score indicating the maximum output that *DMUi* can achieve relative to its inputs.
- $x_{\{ij\}}$: amount of input used by *DMUi*.
- y_{is}: amount of output s produced by *DMUi.*

The solution to this linear programming problem evaluates the efficiency of DMUs (which are the MFIs in our study) by comparing their capacity to transform inputs into outputs. However, for larger datasets, it is essential to utilize a professional statistical program. In our case, we employed the R software[2], allowing us to evaluate each MFI relative to its peers in the same region (see Sections A and B).

Selection of Inputs and Outputs

Input selection is based on the production approach, where financial institutions use manpower and physical resources to process transactions such as grant loans or

receive deposits, much in the same way in which a factory would use capital and labor to manufacture products for selling. After thoroughly reviewing the literature on DEA and financial institutions, we have settled for three inputs and four outputs that differ according to the model type (see the Table 1).

Table 1. Efficiency measurement models.

Model Type	Structure	Variables
Financial efficiency model	Inputs	Total assets
		Staff
		Operating costs
	Outputs	Financial income
		Loan portfolio
Social efficiency model	Inputs	Total assets
		Staff
		Operating costs
	Outputs	% of women borrowers
		Average loans granted
Overall efficiency model	Inputs	Total assets
		Staff
		Operating costs
	Outputs	Financial income
		Loan portfolio
		% of women borrowers
		Average loans granted

The selected inputs are the "*total assets*", which are largely used in the literature as a proxy for the capital factor (Solhi and Rigar 2014); the "*staff*", measured by the total number of employees, reflecting the important role that loan officers and other employees play in the operation and success of institutions; and the "*operating costs*", which are the operating expenses related to the MFI's functioning. On the financial side, "*Financial income*" and the "*loan portfolio*" are essential outputs that allow financial institutions to generate a financial return while ensuring their sustainability in the market. For the social aspect, a variety of proxies are suggested for evaluating their social outreach. Given the lack of harmonized social indicators, we have selected the most common variables in the literature like "*Percentage of women borrowers*"; studies indicate that the microfinance institution services offered were found to have a decisive influence on empowering disadvantaged and poor women by improving their livelihood and the development of their business (Abebe and Kegne 2023). The correlation analysis also indicated a positive and significant association between saving practices, access to credit, skill development training, and the development of women entrepreneurs. Also, the "*number of borrowers*" reflects the outreach of the program, i.e., the capacity of the institution to use its resources to serve the maximum number of clients.

The overall efficiency model refers to the combined efficiency of achieving both financial and social objectives. It reflects the integration of financial sustainability with social outreach. Essentially, an MFI is considered efficient overall if it achieves a good balance between profitability and its social impact.

In summary, while our financial and social efficiency models are more clearly defined, "overall efficiency" covers the holistic assessment of an MFI's performance in fulfilling its objectives.

We established a total of three efficiency models, one for every type of efficiency, under a Variable Returns to Scale hypothesis. Regarding the orientation of the models, the initial objective of an MFI is to achieve maximum impact (maximum output) using limited resources (inputs), which is aligned with an output orientation. However, the choice also depends on the quantities of inputs and outputs that managers can manage. For microfinance institutions, it is evident that managers have much more control over inputs than outputs. Therefore, and following the example of previous studies, we established input-oriented models where MFIs seek to minimize inputs for a given weight of outputs.

3.2. Panel Data Regression

The panel data represent a combination of time series and cross-sections, allowing for a consideration of the various aspects of heterogeneity in the dynamism of the MFIs. Note that panel data regression is a continuation of the previous data envelopment analysis, with the main purpose of assessing the MFIs' efficiency in African regions.

In order to study the effect of different factors on the efficiency of MFIs, three equations were established, for which the endogenous variables are represented by the efficiency scores estimated previously.

$$EF_{it} = \alpha_{it} Iv + \beta_{it} Fv + \delta_{it} EMv + \gamma_{it} ES + \varepsilon_{it} \quad (1)$$

$$ES_{it} = \alpha_{it} Iv + \beta_{it} Fv + \delta_{it} EMv + \phi_{it} EF + \varepsilon_{it} \quad (2)$$

$$EG_{it} = \alpha_{it} Iv + \beta_{it} Fv + \delta_{it} EMv + \phi_{it} EF + \gamma_{it} ES + \varepsilon_{it} \quad (3)$$

To make the models' equations easy to read, we have classified the variables into sets according to their type, where EF: financial efficiency; ES: social efficiency; EG: overall efficiency; Iv: institutional variables; Fv: financial variables; EMv: environmental/macroeconomic variables; α_{it}, β_{it}, δ_{it}, ϕ_{it}, γ_{it}: respectively, the coefficients for each variable for the ith MFI at time t; and ε_{it}: an error term.

The Table 2 provides a brief description of each variable separately.

Table 2. Description of variables.

Type	Abv.	Variable	Description	Unit of Measurement
Efficiency of MFIs	EF	Financial efficiency	Measured by the financial efficiency score (VRS)	Percentage
	ES	Social efficiency	Measured by the social efficiency score (VRS)	Percentage
	EG	Overall efficiency	Measured by the overall efficiency score (VRS)	Percentage
Financial variables	PaR	Portfolio at risk	Portfolio at risk > 30 days/loans portfolio	Percentage
	RA	Return on assets	Calculated by dividing the net profit generated by the MFI by the total assets	Percentage
	EC	Equity capitalization	The ratio of equity to total assets	Percentage
Institutional variables	SUB	Subvention	Whether the MFI receives grants (binary variable)	-
	FJ	Juridical form	Organization status of the MFI (ONG—Bank—Cooperation—FNB) (categorical variable)	-
	LT	Loan type	The loan technique used by the MFI (categorical variable)	-
	Zone	Geographic operating zone	The MFI's operating area (rural—urban)	-
	EXP	Experience	The difference between observation year (2018) and the birth date	Number
Environmental/Macroeconomic variables	EP	Political environment	A score based on the stability and political condition of the country in which the MFI operates	Percentage
	GDPc	Gross domestic product per capita	The GDP per capita is a measure of a country's economic output that accounts for its number of people	Percentage

Furthermore, we estimated three types of models for each equation—ordinary least squares (OLS), fixed effects models (LSDV and Within), and random effects models—for each type of efficiency (EF, ES, and EG). The first type assumes that all MFIs in Africa have an identical structure (full homogeneity). The second type is a fixed-effects model (LSDV and Within), which takes into account the characteristic of heterogeneity by specifying a different constant (fixed coefficients) for each individual (MFI). With the random effect model, the individual fixed coefficients become variable, adding the residual component w_{it} to represent the variability of each individual. It is necessary to choose an appropriate structure, using the selection test, to adequately explain their efficiency.

4. Data and Variables

Our sample contains 1330 observations, comprising data from 95 microfinance institutions from five regions of Africa and covering the years 2005 to 2018, the same regions as those used in the previous analysis. The majority of MFIs concentrate on Eastern and Western regions, representing 24% and 36% of the MFIs studied, respectively. Other countries such as Tunisia and Angola are represented by a single institution. The selection of MFIs by country is based on the number of institutions existing in each country and the transparency level of the data available in the Mixmarket database[3]. To avoid biased estimations, we exclude incomplete data that could hinder the scoring work for our DEA analysis and panel modeling. We focused exclusively on African MFIs whose financial information exhibits a very high level of reliability on the Mixmarket website. Our choice of Africa was based on various reasons, notably the maintenance of data homogeneity by selecting countries with cultural and socio-economic similarities. Furthermore, the African continent contains a mature and well-developed microfinance sector where a plurality of actors coexist, differing notably in their status and aims. The following Table 3 details the MFIs distribution by country and region.

Table 3. Distribution of African MFIs by region.

Regions	Countries	Number of MFIs	MFIs
EAST	Ethiopia	3	Buusaa Gonofaa, PEACE, Wasasa
	Kenya	6	Equity Bank KEN, Family Bank KEN, Faulu MFB, Jamii Bora, Sidian Bank, VisionFund Kenya
	Rwanda	2	Umutanguha Finance Company (UFC), Ltd-Urwego Bank
	Tanzania	5	Akiba, BRAC—TZA, FINCA—TZA, Opportunity Tanzania, PRIDE—TZA
	Uganda	7	BRAC—UGA, Centenary Bank, Finance Trust, FINCA—UGA, Opportunity Uganda, UGAFODE, VisionFund Uganda
WEST	Benin	6	ACFB, FECECAM, PADME, RENACA, SIA N SON, Vital Finance
	Burkina Faso	3	FCPB—BFA, GRAINE sarl, PAMF-BFA
	Ghana	6	ID Ghana, KSF, OISL, PanAfrican Savings and Loans, Sinapi Aba Trust, WWB Ghana
	Mali	3	CVECA Pays Dogon, Kafo Jiginew, RMCR
	Niger	5	ASUSU SA, COOPEC Hinfani Dosso, Kokari, MECREF, Accion MfB Nigeria
	Nigeria	6	DEC, Grooming Centre, Hasal MFB, LAPO-NGR, SEAP, ACEP Senegal
	Sengal	4	Baobab Sénégal, PAMECAS, U-IMCEC, CECA
	Togo	3	FUCEC Togo, UMECTO, WAGES

Table 3. *Cont.*

Regions	Countries	Number of MFIs	MFIs
CENTRAL	Angola	1	KixiCredito
	Cameroon	4	ACEP Cameroon, Advans Cameroun, CamCCUL, SOFINA SA
	Congo	3	CAPPED, FINCA—DRC, Hekima, PAIDEK
AUSTRAL	Madagascar	5	AccèsBanque Madagascar, CECAM, MicroCred—MDG, Otiv Tana, PAMF-MDG
	Malawi	3	CUMO, FINCA—MWI, OIBM
	Mozambique	5	AfricaWorks, CCOM, Hluvuku, MBC, SOCREMO
	Zambia	2	FINCA—ZMB, MicroLoan Foundation Zambia
NORTH	Egypt	5	ABA, Al Tadamun, CEOSS, DBACD, Lead Foundation
	Morocco	6	Al Amana, Al Karama, Attadamoune, ATTAWFIQ MICRO-FINANCE, Fondation Albaraka, INMAA
	Tunisia	1	Enda Tamweel

5. Empirical Results

In this section, we shall present our general observations and findings, including the DEA score estimates (see Appendix A) for 95 African MFIs between 2005 and 2018. Our results show that the efficiency estimates for the five African regions were relatively similar. Also, the financial efficiency model presents higher scores under the variable return assumption compared to the social model.

Moreover, the social scores vary inversely to the financial scores, which indicates a negative correlation between social and financial efficiency. This finding is also consistent with the literature (Gutiérrez-Nieto et al. 2009; Serrano-Cinca et al. 2011). More generally, our finding is in line with the work of Ullman (1985), who carried out an exhaustive review of empirical work on the link between financial and social performance in several microfinance sectors around the world and came to the conclusion that there is an equivocal relationship. Furthermore, the estimates of the overall efficiency of MFIs are closer to those of financial efficiency than to social efficiency, which can be attributed to the strong dependence of the MFI's performance on profitability rather than social outreach.

5.1. Financial Efficiency

According to the estimates presented in Table 4, the signs of most of the variables are more or less similar for the four estimated models. Thus, at the significance level, variables such as ES, EXP, PaR, and RA have *p*-values less than 5%, indicating that these variables contribute strongly to the explanation of the evolution of the financial efficiency of MFIs, regardless of the form of the model used.

Based on the selection tests (see Sections A and B), the LSDV assumption emerges as the most suitable and representative. Consequently, our interpretations will mainly rely on its estimations, as the LSDV model is the most appropriate. Social efficiency (SE) has a positive and highly significant impact at a 1% *p*-value; increasing social efficiency by one percentage point leads to a 0.089 change in financial efficiency.

Of the financial variables, equity capitalization has a positive impact, but is statistically insignificant (*p*-value less than 5%) and therefore does not contribute to explaining the MFIs' financial performance. The portfolio at risk has a negative effect, hindering the MFIs' financial efficiency; an increase in the PaR of 1 percent decelerates the EF by 0.205 percent. On the other hand, profitability positively affects the MFIs' financial efficiency with a high and significant coefficient equal to (0.390).

Table 4. Estimation of the financial efficiency panel model.

Variables	Model			
	OLS	**LSDV**	**Within**	**Random**
(Constant)	0.511 ***	2.094 ***	-	0.699 ***
t-stat	7.247	7.338		4.869
ES	0.136 ***	0.089 ***	0.089 ***	0.099 ***
t-stat	9.915	4.913	4.913	5.904
EXP	0.004 ***	0.015 ***	0.015 ***	0.007 ***
t-stat	4.806	8.265	8.265	6.306
EC	−0.006	0.019	0.019	0.019
t-stat	−0.401	1.136	1.136	1.148
PaR	0.159 *	−0.205 **	−0.205 **	−0.186 **
t-stat	2.494	−3.236	−3.23	−2.990
RA	0.335 ***	0.390 ***	0.390 ***	0.395 ***
t-stat	7.058	8.474	8.474	8.709
LT (I)	0.035	0.066	-	0.059
t-stat	1.377	0.737		0.911
LT (M)	0.072 ***	0.071	-	−0.0724
t-stat	4.702	1.180		−1.849
FJ (C)	−0.093	−0.031	-	−0.369
t-stat	−1.643	−0.321		−0.369
FJ (NBFC)	−0.0269	−0.042		−0.040
t-stat	−1.617	−0.490		−0.958
FJ (ONG)	−0.073	−0.180 **	-	−0.046
t-stat	−1.350	−2.950		−0.33
SUB (O)	−0.092 .	−0.037	-	0.082
t-stat	−1.662	−0.365		0.582
ZONE (U)	0.026 *	−0.106 .	-	0.023
t-stat	2.093	−1.79		0.748
EP	−0.001 **	0.001 **	0.001 **	0.000
t-stat	−3.041	2.729	2.72	0.724
GDPc	0.027 ***	0.184 ***	0.184 **	−0.006
t-stat	3.343	4.794	4.794	−0.344
R-Squared	0.178	0.52	0.14	0.11
F-Statistic	20.390 ***	13.624 ***	28.78	190.97 ***

Significance codes: '***' 0.001, '**' 0.01, '*' 0.05, '.' 0.1.

For the institutional variables, the coefficient of the EXP variable which represents the age of the institution is positive and highly significant, meaning that one more year of experience improves the financial efficiency of the MFI by 0.015; the estimates also show that the use of individual loans has no significant effect on financial efficiency, even though the coefficient has the expected sign (positive). The NGO's legal status shows a significantly negative impact of 0.180, indicating the incompatibility of this form with an institution that favors profits. Thus, from a statistical point of view, the grant variable is insignificant, even though it has an expected negative effect, while the Zone (urban) variable is negatively significant at a threshold of 10%. For the macro-environmental variables, the political environment has a significantly weak effect on financial efficiency (close to 0); as for GDP, the estimate indicates that it significantly influences FE with a positive coefficient of (0.184).

5.2. Social Efficiency

The optimal model for social efficiency is the random effects model. According to the results shown in the Table 5, it appears that the coefficient of financial efficiency is highly significant, which means that any increase of 1 percentage point results in a positive variation of 0.233 in social efficiency. The financial variables (EC, PaR, and RA) are insignificant because their p-values are greater than 5%, which may be due to the incompatibility of this type of variable with a social model. Concerning the institutional variables, unlike the financial efficiency model, the EXP variable seems to negatively impact social efficiency with a significant coefficient of 0.008, while the coefficient estimated for the individual loan mode is positive and significant only at a threshold of 10%.

Table 5. Estimation of the social efficiency panel model.

Variables	**Model**			
	OLS	**LSDV**	**Within**	**Random**
(Constant)	−0.035	−0.784 .	-	−0.040
t-stat	−0.254	−1.729		−0.136
EF	0.509 ***	0.216 ***	0.216 ***	0.233 ***
t-stat	9.915	4.913	4.913	5.435
EXP	−0.004 *	−0.011 ***	−0.011 ***	−0.008 ***
t-stat	−2.217	−3.783	−3.783	−4.076
EC	0.171 ***	0.013	0.0135	0.0246
t-stat	5.464	0.504	0.504	0.930
PaR	−0.112	−0.129	−0.129	−0.112
t-stat	−0.904	−1.303	−1.303	−1.142
RA	−0.292	−0.052	−0.0529	−0.072
t-stat	−3.137	−0.718	−0.718	−0.992
LT (I)	−0.073	−0.548 ***	-	0.096
t-stat	−1.476	−3.899		0.648
LT (M)	0.078 **	−0.007	-	0.067
t-stat	2.617	−0.0803		0.748
FJ (C)	0.676 ***	1.585 ***	-	0.620
t-stat	6.210	11.031		1.878
FJ (NBFC)	0.043	8.274 ***	-	0.0630
t-stat	1.345	6.198		0.650
FJ (ONG)	0.469 ***	7.465 ***	-	0.401
t-stat	4.480	7.998		1.267
SUB (O)	0.312 **	0.206	-	0.220 *
t-stat		2.925		0.683
		1.284		
ZONE (U)		0.066 **	−0.027	0.054
t-stat	2.696	−0.293		0.74
EP	−0.001 **	−0.000	−0.000	−0.000
t-stat	−2.673	−0.048	−0.048	−0.367
GDPc	0.011	0.110	0.110	0.0507
t-stat	0.698	1.824	1.82	1.408
R-Squared	0.165	0.68	0.032	0.041
F-Statistic	18.626 ***	26.965 ***	5.825 ***	57.051 ***

Significance codes: '***' 0.001, '**' 0.01, '*' 0.05, '.' 0.1.

The NGO's legal status has a positive effect of 0.401 on social efficiency and a low level of significance (p-value < 10%). The estimation of the grant variable shows that grant

funding positively influences the social efficiency of an MFI with a significant value of 0.220. Likewise, the zone of operation (urban) positively affects social efficiency (0.054), but statically this variable is not significant. The estimates for the macro-environmental variables are generally statistically insignificant, with a negative impact (close to 0).

5.3. Overall Efficiency

Although the overall efficiency model has the same optimal structure as the social efficiency model (random effect), the parameter estimation shown in Table 6 indicates similar results (in terms of signs) to the financial efficiency model. However, the significance of the variables is weak compared to the previous models, which may be due to the biased estimation of the model in general.

Table 6. Estimation of the overall efficiency panel model.

Variables	**Models**			
	OLS	**LSDV**	**Within**	**Random**
(Constant)	0.320 ***	0.898 ***	-	0.352 ***
t-stat	8.854	5.558		5.617
EF	0.613 ***	0.631 ***	0.631 ***	0.630 ***
t-stat	44.320	39.933	39.933	42.54
ES	0.149 ***	0.163 ***	0.163 ***	0.154 ***
t-stat	20.923	16.100	16.100	17.38
EXP	−0.001 *	0.002 *	0.002 *	−0.0002
t-stat	−1.963	2.522	2.522	−0.462
EC	−0.017 *	0.011	0.011	0.0041
t-stat	−2.107	1.203	1.203	0.466
PaR	0.041	−0.029	−0.029	−0.010
t-stat	1.268	0.035	−0.845	−0.321
RA	0.104 ***	−0.004	−0.004	0.025
t-stat	4.302	−0.179	−0.1794	1.009
LT (I)	0.0283 *	0.079	-	0.031
t-stat	2.197	1.569		1.181
LT (M)	0.023 **	0.050	-	0.0225
t-stat	2.944	1.503		1.428
FJ (C)	−0.041	−0.044	-	−0.030
t-stat	−1.430	−0.821		−0.5314
FJ (NBFC)	−0.009	−0.185 ***	-	−0.011
t-stat	−1.1747	−3.833		−0.672
FJ (ONG)	−0.029	−0.029	-	−0.016
t-stat	−1.088	−0.858		−0.291
SUB (O)	−0.013	−0.145 *	-	−0.521
t-stat	−0.478	−2.546		−0.521
ZONE (U)	−0.023 ***	0.021	-	−0.0233
t-stat	−3.713	0.661		−1.814
EP	0.000	0.001	0.0006	0.0003
t-stat	0.0529	1.942	1.942	1.618
GDPc	0.002	0.073 ***	0.073 ***	0.004 .
t-stat	0.615	3.407	3.407	0.546
R-Squared	0.729	0.811	0.654	0.671
F-Statistic	236.50 ***	51.640 ***	290.70 ***	2688.31 ***

Significance codes: '***' 0.001, '**' 0.01, '*' 0.05, '.' 0.1.

6. Discussion

These empirical findings confirm that financial efficiency (FE) is positively influenced by profitability, equity capitalization, loan type (individual or group), experience, and environment stability, while it is negatively affected by the portfolio at risk, grants, NGO legal status, and operating zone (rural or urban). Profitability significantly enhances the financial efficiency of microfinance institutions, as profitable MFIs can acquire capital at lower costs, leading to higher returns.

The results also confirm that MFI capitalization positively affects both financial and social efficiency. The more highly capitalized the MFI, the more funds it has available to cover itself against the significant risks that result from lending activities.

Furthermore, the type of loan has a positive impact on both the financial and social efficiency of MFIs. Group-based loans, in particular, are more likely to be repaid than individual loans. Borrowers can use the pressure of group members as collateral to ensure repayment of the loan because each member cannot let the others down through the social penalties imposed. In other words, group-based lending ensures a guarantee of repayment and also lowers administrative expenses.

While the age of the institution positively influences its financial efficiency, it concurrently has a negative impact on its social efficiency. These findings are consistent with those of Ahlin and Lin (2006); Mueller and Uhde (2009); and Wijesiri et al. (2017). Although older MFIs perform better than younger ones in terms of achieving financial objectives, they are relatively inefficient in achieving outreach objectives.

Furthermore, there is a significant positive relationship between financial efficiency and GDP per capita, which serves as a proxy for the socioeconomic status of clients, indicating that clients with a higher socio-economic status enhance financial efficiency and performance. Additionally, political stability significantly boosts financial efficiency by fostering trust among market participants, including MFIs, private lenders (banks), and clients.

Theoretically, the main source of risk for any MFI is its unsecured loan portfolio. which is consistent with the negative correlation between the PaR variable and financial efficiency, meaning that a high-risk loan portfolio will reduce the return on microcredit activities and negatively affect the MFI's financial performance.

The results indicate that NGO legal status and grant funding weaken the financial sustainability of microfinance institutions, corroborating the findings of Morduch (2000), Hudon and Traca (2011); D'Espallier et al. (2013); Bogan (2012); and Caudill et al. (2009). Additionally, MFIs operating in rural areas incur higher operating costs, which reduces their profitability. This is consistent with the studies of Mersland and Strøm (2009), Ferro-Luzzi and Weber (2006), and Berguiga (2011).

On another hand, social outreach is profoundly influenced by institutional status (NGO), which can significantly enhance the social outreach of a microfinance bank, particularly by providing access to funding and community engagement, which enable the microfinance institution to reach more underserved populations. This aligns with the findings of Thompson and Hartaska (2008) and Besley and Ghatak (2005), who argue that donor support ensures that NGOs can sustain their social missions over time. Moreover, MFIs operating in rural areas are more likely to target the poorest members of society. This geographic targeting strategy, supported by Welfare theorists, enhances the social efficiency of MFIs, corroborating our research findings.

Maintaining very high-risk portfolios could significantly reduce income, thus hindering microfinance institutions from fulfilling their social mission. Our results indicate that profitability adversely affects social efficiency, implying that more profitable MFIs tend to provide more loans to less impoverished clients, thereby systematically reducing their social impact. These findings align with those of Solhi and Rigar (2014) and Kablan (2012), in contrast to the findings of Lebovics et al. (2016).

Funding from governments and donors appears to adversely affect the social efficiency of MFIs, as it can sustain inefficient institutions only in the short term (Conning 1999).

The age of MFIs proves to have a negative impact on their social performance: the more mature an MFI, the less it tends to favor social outreach. Conversely, mature MFIs often present greater financial efficiency by managing loan risks effectively and reducing defaults. Additionally, the political environment also negatively influences MFI performance. A stable political climate correlates with lower social scores for MFIs. Political instability in these regions has increased poverty, further complicating outreach efforts.

Finally, it is important to note that the growing emphasis on financial performance over social outreach has sparked a demand for standardized and independent social ratings among donors, managers, and shareholders. They typically seek means that can evaluate both the financial and social orientations of MFIs, ensuring that their actions align with their stated intentions (Urgeghe 2010), which will help guide strategic and operational decisions, promoting a path towards improved alignment and achieving financial sustainability while maximizing social impact.

7. Conclusions

In a constrained environment where sustaining institutions without making a profit is challenging, microfinance proves to be a transformative force. By thriving in the market by providing small-scale financial services such as microloans, savings accounts, and insurance to low-income individuals and entrepreneurs, microfinance empowers people to start or expand small businesses, improve their livelihoods, and build resilience against economic shocks. This inclusive financial approach not only fosters economic independence and self-sufficiency but also stimulates local economies, promotes social stability, and contributes to long-term sustainable development. Microfinance institutions operate much like traditional banks but with a main focus on serving vulnerable communities and individuals aiming to initiate or expand their businesses and projects. Achieving their dual mission of profitability and maximizing their social impact presents significant challenges, particularly when assessing their social dimension, due to limited available social indicators. In this study, our primary goal was to evaluate the efficiency of microfinance institutions in achieving their financial and social roles. Secondly, we aimed to identify the key factors impacting their efficiency.

The study sample includes 95 MFIs from five African regions (2005 to 2018) that share similar social and economic conditions. Using the non-parametric approach of a data envelopment analysis, we estimated three types of efficiency: financial, social, and a third one that combines both into overall efficiency. The estimation result for these models indicates a negative correlation between social and financial efficiency. Additionally, the majority of these MFIs' overall efficiency estimates align more closely with their financial efficiency than with their social efficiency, meaning that these institutions' performance is more strongly influenced by profitability than by social outreach.

In the second part of our empirical study, we continue by regressing the efficiency scores on groups of explanatory variables: financial variables that reflect the organization's financial health and performance, institutional variables related to each MFI's specific characteristics, and environmental/macroeconomic variables that represent external factors that influence economic conditions and business operations. Our panel modeling results prove that African microfinance institutions' financial efficiency is positively influenced by profitability, equity capitalization, loan type, experience, and environmental stability. Conversely, it is negatively impacted by the portfolio at risk (PaR), subvention, NGO legal status, and the operational area. Profitability significantly enhances the financial efficiency of microfinance institutions, as profitable MFIs can acquire capital at lower costs, resulting in higher returns.

The estimates also indicate that an MFI's capitalization positively affects both its financial and social efficiency. Higher capitalization allows MFIs to cover significant risks from lending activities. Additionally, the type of loan impacts MFI efficiency; group loans, in particular, are more likely to be repaid than individual loans due to peer pressure within the group, which acts as a guarantee and reduces administrative costs. Moreover, the maturity of an MFI positively influences its efficiency, likely due to accumulated experience. However, it also limits its social impact, which can be explained by a shift in focus towards

profitability at the expense of social outreach. Through this study, our optimal goal was to deepen our understanding of the world of microfinance by assessing the efficiency of its institutions and identifying factors that could potentially enhance it further and strengthen its role in achieving development objectives by fostering economic growth.

However, all research has limitations, and this study is no exception. Future research could build on this work to deepen our understanding of MFIs. One key limitation is the use of the non-parametric DEA method, which cannot detect random effects and is sensitive to data errors and outliers. Therefore, the careful selection of inputs and outputs is essential for accurate results. Another limitation lies in the focus on unidimensional efficiency, without considering the multidimensionality of efficiency, which includes productive efficiency, allocative (economic) efficiency, and technical efficiency. And last, the limited numbers of variables used were due to the difficulty in gathering data across multiple institutions over extended periods.

Lastly, we hope this research can establish a foundation for future studies seeking to optimize microfinance institutions and enhance their financial viability and social impact. Subsequent research could explore advanced methodologies that incorporate variables such as economic crises or robust social indicators to further refine our understanding.

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Appendix A

Table A1. Estimates of the average efficiency scores (ES, EF, and EG) of the East African region.

	Type of Efficiency	Returns	stat.	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
EAST REGION	ES	VRS	Mean	62%	64%	69%	68%	76%	64%	65%	66%	68%	64%	60%	57%	57%	47%
			% Efficients MFIs	43%	48%	52%	43%	57%	48%	39%	35%	35%	39%	30%	35%	35%	30%
	EF	VRS	Mean	79%	80%	86%	88%	87%	88%	92%	90%	95%	95%	90%	85%	89%	88%
			% Efficients MFIs	43%	43%	43%	52%	48%	43%	52%	48%	52%	70%	57%	43%	57%	57%
	EG	VRS	Mean	89%	90%	95%	94%	94%	93%	95%	93%	98%	97%	92%	91%	94%	93%
			% Efficients MFIs	74%	78%	83%	83%	78%	65%	74%	65%	74%	87%	70%	65%	74%	74%

Table A2. Estimates of the average efficiency scores (ES, EF, and EG) of the West African region.

	Type of Efficiency	Returns	stat.	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
WEST REGION	ES	VRS	Mean	41%	44%	42%	43%	40%	39%	48%	43%	39%	38%	39%	45%	41%	40%
			% Efficients MFIs	25%	25%	25%	25%	25%	25%	31%	33%	25%	25%	28%	28%	28%	28%
	EF	VRS	Mean	67%	74%	75%	76%	77%	73%	72%	77%	78%	76%	78%	81%	86%	86%
			% Efficients MFIs	28%	33%	36%	36%	31%	28%	25%	31%	28%	19%	25%	28%	36%	36%
	EG	VRS	Mean	81%	82%	83%	83%	84%	79%	80%	83%	84%	84%	85%	90%	91%	92%
			% Efficients MFIs	50%	53%	56%	50%	50%	44%	42%	50%	47%	44%	47%	53%	56%	56%

Table A3. Estimates of the average efficiency scores (ES, EF, and EG) of the Central African region.

	Type of Efficiency	Returns	stat.	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
CENTRAL REGION	ES	VRS	Mean	70%	90%	88%	76%	77%	80%	81%	81%	81%	74%	84%	86%	86%	82%
			% Efficients MFIs	44%	78%	78%	56%	67%	78%	78%	78%	78%	67%	78%	78%	67%	67%
	EF	VRS	Mean	82%	98%	95%	96%	95%	92%	94%	90%	94%	94%	94%	96%	94%	96%
			% Efficients MFIs	44%	78%	67%	78%	78%	67%	67%	56%	78%	78%	78%	78%	67%	67%
	EG	VRS	Mean	90%	100%	100%	98%	97%	96%	97%	96%	97%	97%	98%	99%	99%	100%
			% Efficients MFIs	67%	100%	100%	89%	89%	89%	89%	89%	89%	89%	89%	89%	89%	89%

Table A4. Estimates of the average efficiency scores (ES, EF, and EG) of the austral African region.

	Type of Efficiency	Returns	stat.	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
AUSTRAL REGION	ES	VRS	Mean	74%	70%	72%	76%	63%	53%	49%	56%	53%	55%	53%	63%	65%	63%
			% Efficients MFIs	60%	47%	47%	67%	27%	27%	33%	27%	27%	27%	27%	40%	40%	33%
	EF	VRS	Mean	85%	82%	92%	58%	49%	53%	75%	77%	85%	85%	87%	93%	90%	90%
			% Efficients MFIs	53%	53%	53%	33%	53%	27%	33%	33%	40%	47%	53%	73%	60%	60%
	EG	VRS	Mean	96%	92%	97%	82%	69%	63%	79%	81%	87%	91%	88%	94%	91%	92%
			% Efficients MFIs	87%	80%	73%	73%	53%	33%	47%	40%	47%	60%	53%	80%	73%	73%

Table A5. Estimates of the average efficiency scores (ES, EF, and EG) of the North African region.

	Type of Efficiency	Returns	stat.	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
NORTH REGION	ES	VRS	Mean	74%	86%	80%	79%	77%	85%	78%	67%	78%	79%	77%	79%	75%	65%
			% Efficients MFIs	58%	67%	67%	67%	50%	75%	58%	50%	58%	50%	50%	50%	50%	42%
	EF	VRS	Mean	84%	89%	91%	92%	90%	95%	96%	94%	91%	93%	94%	93%	92%	94%
			% Efficients MFIs	58%	67%	67%	67%	50%	75%	58%	50%	58%	50%	50%	50%	50%	42%
	EG	VRS	Mean	93%	94%	92%	96%	98%	99%	100%	97%	98%	99%	100%	100%	98%	98%
			% Efficients MFIs	83%	83%	75%	83%	75%	92%	100%	75%	92%	92%	75%	100%	92%	92%

Appendix B

➢ **Selection tests for panel models:**

- **Hsiao tests**

Table A6. Results of model selection tests.

Tests	EF	ES	EG
Fisher 1	10.478 ***	23.789 ***	6.072 ***
	(RH0)	(RH0)	(RH0)
Fisher 2	1.3672	0.57974	0.371
	(AH0)	(AH0)	(AH0)
Fisher 3	2.2624 ***	1.5563 ***	3.560 ***
	(RH0)	(RH0)	(RH0)

Significance codes: '***' 0.001.

- The first Fisher test detects whether there is a total homogeneity of the sample under the null hypothesis of complete homogeneity (an OLS model), meaning all coefficients (constants and slopes) in the models are identical for all individuals.

- The second Fisher test is for determining the source of the existing heterogeneity; we test whether all the coefficients of the model, except the constants, vary between individuals, with the null hypothesis of homogeneity in the slopes.
- The third Fisher test involves testing for the presence of individual effects under the null hypothesis of the absence of individual effects in the model.

- **Hausman test**

Table A7. Results of Hausman test.

Test Stat.	EF	ES	EG
chi-squared	31.728 **	19.305	15.659
	(RH0)	(AH0)	(AH0)

Significance codes: '**' 0.01.

The Hausman test is for choosing between a fixed effects model or a random effects model, based on the null hypothesis that the suitable model is random effects. The alternate hypothesis is that the model has fixed effects.

➢ **Diagnosis of selected models:**

To ensure the reliability of the selected models, we carried out several tests, including the test for an absence of error autocorrelation, the test for error normality, the test for homoscedasticity (stability of error variance), and the test for sequential dependence (Breusch–Pagan LM test).

- **Breusch–Godfrey test:**

Table A8. Result if Breusch-Godfrey test.

Stats	EF	ES	EG
Chisq	404.14	377.48	238.41
p-value	(0.0731)	(0.0599)	(0.0706)

The results of the Breusch–Godfrey test across various models of social, financial, and overall efficiency show critical probability values exceeding the (5%) threshold, which indicates that the errors from all models are not autocorrelated. The hypothesis of no autocorrelation of errors is confirmed.

- **Error normality test (Jarque–Bera test):**

The Jarque–Bera test of normality assumes a null hypothesis that the errors follow a normal distribution. The Jarque–Bera statistic is calculated based on two shape coefficients (Skewness and Kurtosis) that measure asymmetry and flatness, forming the foundation for most normality tests

Table A9. Result of Jarque–Bera test.

Stats	ES	EF	EG
Jarque–Bera statistic	114.529	317.12	217.12
p-value	0.0832	0.0694	0.0584

The probability values are generally higher than 5%, leading us to accept the null hypothesis of the Jarque–Bera test, which states that the errors follow a normal distribution.

- **Homoscedasticity Test (Error Variance Stability)**

Table A10. Result of homoscedasticity test.

Stats	EF	ES	EG
Valeur (LM[4]) value	11163	13061	8921.10
p-value	(0.1270)	(0.1305)	(≈0)
(CD[5]) value	3.0582	2.9411	1.4281
p-value	(0.222)	(0.3207)	(≈0)

According to the results in the table above, Pesaran's CD and Breusch–Pagan's LM tests, which are used to assess sequential dependence among individuals, show critical probabilities significantly higher than 5% for the social and financial efficiency models. This leads us to accept the hypothesis of no sequential dependence. However, for the overall efficiency model, both tests have *p*-values of less than 5%, indicating the presence of sequential dependence. Therefore, the estimates of this model may be biased.

Notes

1 Klimberg et al. (2009). Using regression and a data envelopment analysis (DEA) to forecast bank performance over time. In *Financial modeling applications and data envelopment applications* (pp. 133–42). Emerald Group Publishing Limited.

2 All estimates were made using the R software package-deaR- version 1.2.1.

3 Most of the data in our sample come from the MIXMARKET database (https://databank.worldbank.org/source/mix-market, accessed on 1 January 2019), which is considered the most reliable source of information on microfinance institutions at an international level. These data have been supplemented with macroeconomic variables from the relevant countries, which we collected from the World Bank website (https://databank.worldbank.org, accessed on 1 January 2019).

4 LM: the *Lagrange multiplier.*

5 CD: *cross-sectional dependence.*

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Exploring the Usefulness of Real Options Theory for Foreign Affiliate Divestments: Real Abandonment Options' Applications

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Abstract: Scholars propose that future research on real options theory should shift attention away from option buying during the first investment stage and toward option execution after investment. Researchers maintain that it would be interesting to explore the circumstances under which investors decide to withdraw their investments, thereby exercising the option to abandon their investments. The present research seeks to fill the gap in the literature and investigate the applicability of real options theory when an organization enhances sustainability policies while focusing on disciplined capital allocation through exit strategies. With case study data on Natura &Co's divestment strategy for the Body Shop in November 2023, a real options analysis revealed the method's practical advantages and disadvantages. This paper investigates real options theory in the context of the divestments of foreign affiliates, providing unique viewpoints and enhancing the theory beyond previous knowledge while also increasing our understanding of the divestiture phenomenon. This study concludes with a review of this paper's theoretical contributions to real options theory, the managerial and practical/social implications of real options applications in general, and the valuation methods of abandonment options in particular, shedding light on the potential of future research.

Keywords: international business; restructuring; divestment; real options

1. Introduction

In a recent publication, Sakhartov et al. (2024) asked "Are real options useful for management research?" Sakhartov et al. argued that the question rightfully raised by Adner and Levinthal (2004) twenty years ago in the Academy Management Review "was a graceful invitation to clarify the real options theory and to enrich it with considerations typical to management research" (Sakhartov et al. 2024, p. 1).

Furthermore, Tong and Li (2011) proposed that future research should redirect our focus from option buying at the initial investment stage to option execution at the post-investment stage. For example, it would be intriguing to investigate the circumstances under which investors decide to leave their investments (Tong and Li 2011) by exercising the option to abandon. The current research addresses this gap caused by a lack of empirical evidence or data by investigating the circumstances and international settings under which multinational firms choose to leave their investments in foreign affiliates by exercising the option to abandon.

Scholars have urged that additional research should be conducted on the practical use of real-world options (Reuer and Tong 2007; Driouchi and Bennett 2012). Capturing case study data on the actual use of real options analysis can assist researchers in understanding the method's practical strengths and drawbacks. Furthermore, Adner and Levinthal (2004) and Reuer and Tong (2007) advocated for additional research on topics such as abandonment options. Despite these prospective advantages for further research on the applicability of real options theory, none of the empirical studies have examined real-world options (Ipsmiller et al. 2019). The current study fills a gap in the body of empirical

research by conducting a quantitative examination of the application of the real option of abandoning using the Black–Scholes option pricing model, the Binominal Option Pricing Model, and the option of abandoning with changing strike prices and its impact on the option's premium when a multinational corporation decides to divest oversea affiliates.

Damaraju et al. (2015) argued that, even though real options theory keeps being employed in the study of a variety of investment decisions under scenarios involving uncertainty, little research has explored the impact of this reasoning on divestment decisions—for example, the decision to divest business units (abandon the option). In this vein, this study aimed to investigate the applicability of real options theory to international business research when investors decide to exit their investments by exercising so-called put options, i.e., the option to abandon.

Research finds evidence that previous studies on the prediction of real options theory found that, when a business unit's environment is uncertain, corporations are cautious about selling subsidiaries and prefer to keep their divestment options open (Zingales 1995; Damaraju et al. 2015). However, the present investigation has empirically contributed to real options theory and demonstrated that MNEs gain value by abandoning an option that would have resulted in considerable losses if left open.

More recent research on foreign affiliate divestments has shown that real options considerations can delay exit choices, even when affiliates perform poorly and under unclear macroeconomic conditions (Belderbos and Zou 2009; Damaraju 2008; Damaraju et al. 2015). In contrast, the findings of this study reveal that total divestments may be better than deferring options when the business environment is highly uncertain. As a result, the findings of this study oppose the assumptions which suggest that gradually implemented divestment is preferable to complete divestment in uncertain conditions (e.g., Huchzermeier and Loch 2001; Trigeorgis 1997; Damaraju et al. 2015).

This study posed two research questions. First, in what circumstances and international contexts do international corporations decide to leave their investment in foreign affiliates by exercising the option to abandon? Second, how is the premium of the option to abandon valued when an international corporation decides to divest foreign affiliates?

In answering these research questions, this study on real abandonment options makes various contributions to the field. The first is the empirical nature of the research. This paper presents a case study of a real-world strategic project in which abandonment options were exercised and analyzed. The second contribution is the interdisciplinary approach. After investigating the usefulness of real options theory for foreign affiliate divestments, this study identified a rich tapestry of research prospects in the intersection of international business, strategic management, and financial management, and proposed several hypotheses for future quantitative research.

The third contribution is a proposal to advance the methodology. In terms of the research methodology, this study proposes a hybrid research model that combines standard option pricing methods such as the BSOPM with the BOPM and real abandonment options with changing strike prices as a sophisticated methodology to improve the research's accuracy and efficiency. In fact, incorporating changing strike prices introduces additional complexity into the option valuation process. However, the proposed model is needed for the risk management of MNEs because the ability to adjust the strike price provides greater flexibility in managing the option, allowing MNEs to have more nuanced decision making.

The rest of the current paper is organized as follows. This paper initially outlines real options theory and its application in investment decisions. Next, this paper explores the limited research on real options abandonment, including measurement methods, benefits, and drawbacks. Two theoretical propositions summarize a key literature review outcome. Next, this paper explores a case study on Natura &Co's divestment strategy for the Body Shop in November 2023. Having applied the Black–Scholes option pricing model (BSOPM) and Binominal Option Pricing Method (BOPM) with changing strike prices, the value of this abandonment option has been measured. The key conclusions of this empirical research justify the theoretical propositions and are congruent with the theory of real options. A

higher uncertainty in a foreign affiliate strategic setting may lead to a complete divestment (sell-off) strategy.

In other words, the paper's empirical findings imply that, having exercised the real option to abandon that may have been incorporated in the strategic choice due to a highly uncertain context, an international corporation can add more value than by exercising deferral options. In conclusion, the paper discusses its theoretical contributions to real options theory, practical managerial implications for real options applications and abandonment option valuation, and potential avenues for future research.

2. Key Literature Review

2.1. Real Options Investment: Definition, Types, and Reasoning

Real options investments are defined as sequential, definitive investments carried out in uncertain circumstances (Dixit and Pindyck 1994). According to the concept, obtaining a real option on a strategically important opportunity allows enterprises to postpone investment until a significant percentage of the uncertainty surrounding the opportunity is resolved. After making an initial investment, management should shift its focus to other concerns and wait for a signal indicating whether it is time to begin harvesting or grow the initial investment (Adner and Levinthal 2004).

In numerous strategic settings, a comprehensive valuation of M&A deals is an essential strategic responsibility; practitioners often accomplish this with high accuracy using a thorough discounted free cash flow (DFCF) valuation and scenario-based analysis. However, in settings where significant uncertainty and managerial adaptability are involved, such as flexibility to change paths, move forward, or abandon, the value of such flexibility must be explicitly considered (Chevalier-Roignant and Trigeorgis 2011). This flexibility may allow for capitalizing on positive market developments or reducing the impact of negative changes in the marketplace, and thus affects strategic choices (Chevalier-Roignant and Trigeorgis 2011, p. 198).

Tong and Li (2011) stated that initial investments provide investors with the option to grow, delay, or abandon. The ability to abandon a "bad" investment is critical to the flexibility advantage, as seen in a sequential strategic acquisition of a target company, because downside risk can be contained by exercising the option to defer, or resources can be redirected to other, more promising projects by exercising the option to abandon (Tong and Li 2011; Sahlman 1990).

However, Adner and Levinthal (2004) argued that the problem of abandonment is exacerbated by the fact that most abandoned options for strategic opportunities lack a specific, extrinsic expiration time. Indeed, the problems of discontinuing a venture may be greater than those of initiating it (Adner and Levinthal 2004). How much longer can a corporation keep the abandonment option open?

2.2. Options for Abandoning: Argumentation

Conventionally, most expansion options are akin to long calls, whereas abandonment options and several switching options may be technically viewed as long puts (Mun 2002, p. 100; Damodaran 2005). Unlike most other real options, an abandonment option is a long-put option whose value on a large scale depends on the irreversibility of the real assets—as sunk costs increase, the exit option's value decreases (Rivoli and Salorio 1996).

An abandonment option is sometimes regarded as a switching option, and, in such a way, management strives to look good, by keeping, often futilely, the project going despite its obvious deficiencies (Mun 2002, p. 245). Alternate names or sub-types of an option to abandon include the exit option (Schwartz and Trigeorgis 2004) and the disinvestment option (Mauboussin 1999). Therefore, the abandonment option provides the possibility to terminate a loss-bearing or criteria-failing undertaking (Mauboussin 1999).

Damaraju et al. (2015) argued that most real options scholars appear to have adopted the premise that divestment decisions—the exercise of so-called put options—can be analyzed using the same real options logic as investment decisions (Damaraju et al. 2015;

Dixit and Pindyck 1994). However, according to Damaraju et al. (2015), while there is growing literature on the impact of real options logic on strategic investments, there is limited research on its implications for the option to abandon.

As doubt about future cash flows is clarified, investors may choose to abandon a corporation for its liquidation value. Berger et al. (1996) clarified that an abandonment option is the same as an American put option and is analogous to buying an insurance policy that pays out if the company performs below expectations.

Options are flexible not because they replace a stream of installments with a larger lump sum payment, but because the payment process can be canceled in the event of a poor outcome (Adner and Levinthal 2004). Abandonment is vital for lowering downside risk, which is a key component of real options investments.

However, Adner and Levinthal (2004) argued that flexibility in the pursuit of growth options can erode the flexibility related to abandonment options. Moreover, Adner and Levinthal (2004) ultimately maintained that any strategic investment in which precise abandonment circumstances cannot be established ex ante should not be considered a real option (McGrath et al. 2004).

However, imposing a strict time frame for exercising or abandoning the strategy increases the danger of quitting the project prematurely if the expected event occurs after the imposed date, or not exercising the option if the positive event comes "too early" (i.e., before the imposed date) (Zardkoohi 2004).

Zardkoohi (2004) argued that the primary rationale for investing in options is to enhance flexibility. Forecasting a certain date for exercising or abandoning an option diminishes the original flexibility for which the option was obtained. Adner and Levinthal's (2004) assertion that real options without explicit dates for abandoning should not be called options is challenging to argue empirically.

Most business organizations possess rules and procedures, performance evaluation criteria, and other methods to prevent the systematic pursuit of failing strategies (Zardkoohi 2004). Some previous empirical studies have begun to investigate the implications of real options theory for divestment decisions.

For example, Alibeiki and Lotfaliei (2022) considered and applied a real abandonment option for Ford Motor Company and battery storage investments for electricity distribution networks. Borges et al. (2018) have shown that an application to calculate the real abandonment option for petroleum-producing fields can easily be used for project valuation under uncertainty. Fleten et al. (2017) have examined empirically the decisions to abandon existing production using information from 1,121 individual electric power generators located in the U.S. for the period 2001–2009.

Compernolle et al. (2014) demonstrated when the option to abandon innovative technology is considered regarding the adoption of an innovative groundwater remediation strategy. These findings align with the predictions of real options theory for divestments. In this vein, real options theory can provide valuable insights for international business (IB) research to understand the implications of international holding corporations' decisions about whether to divest foreign affiliates in uncertain strategic settings.

Proposition 1. *Real abandonment options can be applied in IB studies to provide a fair estimation of market value added when an international corporation divests foreign affiliates in the context of complex strategic settings.*

2.3. Valuation of Options to Abandon: Simple Version and with Changing Strike Prices

The option to abandon is a put option, which has value if the underlying asset value (current market value) falls below the strike price (selling price) and earns value as the strike price rises. In contrast, a call option has no value if the asset value is less than the strike price, and its value increases as the strike price falls. According to Hull (2012), the

Black–Scholes formula for the price of the put option at date $T = 0$ before maturity is given in Equation (1) as follows:

$$p = K\, e^{-r_f T}\, N(-d_2) - So\, N(-d_1) \tag{1}$$

where p is the price of the put option, and $N(d)$ is the cumulative probability distribution for a variable that has a standard normal distribution with a mean of zero and a standard deviation of 1. The area under the standard normal density function from $-\infty$ to d is the likelihood that a random draw from the standard normal distribution would have a value less than or equal to d. Therefore, an analyst gets that $0 \leq N(d) \leq 1$ with $N\,(-\infty) = 0$, $N(0) = \frac{1}{2}$ and $N(+\infty) = 1$. The term r_f is the continuously compounded risk-free rate of interest, and d_1 and d_2 satisfy Equations (2) and (3).

$$d_1 = \frac{\ln\left(\frac{So}{K}\right) + \left(r_f + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} \tag{2}$$

$$d_2 = \frac{\ln\left(\frac{So}{K}\right) + \left(r_f - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} \tag{3}$$

Here, σ is the volatility of the underlying asset, So is the price of the underlying assets at time zero, and e is a mathematical constant approximately equal to 2.71828, the base of the natural logarithm. A European put option with a strike price of K at maturity date T gives the right to sell underlying assets So at the strike price of K (Hull 2012, pp. 313–14). The Black–Scholes calculations are difficult because they rely on the geometric Brownian motion assumption for the underlying asset price. In this vein, the Black–Scholes option-pricing model is more accurate, but less intuitive for valuing real options than the binominal model (Čirjevskis 2021).

Virtually every investment has the option to be abandoned. This strategy is especially valuable where the net present value (NPV) is marginal but there is a large possibility of losses (Kodukula and Papudesu 2006). In this way, losses can be reduced by selling the affiliate's business. A multinational corporation may have the option of abandoning an affiliate if the performance results do not meet the expectations of the headquarters. If abandoning the affiliate permits the headquarters to avoid more losses, the abandonment option may provide more value than the deferral option.

To put it simply, the contingent decision in this option is to forsake the affiliate if the projected reward (the underlying asset value) is less than the affiliate's liquidation value or strike price. This option possesses the features of a put option. But how should a multinational corporation value the abandonment option? The current paper follows Kodukula and Papudesu's (2006) methodological recommendations.

To value a put option, construct a binomial tree with one-step time intervals for one year and calculate asset values over the put option. The binominal option pricing lattice begins with So at the first node on the left and multiplies it by the up and down factors to obtain Sou and Sod, respectively, for the first step. Moving to the right, the binominal lattice follows an identical sequence for each node in the binomial tree until the final time-step. Each node's top value represents its asset value as shown in Figure 1.

The option values must then be calculated at each node in the tree using backward induction. This calculation displays the option values (bottom italicized numbers) at each node of the binomial tree using backward induction. Each node shows the maximum value of abandonment versus continuation. At each node, an analyst can choose to either abandon the project for a liquidation value or keep the option open until it expires. In the final node $Sou3$, the expected asset value should be compared to the liquidation value of the foreign affiliate.

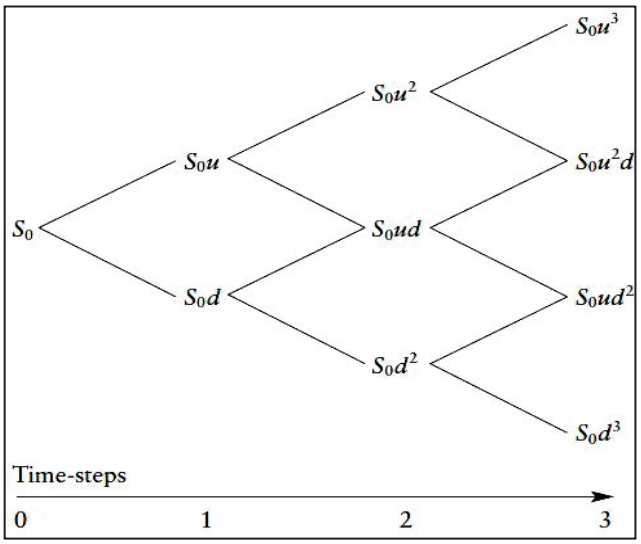

Figure 1. Generic recombining lattice of the underlying assets with three time-steps (Mun 2003, p. 75).

Because a multinational corporation wishes to maximize its return, an analyst would continue rather than exit the affiliate if the underlying value of assets exceeds the liquidation price or exercise the option if the opposite is true. It should then go to the intermediate nodes, which are one step further from the previous time-step. Starting at the top, calculate the asset value of node *Sou2* to keep the option open, applying Formula (4) of the intermediate value that was recommended by Mun (2002, p. 157), as follows:

$$IV = [(p)up + (1-p)down]e^{-r_f \Delta T} \tag{4}$$

where IV is the intermediate value, p is risk-neutral probability, up is the value if the price goes up, $down$ is the value if the price goes down, e is the base of the natural logarithm, r_f is continuously compounded risk-free rate of interest, and ΔT is time increment (years).

This is the discounted (at the risk-free rate) weighted average of hypothetical future option prices with risk-neutral probability weights. As a result, the risk-neutral probability should be used to calculate the starting node's value at time zero. The difference between the underlined asset value and the real option to abandon in the first node *So* is the market value added (put option premium) that the corporation achieves by exercising this option.

According to Kodukula and Papudesu (2006), valuing an abandonment option has major limitations. First, the liquidation value cannot be determined with absolute accuracy because it is the result of negotiations with a buyer. Second, the strike price (affiliate liquidation value) may fluctuate during the option's life cycle. Changing strike prices is an important issue in a setting where affiliates might lose significant value over time owing to severe competition, outdated technology, a loss of demand, and other variables.

As a result, if there is any question about the liquidation value, an analyst can use sensitivity analysis with option Greeks (delta, vega, gamma, rho, and theta) that quantify the sensitivity of option prices to changes in underlying price, volatility, interest rate, and time to expiration, as demonstrated in the case study below. These Greeks collectively offer useful insights for risk management.

Furthermore, if the strike price changes over the life of the option, the changes can be easily integrated into the real option valuation during the backward induction process, as will be seen in the Body Shop's Natura &Co disinvestment strategy case study. Despite the limitations of using the Binomial Option Pricing Model to value an option to abandon, this technique improves communication with practitioners by making calculations apparent and tactically flexible.

Thus, Proposition 2 is as follows:

Proposition 2. *Real abandonment options exercised by international corporations by divesting foreign affiliates strategizing in complex settings are a strategic decision-making tool, being both an appropriate valuation technique of market value added by exercising a simple put option and a strategic "roadmap" observation by exercising a put option with changing strike prices.*

To test the internal and external validity of the propositions, as well as to contribute to real options theory on an option to abandon, the following case study on the Natura &Co divestment strategy for the Body Shop in 2023 was analyzed and interpreted. This case study should help readers better understand the phenomenon of divestment decisions (Damaraju et al. 2015) in terms of the antecedents and consequences of divestments for firm performance.

3. Case Study of Natura &Co: Divestment of the Body Shop in November 2023

Natura &Co Holding SA sold the Body Shop to Aurelius, a global private equity organization, in November 2023 for £207 million ($254.32 million) (Araujo et al. 2023a). The deal was part of Natura's consolidation plan following the $2.5 billion sale of Aesop to L'Oréal earlier in 2022 (Douglass 2023). What was driving this uncommon strategic restructuring deal?

Natura was founded in 1969 in Sao Paulo, Brazil, and has a strong product portfolio that includes soaps and moisturizers. It is known not only for cosmetics but also for its overall natural and sustainability theme, which has a high resonance in Brazil due to Natura's constant striving for excellence and enhancing of sustainability practices (Choudhary 2023). The company expanded beyond Brazil and Latin America, sequentially acquiring the brand name of Aesop in 2012 and 2016 (Čirjevskis 2023) and carrying out the full acquisition of the Body Shop in 2017 and Avon in 2019 (Čirjevskis 2020).

The Body Shop (TBS) was started in Brighton in 1976, growing rapidly through a franchise model because of its ethical stances, which include refusing to offer animal-tested goods and obtaining natural components that are ethically handled. The company was sold to the French cosmetics corporation L'Oréal for £652 million in 2006. This transaction did not provide L'Oréal with any synergies (Čirjevskis 2020). When the Body Shop's sales and earnings declined, L'Oréal sold it to Brazil's Natura, which already owned Australian natural cosmetics brand Aesop (Butler and Davies 2024).

However, the true issue for Natura was the acquisition of Avon. In 2019, Natura paid $2 billion in shares for Avon. It was a relatively weak takeover (Choudhary 2023). The transaction was poorly timed, leaving Natura "with a hefty debt pile as the COVID-19 pandemic hit and then interest rates began to rise around the world" (Butler and Davies 2024, p. 1). Natura lost money for four quarters in a row over the year 2022. It lost $169.7 million in the fourth quarter of 2022, owing to lower revenues across all its business areas.

Natura's top management stated that 2022 began on a rough note, with the company navigating a difficult macroeconomic situation that became worse with the Ukraine war along with "uncertainty surrounding the performance of a few business units after a post-pandemic change in consumer behavior" (Choudhary 2023, p. 1). In this vein, Natura opted to focus on its core Latin American market and pay off its debts by selling Aesop and the Body Shop, and Aurelius was one of the few bidders that came close to the asking price.

Natura &Co was now focused on disciplined capital allocation and deleveraging after agreeing to sell the Aesop brand to L'Oréal and the Body Shop to Aurelius (Araujo et al. 2023b). Thus, Natura &Co has exercised two viable exit strategies by selling Aesop and the Body Shop. As a result, the answer to the first research question—"In what circumstances and international contexts do international corporations choose to exit their investment in foreign affiliates by exercising the option to abandon?"—became evident.

The following section of the paper examines the application of a simple real option to abandon and a real option with changing strike prices in the context of the Body Shop's disinvestment to answer the second research question—how to value the premium of the

option to abandon when an international corporation decides to divest foreign affiliates—and to justify the theoretical propositions.

3.1. Measuring Real Options to Abandon with the Application of the BSOPM and BOPM

The Body Shop could be valuable to the buyer due to its brand awareness, global retail network, and established client base. Natura &Co could either continue doing business with the Body Shop affiliate or sell it to a strategic buyer for $254.32M (the liquidation value). The yearly volatility of the logarithmic returns of future cash flows is calculated to be 45.0%, with a continuous annual riskless interest rate of 11.61% for the next ten years. What is the value of the abandonment option? Table 1 below summarizes the input data for valuing a put option using the BOPM and BSOPM.

Table 1. Inputs to put option valuation model: the Body Shop in November 2023.

Model Input	Estimated as	In General...	For the Body Shop	Source of Data
S	Market value of affiliate at the moment of liquidation	Discounted cash flow for the project	The Body Shop's valuation in November 2023 was $258.83M	CBINSIGHTS (2024)
K	Liquidation price (selling price)	Capital expenditure of the project	Brazil's Natura sold the Body Shop to Aurelius in a $254.32M deal	Araujo et al. (2023a)
σ	The volatility of the stock of headquarters within one week after the announcement of the deal.	Risk for assets of the project	Natura &Co GARCH volatility from 14–21 November 2023 was 45.0 percent	Dunis and Klein (2005), V-Lab (2023)
r_f	Risk-free rate of the country of the headquarters	Time value of the money	Brazil's 10 y bond yield was 11.61 percent on 14 November 2023	Trade Economics (2024)
T	One year	Measures an annual value for flexibility	$T = 1$	Dunis and Klein (2005)

Source: Adopted from Damodaran (2012) and Vintila (2007) and extended by the author.

First, a binomial lattice was created using Microsoft Office 2010 Excel tables, as illustrated in Figure 1, with two-month time intervals (ΔT is 0.17 of a year) for the following year, which establishes the market value and potential changes in the Body Shop's value during the option's life. The underlying lattice depicts the evolution of the underlying asset (S) over the life of the real option. However, before the underlying lattice can be produced, it must be determined how many discrete periods will be built—the number of time-steps. The number of time-steps is determined randomly based on the situation at hand. Mun (2002, pp. 153–54) observed that the binomial lattice approach unavoidably loses some precision in determining ROV; hence, with a small number of steps, the fundamental shortcoming of the binomial lattice approach becomes clear.

However, a shorter stepping time results in a lattice with greater granularity (more nodes). Lattices with increased granularity will produce more precise results, bringing them closer to the outcomes of a closed-form model, if appropriate (Kodukula and Papudesu 2006, p. 74). While Kodukula and Papudesu (2006, p. 96) state that, in ROV, four to six time-steps are typically sufficient for good approximations, the current study included six phases, each of which lasted about two months.

To address "a valuation" in the research question, the real options parameters were calculated, and the results are detailed in Table 2.

Table 2. Real options binomial option pricing model parameters: Natura &Co divestiture of the Body Shop.

Parameters of the Binominal Tree	Numbers
Time increment (years) ΔT	0.17
Up factor $(u) = e^{\sigma\sqrt{\Delta T}}$	1.202
Down factor $(d) = d = \frac{1}{u}$	0.832
Risk-neutral probability $(p) = p = \frac{e^{rf\Delta T} - d}{u - d}$	0.507

Source: Developed by the author, where e is the base of the natural logarithm, rf is continuously compounded risk-free rate of interest, and ΔT is time increment (years).

For the first step, the underlying lattice begins with node "A" at the first node on the left and multiplies it by the up and down factors to obtain node "B" ($258.83M × 1.202 = $311.03M) and node "C" ($258.83M × 0.832 = $215.39M). Moving to the right, repeat for each node in the binomial tree until the final time-step. Figure 2 depicts the top value at each node as the market value of TBS at that node.

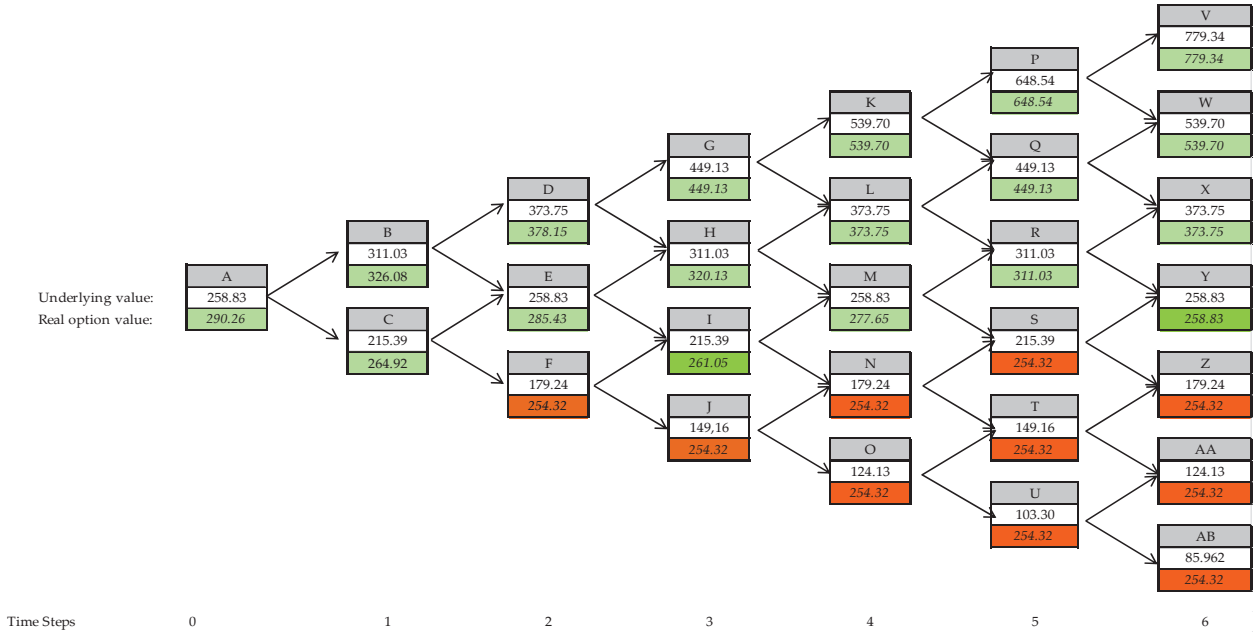

Figure 2. BOPM: underlining lattice: the value forecast of the Body Shop after the disinvestment by Natura &Co (upper digits); and real options lattice of the put option (lower digits) (in USD million). Source: Developed by the author.

Then, Figure 2 illustrates the option values (bottom italicized numbers) at each node of the binomial tree by using backward induction with the risk-neutral probability. Each node represents the value maximization of the abandonment versus continuation of TBS's business. At every node, the lattice has the option to either abandon TBS's business for a selling price of $254.32M or continue keeping the option open until it expires.

Beginning with the terminal nodes representing the last time-step, the binomial tree uses backward induction with the risk-neutral probability. TBS's estimated asset value at node "V" is $779.34M, whereas its liquidation value is $254.32M. Natura would rather continue (green node) than abandon TBS (red node) since Natura seeks to maximize its value. Thus, the option value at this node is 779.34M (green). At node "Z", the expected asset value of TBS is $179.34M, compared to the liquidation value of $254.32M; thus, it makes sense to sell off TBS and exercise the abandonment option (red), resulting in an option value of $254.32M at this node. Using the strike price as a liquidation price ($254.32M

throughout the whole binomial tree), the option value for the Body Shop disinvestments is $31.43M.

The market capitalization of TBS is $258.83M, but the liquidation (selling) price is $254.32M, giving a relatively small loss of $4.51M. Real options analysis, however, shows a TBS value of $290.26, yielding an additional $31.43M ($290.26M minus $258.83M) due to the abandonment option. In other words, real options analysis shows that this strategic deal of selling TBS resulted in an expanded net present value (*eNPV*) of approximately $26.91M, namely, $31.42M plus a loss of $4.51M using Mun's formula (Mun 2002, p. 168), where *eNVP* equals static (passive) NPV plus option value of managerial flexibility.

Second, the same option value was produced by using the Black–Scholes equation for this put option, which was calculated with DerivaGem 2.0 (Hull 2012), as shown in Figure 3. The abandonment option increased Natura &Co's market value by $26.92 million.

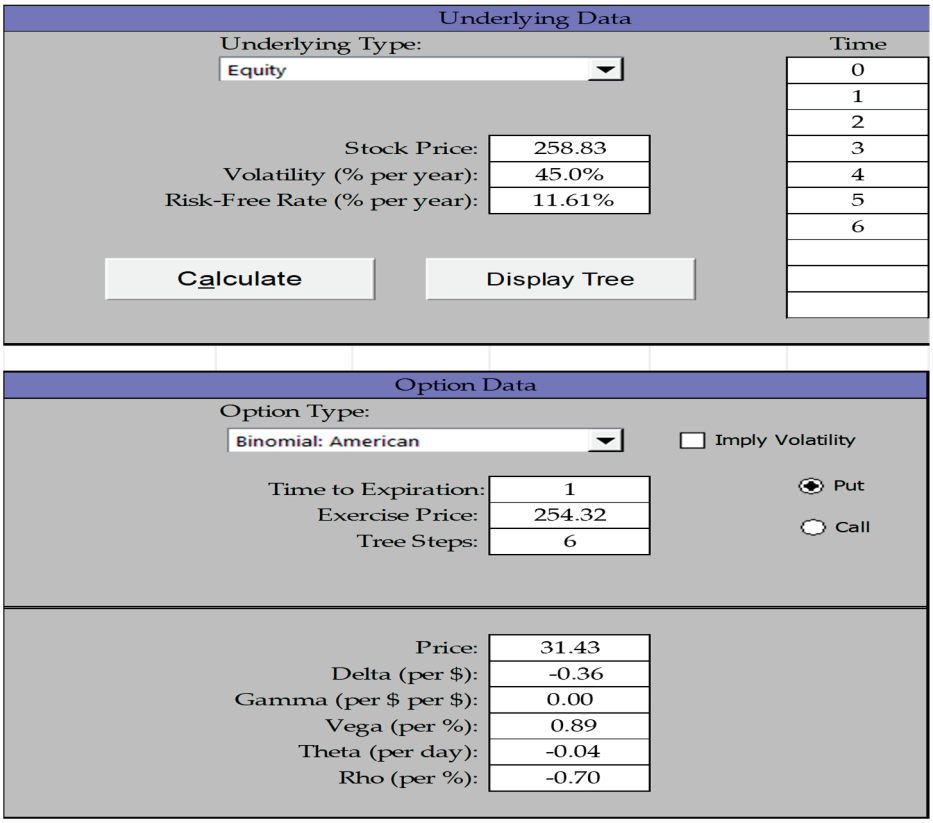

Figure 3. The divestment of the Body Shop by Natura &Co in November 2023. The result of the put option calculation by DerivaGem 2.0. Developed by the author.

As a result, the first theoretical proposition was justified by demonstrating that real abandonment options can be applied in IB studies when an international corporation divests foreign affiliates in the context of complex strategic settings. This also provides an answer to the second research question.

3.2. Measuring the Value of an Option to Abandon with a Changing Strike Price

As previously stated, adjusting strike prices is an essential concern in situations where affiliates may lose significant value over time, as occurred with the Body Shop when it was sold to Aurelius in November 2023. On 15 February 2024, Aurelius placed the Body Shop's UK division in administration, a procedure under the insolvency laws of several common law jurisdictions, like bankruptcy in the United States, and hired a business advisory firm as administrators to help the company through the procedure (Butler and Davies 2024).

On 16 February 2024, only one day after the UK division declared bankruptcy, the Body Shop Germany entered administration and stated that all 60 stores would be closed within the next few months. That same day, the Body Shop appointed administrators for its Belgium, Ireland, Austria, Luxembourg, and France subsidiaries, all of which were scheduled to be placed under administration as early as the next week (Butler 2024).

Moreover, on 1 March 2024, Body Shop Canada filed for creditor protection and stated that it would halt online operations and close 33 of its 105 locations. On the same day, Body Shop USA closed all its locations and stopped operating online. On March 10, Body Shop USA filed a petition for bankruptcy under Chapter 7 liquidation. Thus, how does one value a put option (an option to abandon) when the strike price (affiliate liquidation value) varies throughout the option's life cycle?

After analyzing the dropping revenues generated by the Body Shop worldwide from 2020 to 2022 (Statista 2024b) and the decreasing EBITDA of the Body Shop from 2019 to 2023 (Statista 2024a), it was assumed for the showcase that the market value would be reduced by 33% at every step of the options life cycle. In terms of the options life cycle, L'Oréal sold TBS to Brazilian beauty giant Natura for €1 billion in September 2017 (Butler 2017), then Natura sold it to Aurelius six years later in November 2023. In the same vein, the option life cycle was set at six years in this case.

Table 3 summarizes the input parameters, as well as the u, d, and p values for this problem.

Table 3. Option to abandon with varying strike prices. Input parameters: Natura &Co divestiture of the Body Shop.

Parameters of the Binominal Tree with a Changing Strike Price	Numbers
Time increment (years) ΔT	1.00
Up factor $(u) = e^{\sigma\sqrt{\Delta T}}$	1.568
Down factor $(d) = d = \frac{1}{u}$	0.638
Risk-neutral probability $(p) = p = \frac{e^{rf\Delta T} - d}{u - d}$	0.522
So	\$258.83M
T	Six years
K	\$254.32M
$K\Delta T_1$	\$173.39M
$K\Delta T_2$	\$114.16M
$K\Delta T_3$	\$76.49M
$K\Delta T_4$	\$51.25M
$K\Delta T_5$	\$34.34M
$K\Delta T_6$	\$23.01M

Source: Developed by the author, where So is the price of the underlying assets at time zero, K is a strike price at maturity date T, and $K\Delta T_n$ is a varying strike price, e is the base of the natural logarithm, rf is continuously compounded risk-free rate of interest, and ΔT is time increment (years).

To solve this problem, first, a binomial tree representing the asset values was constructed as shown in Figure 4. The top values at each node of the tree depicted in Figure 4 represent asset values. However, instead of applying the same strike price of \$254.32M to each node of the binomial lattice to determine the contingent decision, the strike price of \$23.01M is applied for Year 6 at the end nodes, \$34.34M is applied at the nodes for Year 5, \$51.25M is applied at the nodes for Year 4, and so on.

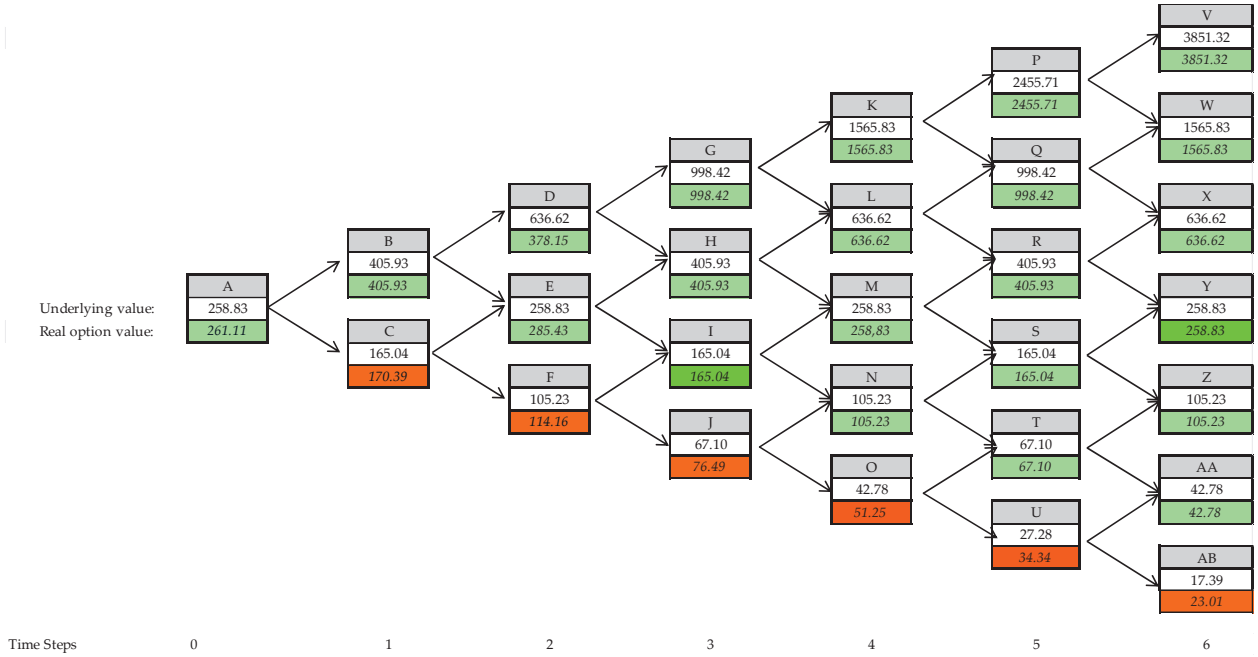

Figure 4. BOPM with changing strike prices: underlying lattice: the value forecast for the Body Shop (upper digits); and real options lattice of the put option (lower digits) (in USD million). Source: Developed by the author.

For example, at node "AB", the estimated asset value is $17.39M, compared to a liquidation value of $23.01M in Year 6. Because the liquidation value is higher, the choice will be made to abandon the business (red color). At node "U" for Year 5 ($K\Delta T_5$), the liquidation value is $34.34M (red color), which is compared to the projected asset value of TBS for keeping the option open, considering the downstream optimal decisions using Formula 4 as follows: [0.522 ($42.78M) + (1–0.522)($17.39M)] * exp(−0.1161)(1) = $27.28M. Because the liquidation value is higher, the node "U" is abandoning the project. Using different strike prices (liquidation prices) across the whole binomial tree, the option value for the Body Shop disinvestments is calculated to be $2.28M. Thus, real options analysis shows a TBS value of $261.11M, yielding an additional $2.28M ($261.11M–$258.83M) due to the abandonment option.

DerivaGem has provided the put option value with an unchanged strike of $48.53M. Therefore, if the strike price were $254.32M across the entire lattice, the option would be overvalued by $46M. Comparably even with an average strike price of $103.42M over the option's entire period, the option would also be overvalued by $2.16M according to the BSOPM result. Thus, the BOPM approach not only allows for the incorporation of changing strike prices into the option solution but also makes it transparent for practitioners, unlike the other methods. As a result, the solution to the second research question has been presented, and the second theoretical proposition is justified.

4. Findings and Discussion

Despite the growing literature on the implications of real options logic for strategic investments, research on its implications for divestments is still in its early stages (Damaraju et al. 2015). Divestments can be understood as the exercise of put options (Dixit and Pindyck 1994). Previous empirical research has begun to investigate some of the implications of real options theory for divestment decisions. This research investigated the implications of real options theory for company divestiture decisions, strategizing in complex settings and empirically justified theoretical propositions that real options theory can be fruitfully explored in the context of divestment of affiliated companies abroad.

This research has contributed to real options theory as follows: Previous research on the predictions of real options theory stated that, when a business unit's environment is uncertain, firms are hesitant to divest it and instead prefer to leave their divestiture options open (Zingales 1995; Damaraju et al. 2015). However, the current paper has evidenced that Natura has added value by abandoning the option and that significant losses would result if it were kept open.

More recent research on foreign affiliate divestments has indicated that real options considerations will lead to delayed exit decisions, even when affiliates perform poorly if macroeconomic conditions are unpredictable (Belderbos and Zou 2009; Damaraju 2008; Damaraju et al. 2015). In contrast, the findings of this study show that complete divestments may be preferable to defer options when the business environment is highly uncertain. As a result, the findings of this study also contrast with the predictions of real options theory, which states that incremental divestment will be preferred over complete divestment under uncertain circumstances (e.g., Huchzermeier and Loch 2001; Trigeorgis 1997; Damaraju et al. 2015).

5. Conclusions, Research Gaps Addressed, Limitations, and Future Work

Exploring real options theory in the context of divestments of foreign subsidiaries can lead to new perspectives and advance the theory beyond what is already known. In this vein, the research presented here makes important theoretical improvements as well as managerial and practical implications for furthering real options theory and extending our understanding of the phenomenon of divestments.

The current paper has shifted the research focus from initial investment to the post-investment stage and addressed several research gaps. The importance of this shift in the research focus is fourfold. First, previous research primarily focused on the initial investment stage of real options theory, neglecting the execution phase, particularly the option to abandon investments. This paper shifts the focus to the post-investment stage, specifically investigating the circumstances under which investors decide to withdraw their investments by exercising the option to abandon.

Second, there is a scarcity of empirical studies examining the practical application of real options theory in the context of divestments. This paper provides empirical evidence by analyzing Natura &Co's divestment strategy for the Body Shop, demonstrating the practical advantages and disadvantages of real options analysis in real-world scenarios.

Third, having contributed to the limited research on the valuation methods for abandonment options, particularly with changing strike prices, this study advanced the methodology by proposing a hybrid model that combines the Black–Scholes Option Pricing Model (BSOPM) and the Binomial Option Pricing Model (BOPM) with changing strike prices, enhancing the accuracy and efficiency of abandonment option valuation.

Fourth, there has been insufficient exploration of how real options reasoning influences divestment decisions, especially under uncertain conditions. This paper empirically demonstrates that MNEs can gain value by exercising abandonment options, even in highly uncertain environments, challenging previous assumptions that deferral options are preferable.

Therefore, the current paper enhances real options theory by providing a deeper understanding of its applicability in divestment decisions. In addition, the study proposes new theoretical propositions that real abandonment options can be applied in international business studies to estimate market value added during divestments. When it comes to methodological advancement, the paper introduces a sophisticated hybrid model for valuing abandonment options, incorporating changing strike prices to reflect real-world complexities. Thus, having demonstrated the practical application of this model through a detailed case study, the paper provides a clear roadmap for future research and practice.

5.1. Managerial Implications

When it comes to managerial considerations, there is not much doubt that real options analysis fosters more insightful discussions among senior executives. In this vein, the current study provides a practical model of real options analyses and contributes to facilitating and enhancing decision-making processes and strategizing in complex settings. It aids in the discovery of additional value that traditional NPV methodologies do not fully recognize and, more importantly, it fosters a systematic conversation about the sources of risk and how a company intends to respond to those risks (Chevalier-Roignant and Trigeorgis 2011).

While an ordinary investment business case just outlines potential risks, real options analyses place a far greater focus on these risks, as well as the managerial flexibility to respond. Senior managers who have had limited training in real option methods frequently revert to familiar ways, notwithstanding the limitations these methods entail when dealing with specific scenarios (Chevalier-Roignant and Trigeorgis 2011, p. 200). Therefore, the hybrid model of real options analyses, as presented in the paper, appears to be a valuable tool for strategic management and international business research and practice, particularly in the context of divestitures.

The paper's empirical findings can be stated as follows: by exercising the real put option (option to abandon), which may have been included in the strategic decision due to a highly uncertain context, an international corporation can add more value than by exercising a deferral option. Moreover, the application of real options to abandon with changing strike prices is often more realistic in real-world scenarios, as market conditions and project circumstances may evolve. This makes the proposed model more applicable to practical situations.

5.2. Practical and Social Implications

Driouchi and Bennett (2012) stated that only a small number of large corporations have heard of or used this approach. As a result, future empirical research could focus on strengthening the practicality of real options reasoning and making it more accessible to businesses and managers when making uncertainty-based decisions. An examination of the application of a simple real option to abandon and a real option with changing strike prices in the context of Natura &Co's divestment of the Aesop brand in 2022 could also be a future research direction.

Managers can take numerous practical actions to integrate real options analysis into the decision-making process. First, they can invest in training programs to familiarize the team with real options analysis and its applications. Second, they can implement software tools that support real options analysis, such as DerivaGem or other financial modeling tools. Third, management can start with pilot projects to apply the methodologies in real-world scenarios, gradually scaling up as the team gains confidence and expertise. Fourth, managers can involve academic institutions to stay abreast of the latest research and incorporate cutting-edge methodologies into practice. By applying these findings, practitioners can make more informed, flexible, and strategic decisions, ultimately enhancing their organization's performance and resilience in the face of uncertainty.

Regarding the social implications of this study and, particularly, findings on the United Nations SDGs' good practices, the case study and real options abandonment analyses revealed how Natura &Co is improving sustainability practices by focusing on disciplined capital allocation. In this sense, there are a few potential avenues for future groundbreaking innovations in real options theory. The concept of sustainable investments can connect real options theory with sustainability. Therefore, developing real options models that incorporate environmental, social, and governance (ESG) concerns could be a promising research area that could assist corporations in making more sustainable investment decisions.

5.3. Opportunities for Future Research

Furthermore, to enrich the future of scientific literature with fresh theoretical contributions and professional implications, the author developed numerous hypotheses that might be tested in future quantitative research as follows: Null Hypothesis (H0): There is no significant relationship between the level of competition in the foreign market and the likelihood of an international corporation exercising the option to abandon. Alternative Hypothesis (H1): Foreign affiliates operating in highly competitive markets are more likely to be abandoned by international corporations. Thus, the answer to the first question of the study can be definitively clarified by quantitative research.

Regarding the answer to the second research question, the following hypotheses can be tested: Hypothesis 1: Null Hypothesis (H0): There is no significant difference in the premium of the option to abandon between foreign affiliates with high profitability and those with low profitability. Alternative Hypothesis (H1): Foreign affiliates with high profitability have a significantly higher premium associated with the option to abandon compared to those with low profitability. Hypothesis 2: Null Hypothesis (H0): There is no significant relationship between the volatility of the foreign affiliate's market value and the premium of the option to abandon. Alternative Hypothesis (H1): The premium of the option to abandon a foreign affiliate is positively correlated with the volatility of its market value.

These hypotheses could be further refined based on specific research objectives and the availability of relevant data. Quantitative research methods, such as regression analysis and/or option pricing models, could be employed to test these hypotheses and estimate the premium of the option to abandon. Therefore, future studies could contribute by carrying out a more systematic examination of the existing research on this issue as well as investigating how and why real options logic is (or is not) employed in IB practice.

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Assessing the Impact of Federal Reserve Policies on Equity Market Valuations: An Instrumental Variables Approach

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Abstract: This study investigates the impact of Central Bank interventions on the pricing dynamics of select stock markets. The research utilizes the instrumental variables three-stage least square (3SLS) model approach. It analyses the effects of variations in the Federal Reserve's balance sheet size across three distinct intervention scenarios: the 2008–2013 Great Recession, the 2020–2021 COVID-19 pandemic periods, and an overarching analysis spanning these timelines. Our methodology includes estimations of the Seemingly Unrelated Regression Equations (SURE), and the results are robust under the two-step Generalized Method of Moments (GMM). Our findings indicate that changes in the size of the Fed's balance sheet correlate significantly with the pricing of principal U.S. equity market indices. This correlation reflects a time-dependent effect emanating from the Fed's balance sheet expansion, marking a growing divergence between the adaptability of pricing mechanisms in equity and debt markets. Notably, the Federal Reserve's interventions during the COVID-19 crisis are associated with an increase of approximately 0.0403 basis points per billion in treasury yields. This research makes a significant contribution to the understanding of financial asset pricing, particularly by elucidating the extent to which interventions in government debt securities engender price distortions in certain equity markets.

Keywords: Fed's balance sheet; great recession; instrumental variables; quantitative easing; tapering; COVID-19

JEL Classification: E50; G12; G18; H12

1. Introduction

In response to the 2007 financial crisis, the Federal Reserve (Fed) implemented a number of programs, including policies to uphold liquidity of financial institutions and the stability of financial markets (Federal Reserve 2021a). Although these crisis-response programs have ended, the Fed continues to take action to meet relevant monetary policy objectives such as high employment and price stability. Many of these actions have involved substantial purchases of long-term securities over recent years, with the objective of maintaining long-term interest rates as low as possible and facilitating overall financial conditions. The immediate response to the crisis started with the implementation of programs that provided short-term liquidity to financial institutions, as well as programs that provided liquidity directly to borrowers and investors in key credit markets, for the first few years that followed the crisis. Then, afterwards, in addition to those programs, the Fed expanded its open market operations monetary tool to bolster credit markets' activity in order to maintain long-term interest rates as low as possible, and to help make broader financial conditions more stable through the purchase of long-term securities. That is when, in late November 2008, the Federal Reserve started buying USD 600 billion

in mortgage-backed securities (MBS). By March 2009, it held USD 1.75 trillion of bank debt, mortgage-backed, and Treasury securities, reaching a height of USD 2.1 trillion by June 2010. In November 2010, the Fed announced a second round of quantitative easing (QE)[1], buying USD 600 billion of Treasury securities by mid-2011. Nonetheless, starting in September 2012, the Federal Open Market Committee (FOMC) increased the Fed's purchases of agency-guaranteed MBS at a pace of USD 40 billion per month in order to support a stronger economic recovery, but most specially, to help ensure price stability over time. Then, starting in January 2013, the monthly purchase of long-term Treasury securities increased to USD 45 billion, in addition to the MBS purchases, for a total of USD 85 billion monthly. However, starting in January 2014, following signs of economic recovery, the FOMC started gradually reducing the pace of those asset purchases, at a rate of USD 10 billion per month, and finally ending them by October 2014 (Federal Reserve 2021b).

The Fed started to intervene in the U.S. credit markets again in the spring of 2020 in response to the financial distress caused by the outbreak of COVID-19. The central bank implemented actions to stimulate the economy by intervening in the debt markets, understanding their crucial role in the credit flow within the economy as major sources of liquidity. The Fed then started the large-scale purchases of debt securities again, a tool heavily employed during the Great Recession. That is when, in March of 2020, the Fed announced the purchase of at least USD 500 billion in Treasury securities and USD 200 billion in government-guaranteed MBS over the months that followed, a decision that was changed shortly after to monthly amounts as required to support smooth market operations (Federal Reserve 2020). In June 2020, the Fed set the amount of these purchases to at least USD 80 billion per month in Treasuries and USD 40 billion in mortgage-backed securities, conditional on the progress of the economy with regard to the Fed's goals of price stability and minimum unemployment.

On 3 November 2021, the Fed announced cuts of USD 15 billion per month, USD 10 billion in Treasuries, and USD 5 billion in MBS from the monthly USD 120 billion that the Fed was buying at the time, expecting to end them by July 2022 (Cox 2021). This decision was the result of observing the recovery of economic activity and employment figures in the U.S. economy, as well as progress on the COVID-19 vaccinations after the breakout of the virus in February of 2020 (Federal Reserve 2021c). At the time of this decision, the federal funds rate was at its lowest level of 0.25 percent and the 10-year treasuries were trading at yields near 1.5 percent throughout 2021, for which the continuation of the central bank's active intervention was no longer required. Moreover, the stock market indices showed solid proof of recovery from the bottom levels of 2020 at the midst of the pandemic outbreak. While the Dow Jones Industrial Average (DJIA) and NASDAQ composites had completely cleared all losses from the pandemic, the S&P 500 was quoting at its maximum historical levels. However, in December 2021, the Fed accelerated the tapering by reducing its purchases by USD 20 billion and USD 10 billion, respectively, as signs of rising inflation emerged (Federal Reserve 2021d).

Although the 2021 tapering had begun, market health indicators continued to improve, reminding us of the times after the first tapering employed to support the economy during the Great Recession. However, this time would be different, as unexpected side effects developed such as the inflation outbreak. While a lack of inflation was a concern to investors back in 2013–2015, the Fed was now facing rising inflation to levels not seen in the last forty years. Figure 1 shows the performance of the 10-year treasury yields as the main indicator of the effects in the credit market interest rates in direct connection to the securities purchased by the central bank. The Fed's purchases increased its balance sheet, maintaining the yields lower than 1 percent while also lowering the federal funds rate to 0.25 percent in the spring of 2020. The figure also shows how the U.S. Consumer Price Index CPI escalated through the COVID-19 QE program in comparison to the various QE programs implemented in connection to the previous credit crisis. While high inflation was not a concern in 2013 at the beginning of the first tapering with this rate well below 2 percent, inflation reached levels of 8.5 percent in early April of 2022. Perhaps the size of the last QE may explain such a rise in such a short period. However, with a much larger

debt market size, larger securities purchases were required in order to keep pressure away from treasury yields, which was, indeed, well accomplished by the Fed.

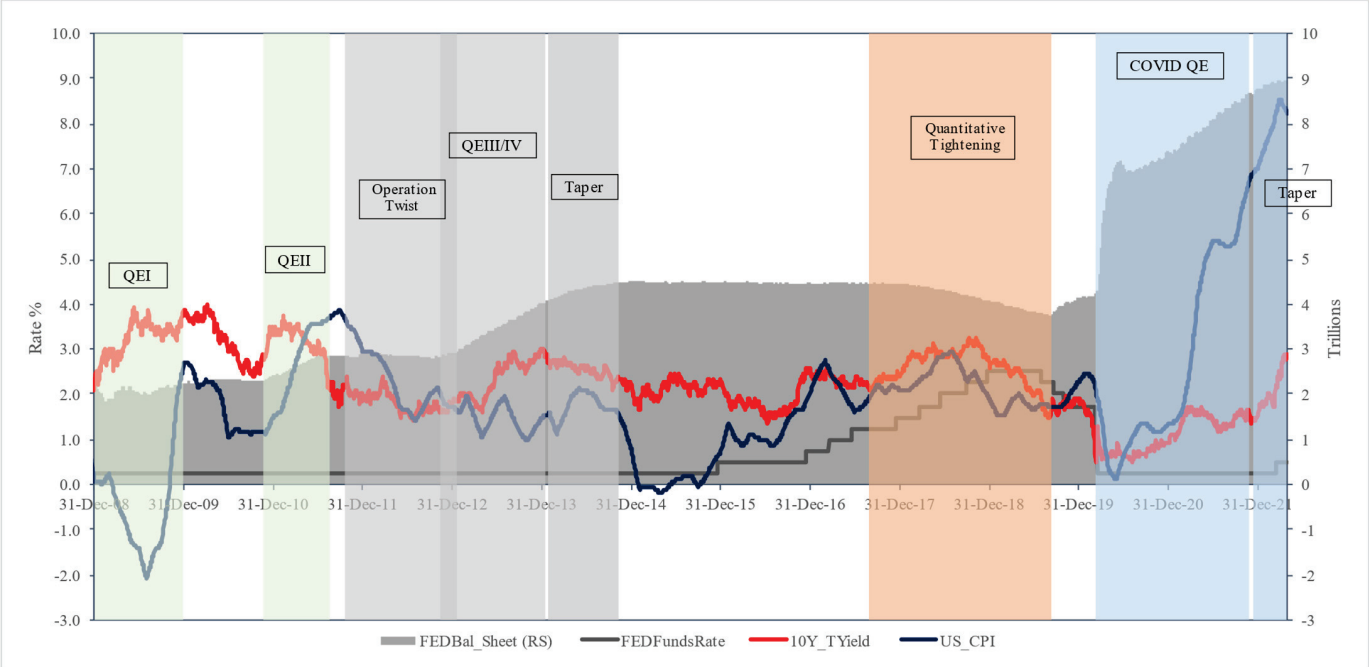

Figure 1. Fed balance sheet, interest rates, and inflation (from 16 December 2008 to 29 April 2022). Source: author's work based on the EIKON Refinitiv database.

While the credit market was being stimulated, so were the equity markets. It is commonly expected that as lower costs of funds are available to businesses, economic activity flourishes. The investment public views this as better future prospects for businesses, hence the higher value of the companies. This rationale is typically reflected in the performance of the stock market indices. Figure 2 shows the performance of the four major U.S. indices: the Dow Jones Industrial Average (DJIA), the NASDAQ, S&P 500, and the Russell Small Cap 2000 (the SMLCAP 2000) from 16 December 2008 until 29 April 2022. Although all four indices display trends alike, they are not identical. For instance, while the DJIA and the S&P 500 mimic each other, the SMLCAP 2000 and NASDAQ differ slightly in the past QEs. Moreover, although all four indices completely recovered all losses from the COVID-19 correction, the first two slightly diverged in the summer of 2021, and the other two tended to match in early 2021, however they diverged again thereafter.

Key recent moments in the indices' trajectories are worth analyzing. Take the S&P 500, for example, it quoted its maximum historical value of 4796.56 on 2 January 2022, returning some 42 percent before the COVID-19 correction when it traded at 3386.15 on 19 February 2020, and at 114 percent from 2237.4 at the bottom of the pandemic crisis on 23 March 2020. Even though, the difference in the performance of each index relies on the way each index is constructed (that is, the number, type, and size of firms that constitute each index), it is reasonable to conclude that the stock market came out stronger from both crises under analysis in this research.

Figure 3 shows the performance of the S&P 500 in comparison to the evolution of the Fed's balance sheet. Peculiarly, the trajectory of the S&P 500 suggests mimicking that of the Fed's balance sheet. Moreover, this relationship grows over time. By measuring the difference between the index level and that of the Fed's balance sheet at the beginning of the tapering of 2013 and the COVID-19 tapering of 2021 using an exponential regression analysis of both series, the dotted lines show that the spread widens over time. This visualization suggests a possible cumulative effect of the central bank balance sheet growth on the index valuation. Hence, it is possible to infer that the index valuation may have

been priced at levels far different from its fundamental values, had the Fed's balance sheet remained unused.

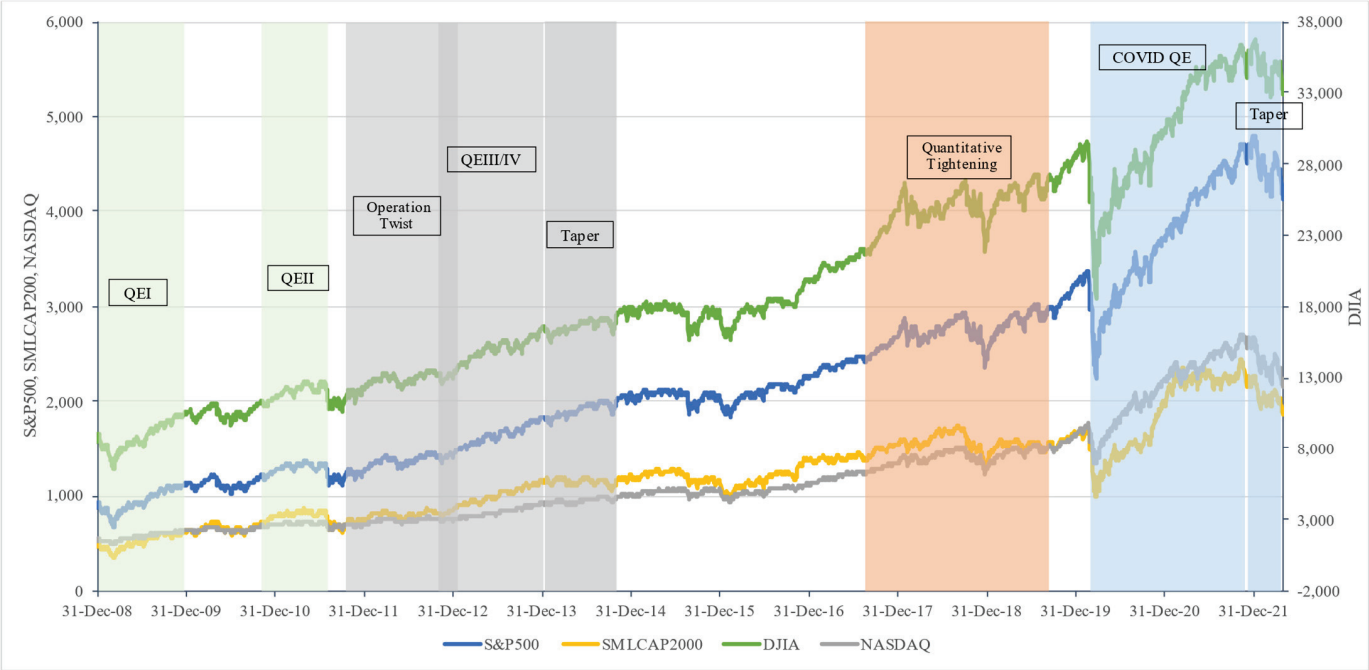

Figure 2. Performance of main U.S. indices (from 16 December 2008 to 29 April 2022). Source: author's work based on the EIKON Refinitiv database.

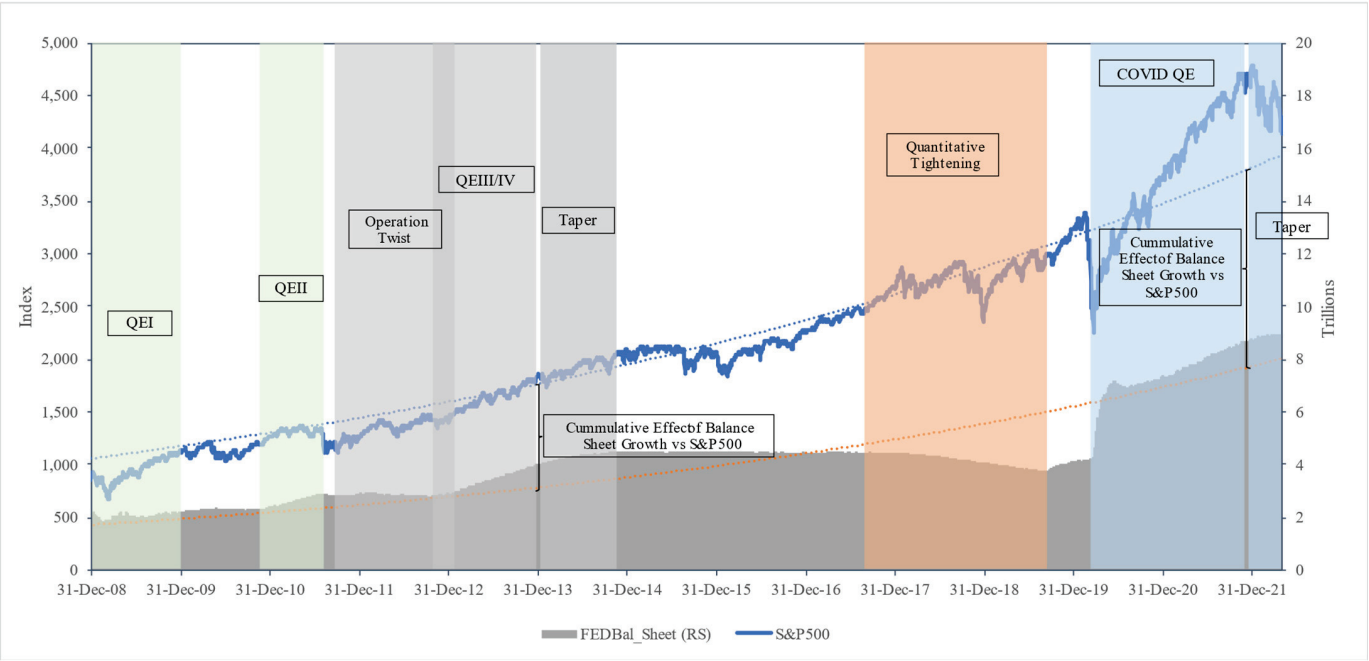

Figure 3. Fed balance sheet and S&P 500 index (from 16 December 2008 to 29 April 2022). Source: author's work based on the EIKON Refinitiv database.

Price distortions in financial assets pricing refer to mark-to-market prices substantially far from a plausible range of the economic values of those assets. Similar to market failures, price distortions derive from the mispricing of financial assets relative to their fundamental value (Vukovic et al. 2021). In the context of this study, we identify that the Fed's intervention on the credit market via the purchase of government debt securities in

the 2008–2013 and the 2020–2021 periods made the value of the majority of stocks in the U.S. equity market to be priced at levels significantly different from their fundamental values.

The goal of this research is to ascertain the influence of the Federal Reserve's purchases of government securities on the pricing of stocks within major U.S. indices. This study investigates the extent of any resultant price distortions and their magnitudes. Utilizing the credit market interventions of 2008–2013 and 2020–2021 in the U.S. as a quasi-natural experiment, our paper explores the potential impact of government interventions in credit markets on the pricing of equity securities. The analysis incorporates daily trading data from the DJIA, S&P 500, the NASDAQ, and the SMLCAP 2000 indices in the U.S. equity market, spanning from 16 December 2008 to 29 April 2022. This period encompasses the Great Recession and the COVID-19 crises. The research addresses crucial questions: Do central bank interventions, such as QE or its tapering, in government securities within the credit markets affect the pricing of equity securities? If so, what is the significance of these effects?

To respond to these inquiries, the study employs the Instrumental Variables (IV) Three-Stage Least Squares (3SLS) method. Findings from this research may carry policy implications, suggesting that when policymakers seek to reduce financing costs in capital markets during financial distress through market interventions, the investment public considers the enduring effects on the pricing of financial assets, including those not directly targeted by the interventions. This could have implications for the efficient allocation of resources in the future.

Consequently, the novelty of our study lies in identifying the structural, long-term effects of such interventions, as opposed to the existing literature's focus on short-term, impulse-response analyses. That is, our study identifies the trends rather than the instant effects of the variables involved in the valuation of equity indices in the U.S. market. To achieve this, the study utilizes advanced long-term identification models like the IV 3SLS, corroborated further by Seemingly Unrelated Regression Equations (SURE) and the Two-Step Iterated Generalized Method of Moments (GMM) to estimate trends instead of short-term impulse-response estimations of other methods such as structural VAR. Hence, our estimations aim to go a step further than short-term valuations. Our research makes a significant contribution by thoroughly examining the influence of central bank interventions in government debt securities amidst major economic downturns. This investigation reveals pronounced price distortions within principal U.S. equity markets. It unveils novel insights regarding the discrepancy in adaptability between equity market pricing and the dynamics of the debt market, underscoring the ongoing impact of central bank policies on the valuations of equity over time. Furthermore, this study provides imperative policy implications. It underscores the necessity for policymakers and the investment public to acknowledge the long-term consequences on the pricing of financial assets. This consideration is crucial to mitigate the risk of fostering inefficient valuations in assets during future implementations of market interventions.

This paper is divided into seven sections, including this introduction. In Section 2, we review the existing literature related to the key factors and variables to consider in the proposed methodology of the study, develop its theoretical framework and hypotheses. In Section 3, we develop the methodological framework and its empirical models, relying on the instrumental variables approach. In Section 4 we present the empirical results, and a thorough discussion about the key results of our modeling are outlined in Section 5. In Section 6, we discuss the results one step further and develop several key implications regarding the dynamics of these results. Finally, in Section 7, we draw the conclusions of our study.

2. Literature Review

2.1. Complex Dynamics of Government Interventions: Monetary Policy Impacts on Asset Prices and Financial Markets

The task of estimating the effects of government interventions (Samuelson 1954), via changes in monetary policy, on asset prices may be rather complex due to the endogeneity of policy implementations, on the one hand, and because interest rates and asset prices are influenced by multiple other variables on the other. Rigobon and Sack (2004) have indicated that an increase in short-term interest rates generates a decline in stock prices and an upward shift in the yield curve. However, that shift becomes smaller for longer maturities. Their findings also suggest that, due to some biases, the estimated effects on treasury yields are rather large, while too small on stock prices. Moreover, Bernanke and Kuttner (2005) have shown that, on average, an unexpected 25 basis points cut in the Fed funds target rate may be associated with an approximate 1% rise in stock market indices. They also found that the effects of unforeseen monetary policy actions on expected excess returns may add to most of the stock price response.

Regarding the study of equity premiums, the work of Fama and French (2002) pointed out that the average stock return for the period 1951 to 2000 was much higher than expected as their evidence suggested that the high average return for that period was due to declining discount rates that produced large, unexpected capital gains. In agreement with this view, this brings us to believe that any actions by the central bank that help steadily reduce the interest rate levels should translate into a larger equity premium (Cochrane 2005; Sharpe 1964).

Since the midst of the great recession (end of 2008), the target federal funds rate, the Fed's conventional policy instrument, had been at its lowest levels ever. As the economic prospects deteriorated, in an attempt to further ease its monetary policy, the Fed implemented an unconventional monetary policy (UMP) which primarily included a program of massive purchases of assets of medium and long maturities. Gagnon et al. (2011) presented evidence that those purchases led to economically meaningful and long-lasting reductions in longer-term interest rates on a range of securities, including securities that were not included in the purchase programs. In turn, those interest rate reductions reflected lower risk premiums in the fixed income markets, including long-term premiums. Consequently, Khemraj and Yu (2015) found evidence that QE stimulated the level of aggregate investment via the interest rate channel by narrowing the corporate bond spread to benchmark. In short, they found that the Fed's purchases of MBS had a high statistical significance effect on aggregate private investment.

Interestingly, Yildirim and Ivrendi (2021) found that U.S. UMP highly affects the financial conditions in emerging and advanced economies by modifying investors' risk premiums. This finding suggests that the risk-taking venue plays a crucial role in transferring the effects of these policies to the rest of the world. QE measures such as security purchases that lower the US mortgage spread translate into more significant spillover effects on international financial markets than those that reduce the US term spread.

Further works on government interventions have researched the effects of the discontinuation of such interventions on asset prices. Albu et al. (2016) suggested that both the QE policy and the gradual reduction of it ("Tapering") had relevant effects in terms of the volatility of the indices they analyzed. Furthermore, Chari et al. (2017) analyzed the impact of U.S. UMP on capital flows and asset prices in emerging markets. They found that U.S. monetary policy shocks represent revisions to the expected trajectory of short-term interest rates and the required risk compensation, with this risk compensation factor becoming especially important during UMP periods. They also suggested that the relative effects of U.S. monetary policy shocks are larger for emerging markets asset returns in relation to physical capital flows, and are larger for emerging equity markets relative to fixed income markets. Surprisingly, they found that these effects were larger when the Fed implemented a "tapering" or reduction of its asset purchase program.

Other academic literature has disputed the effects of central bank's balance sheet expansions on inflation. Moessner (2015) found no strong evidence that announcements about expansions of the European Central Bank (ECB) balance sheet lead to higher inflation expectations. However, Boeckx et al. (2014) affirmed that inflation in Europe could have been 1 percent lower in 2012, had the LTRO programs not been implemented by the ECB. Perera et al. (2013), on the other hand, found that inflation and central bank's balance sheet size were negatively associated, especially in the presence of other determinants of inflation in their modeling. In line with this, Cochrane (2018) suggested that inflation could be low and stable when nominal interest rates are near zero, to the extent that a larger interest-paying balance sheet can be maintained indefinitely.

Other studies, however, reveal links between interest rates and exchange rates. Moreover, further research has suggested ties of both rates to oil prices. For instance, Krugman and Obstfeld (2006) indicated that increases in a country's money supply cause its currency to weaken in the foreign exchange market, as the former decreases the interest paid on deposits of that currency. Also, Krugman (1980) suggested that the short- and long-term effects of oil price changes on currency may go in opposite directions. That is, oil price increases will initially lead to a dollar appreciation and eventually depreciate. While Amano and van Norden (1995) pointed out that oil prices best capture exogenous terms-of-trade shocks that are crucial in currency price determination in the long run, and Beckmann et al. (2020) confirmed that links between exchange rates and oil prices are strong, however these links are frequently observed over the long-run.

Curiously, Fratzscher et al. (2013) revealed that the U.S. dollar, oil prices, and equity market returns are strongly linked mostly due to the rising use of oil as a financial asset. Moreover, Mokni (2020) found evidence of country time-varying reactions of stock returns to oil shocks. In general, oil demand shocks impact positively on the oil-exporting stock returns and negatively on oil-importing countries. In addition, stock returns react more to demand-side oil shocks over supply-side shocks, with a positive effect on almost all stock returns in the first, while negative and modest in the latter case. Degiannakis et al. (2018) found that the effect of oil prices on stock prices is merely in terms of volatility. That is, as volatility in the oil prices increases, so would the stock prices' volatility.

Another aspect to consider are market structures, price levels, and liquidity issues that may condition the magnitude and direction of the above-discussed effects in the financial markets. For example, Rocheteau et al. (2018) stated that injecting money via open market operations is different than transfers form fiscal policy, and that under various market structure specifications and asset liquidity, negative nominal yields and liquidity traps can emerge. Hommes et al. (2019) revealed adaptive learning effects of interest rates near the zero lower bound turning monetary policy alone not enough to prevent liquidity traps. Duly, Cochrane (2017), Guerrieri and Lorenzoni (2017), and Korinek and Simsek (2016) share the finding that liquidity traps are often present when interest rates are near the zero lower bound. Nonetheless, Acharya and Bengui (2018) asserted that capital flows reduce inefficient fluctuations of asset prices by adjusting the exchange rate, for which restricting capital mobility curbs such an adjustment. Moreover, terms-of-trade manipulations drive countries to inefficiently restrict capital flows, causing price distortions.

Several studies have assessed the UMPs' transmission effects on financial markets. Their methodologies rely mostly on Vector Autoregressive (VAR), pooled Ordinary Least Squares (OLS), and event-study approaches, including during the COVID-19 crisis for the U.S., Europe, China (D'Amico and Seida 2024; Herradi and Leroy 2023; O'Donnell et al. 2024), India (Rao and Kumar 2023), and Thailand (Schrank 2024). In order to find evidence that supports the hypotheses of this study, the instrumental variables approach was employed. Different strategies may be used under this approach, though. Jiang (2019) and Vukovic et al. (2021) used this approach under the two-stage least squares (2SLS) method to estimate the effects of government and currency dis-interventions on the risk premiums in the fixed income markets. However, given the complexity and how highly interconnected financial markets have become, resemble simultaneity of estimations in different markets

at once. Hence, a 3SLS method, first proposed by Zellner and Theil (1962), and further developed by (Fisher 1970) and Hausman et al. (1987), provides appropriate solutions for tackling biases and endogeneity issues, but specially the simultaneity in causalities, allowing us to link several market clearings at the same time in different moments.

Although further academic research has been devoted to the effects of the large-scale purchases of treasury securities by the Fed, these effects revolve around the pricing of debt securities and interest rates. Prominent contributions in this area come from D'Amico and King (2010), D'Amico et al. (2012), Doh (2010), and Hamilton and Wu (2012), among others. The literature linking these effects to the equity markets' pricing, however, is rather tangential to the present day, especially given how recently the last crisis took place. Vukovic et al. (2019) found changing effects on the bond pricing dynamics before and after the economic crisis in the European market for the 2005–2017 period that may give hints of probable changing effects on the pricing of bond securities during the COVID-19 crisis as well (Chen et al. 2021). This research not only pursues the findings of such links and effects, but also tests the empirical methods available and contribute to filling the research gap in these spheres.

2.2. Theoretical Framework

Structurally speaking, the value of a given equity index is influenced by the quotations of the stocks that compose the index. Hence, the performance of the holdings within the index will determine the trends of it. As the companies weighted within the index prosper, so would the performance of its stock. Most firms depend highly on low-cost funding to carry on with their business objectives to become more profitable. Accordingly, as lower cost funds are made available to firms, the more able they are to reinvest them into their activity, thus creating higher value for the company, which in turn is reflected in a higher value of its stock, and ultimately contributes to a higher value of the index of which they are part. Moreover, as low-cost funds become available through the banking system, the faster the transmission of those funds to the firms is. These arguments, and based on the literature discussed above, lead a conclusion about the relevance of the treasury yields (*t_yield*) and the Federal Funds rate (*Fed_FRate*) on the index's expected performance. Moreover, the value of key commodities such as oil and gas, as well as of other inputs, aggravate the costs of most enterprises (Peersman et al. 2021). Furthermore, imported inputs add to the list of costs that may expand with a weaker local currency. Consequently, price indicators such as oil prices (*wti_spot*), consumer price indices (*us_cpi*), and exchange rates (*usd_eur*) must be considered in the index performance analysis. Finally, measures of risk for investing in risky assets must be considered as well, as signs of unexpected risks in the markets tend to make investors reduce their positions in assets within the index, driving it down. This last factor is best captured by volatility indices such as the (*vix*). Accounting for all these factors in a time series setting, the value of a given equity index function (1) can be expressed as follows:

$$Index_t = f\,(t\_yield_t,\ Fed\_FRate_t,\ wti\_spot_t,\ us\_cpi_t,\ usd\_eur_t,\ vix_t) \tag{1}$$

Throughout the period under analysis, as learnt from the literature, the treasury yield rate is influenced by the size of the central bank balance sheet, as it expands as the treasury securities are purchased by the Fed. Additionally, given the size of the U.S. treasuries market, changes in the treasury rate drives the value of its currency as well. In this study we describe how the dynamics of an equity index in the U.S. are influenced by the dynamics in the central bank balance sheet through its impact on the treasury yields. Moreover, the dynamics of its currency value are influenced by those of treasury yields and the oil prices due to the large international exchange of this commodity (Amano and van Norden 1995; Beckmann et al. 2020; Fratzscher et al. 2013; Krugman 1980; Mokni 2020).

In particular, following Krugman and Obstfeld (2006), the relationship between the treasury yields and the central bank's balance sheet may be described by a function with a negative slope in the money market, such as that displayed on the left-hand side of Figure 4.

In this figure, the yields are shown on the vertical axis, and the size of the balance sheet is located on the horizontal axis on the left-hand side, where a rise in the Fed's balance sheet from B-S_0 to B-S_1 is associated with a drop in yields from Y_0 to Y_1.

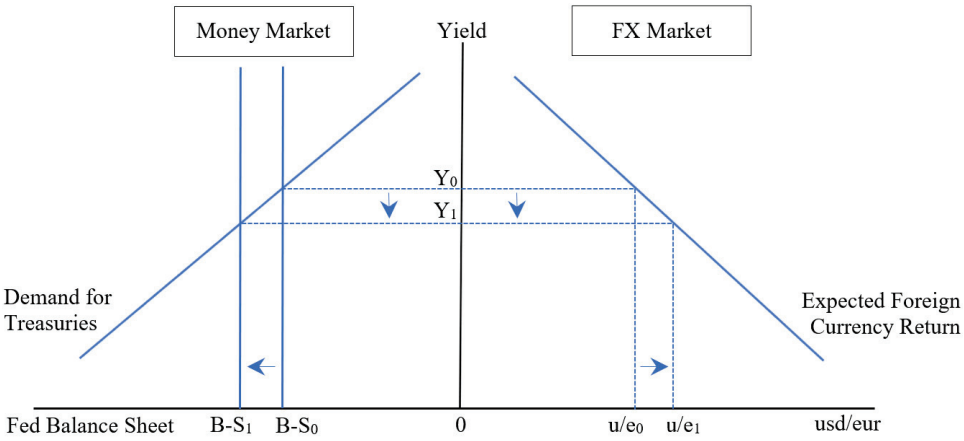

Figure 4. Treasury yields and dollar/euro exchange rate as a function of Fed's balance sheet. Source: own estimations.

Simultaneously, as foreign investors add to a portion of the demand for treasuries, the foreign capital flows of arbitrage pressure the currency price to maintain the interest rate parity (Krugman and Obstfeld 2006). Hence, a function of expected foreign currency returns against yields with a negative slope in the foreign exchange market is also supported, such as that displayed on the right-hand side of Figure 4. In this chart, the yields are also shown on the vertical axis, and the currency price is shown on the horizontal axis, where the drop in the yields from Y_0 to Y_1 is associated with a rise in the currency price from u/e_0 to u/e_1.

Under the above assumptions and mechanisms, the following hypotheses emerge, on which this paper will offer evidence:

H1: *Excess liquidity from interventions leads to the overpricing of equity assets. The results of our regressions will show that, although the estimations of long periods of data are quite reliable, there is a larger effect as the data periods become much larger (Brana and Prat 2016).*

H2: *The pricing in the debt market is directly affected by the size of the Federal Reserve's balance sheet. In line with Krugman and Obstfeld (2006), our models show the exact effects of the Fed's UMP on the treasury yields, a necessary condition (not sufficient) to prove H1.*

H3: *The pricing in both the debt market and currency market, potentially influenced by Federal Reserve interventions, affects the pricing of equity securities in the long run.Also in line with Krugman and Obstfeld (2006), our models show the simultaneous effects of the Fed's UMP on the treasury yields and the currency exchange rate, necessary conditions to prove H1.*

H4: *There exists a divergence in adaptability between equity pricing and debt market pricing. Although the links among the four variables discussed in H1, H2, and H3 are identified, the adaptability of each market differs as the agents in each react differently.*

H5: *Although similar types of monetary interventions were implemented in two different crisis periods, different effects were observed. That is, our results identify opposite effects even though the same monetary tools were used during the great recession compared to the COVID-19 crisis.*

3. Methodological Framework

3.1. The Data

This study employs daily data from major financial indices—the DJIA, S&P 500, NASDAQ, and the SMLCAP 2000—as well as the Federal Reserve's balance sheet size, the federal funds interest rate, and the yields of 10-year treasury bonds. Additionally, it incorporates other pertinent data, including the USD/EUR currency exchange rate, WTI oil spot prices, the Volatility Index (VIX), and the Consumer Price Index (CPI) for inflation. We employ VIX to forecast the anticipated market volatility over the ensuing 30-day period. This index is computed by the Chicago Board Options Exchange, and it derives its calculation from the implied volatilities of numerous options within the S&P 500 index. The temporal scope of the data extends from 16 December 2008 to 29 April 2022, encompassing periods of both central bank interventions and dis-interventions. All data have been sourced from the EIKON Refinitiv (2022) database. A comprehensive summary of the statistics for all data variables is presented in Table 1.

Table 1. Summary descriptive statistics for all variables (from 16 December 2008 to 29 April 2022).

Variable	Obs	Mean	Std.Dev.	Min	Max	Variance	Skewness	Kurtosis
SP500	3366	2210.98	981.02	676.53	4796.56	962,396.9	0.77631	2.91983
DJIA	3366	19,267.45	7585.67	6547.05	36,799.65	57,500,000	0.53529	2.31663
NASDAQ	3366	5869.56	3670.72	1268.64	16,057.44	13,500,000	1.11896	3.39836
SMLCAP 2000	3366	1220.94	472.38	343.26	2442.74	223,147.1	0.51269	2.71154
Fed_BalSht	3366	4.2554	1.7627	1.8434	8.9650	3.106988	1.12002	3.68414
lag1d_Bal_Sh	3365	4.2540	1.7611	1.8434	8.9650	3.101389	1.12016	3.68722
lag1w_Bal_Sh	3361	4.2484	1.7547	1.8434	8.9650	3.078825	1.12061	3.69917
Fed_FRate	3366	0.6326	0.6877	0.250	2.500	0.472965	1.64255	4.22399
t_yield	3366	2.2673	0.7317	0.499	3.994	0.535385	−0.06953	2.71556
usd_eur	3366	0.81961	0.07531	0.6605	0.9627	0.005672	−0.15913	1.74796
wti_spot	3366	68.8356	23.1513	7.79	126.47	535.981	−0.08693	2.23274
us_cpi	3366	1.9182	1.6700	−2.10	8.56	2.788834	1.36117	6.63550
vix	3366	19.3887	8.2991	9.140	82.690	68.875	2.04447	9.36145

Note(s): This table presents the dataset key statistics. Symmetric distributions for coefficient of skewness zero, negative coefficients skewed left, and positive skewed right. Smaller kurtosis coefficients for flatter distributions (fat tails), assuming normal distributions have a coefficient of kurtosis of 3. Source: own estimations.

It is noteworthy that the model excludes certain variables or controls for the sake of simplicity, aligning with the study's aim which does not include testing the robustness of the proposed model. Additional note: the Fed's balance sheet shows a mean of around 4 trillion, with very little variance, indicating relative stability during the observed period. The VIX has a mean of 19.3887, and its high maximum value of 82.690 suggests periods of significant market stress.

3.2. Empirical Model

In order to establish the above stated causalities and linkages, the first identification strategy that comes to mind is the use of vector autoregression models (VAR). Chen et al. (2014) and Broadstock and Filis (2014) used this approach for estimating the effects of oil price shocks on stock market returns using a structural VAR model as an extension of the work by Kilian (2009). Moreover, Stock and Watson (2001) tested the effects on inflation and unemployment of a surprise increase of 100 bps in the federal funds rate, proving this approach to be a good tool for showing the impulse responses of those two variables to monetary policy shocks. However, for longer-term monetary policies such as large-scale security purchases, these would not be regarded as surprise shocks, and given that monetary policy rules change over time, constant parameter structural VARs that miss this instability tend to be improperly identified (Stock and Watson 1996).

As the type of policy analyzed in this paper is not a surprise while it is being executed, we suggest the use of the instrumental variables approach as the identification strategy of

this research. Given that we assume that the index value may be explained in part by the treasury yield and the currency levels, both of which are explained by the balance sheet and oil price levels, respectively, a 3SLS method proposed by Zellner and Theil (1962) can be used to solve the endogeneity issue between treasury yields and the central bank balance sheet levels, and between the currency, treasury yield, and oil price values. The causalities, thus, are best characterized by the following three simultaneous equations system[2]:

$$\text{Stage 1: } t\_yield_t = \pi_0 + \pi_1 Fed\_BalSht_t + \Sigma \pi_i Z_{i,t} + v_t \tag{2}$$

$$\text{Stage 2: } usd\_eur_t = \delta_0 + \delta_1 t\_yield_t + \delta_2 wti\_spot_t + \Sigma \delta_i Z_{i,t} + e_t \tag{3}$$

$$\text{Stage 3: } Index_t = \beta_0 + \beta_1 t\_yield_t + \beta_2 usd\_eur_t + \beta_3 Fed\_FRate_t + \beta_4 us\_cpi_t + u_t \tag{4}$$

In the first equation of the system, the variable Fed_BalSht_t represents how the endogenous variable t_yield_t is affected by the Fed's balance sheet level, so that here the control variable is Fed_BalSht_t. In the second equation, the usd_eur_t dependent variable is affected by t_yield_t, determined by the former equation, and by wti_spot_t, an exogenous variable, the price of which is determined by the international oil market. Conversely, in the third, or principal, equation, the $Index_t$ variable is dependent upon the levels of the federal funds rate, Fed_FRate_t, of the general price levels, us_cpi_t, t_yield_t, and usd_eur_t, from the first and second equations. $Z_{i,t}$ are the vectors of covariates in (4). The solution of this model system can be found in Appendix A.

Although alternative empirical approaches may be used to support the formulated hypotheses, the 3SLS approach is preferred to the full information maximum likelihood (FIML) and the two-stage least squares (2SLS) method as it is less complicated to compute on the one hand, and it goes one step further, on the other, as Zellner and Theil (1962) thoroughly validated. This further step covers two critical aspects in this research. First, it uses the moment matrix of the structural disturbances of the 2SLS to estimate all the coefficients of the whole system simultaneously, and, second, the estimation of the coefficients of any identifiable equation becomes even more efficient upon other over-identified equations, should the moment matrix of the structural disturbances have non-zero simultaneous covariances. This last aspect will be crucial for the interpretation of the validity of instrument tests performed later in this paper. While computation of the 3SLS estimates by Narayanan (1969) and Hausman (1983) proved the goodness of this approach in these two aspects, Wooldridge (2002) gave attention to the identification issues of choosing the right estimator. That is, for just-identified equations, the 2SLS and the 3SLS estimations coincide, in which case the latter would not offer added efficiency.

A key feature of the simultaneous equations approach proposed here is that, although every equation is specified to be linear, the relationships among the variables considered are presumed non-linear. That is, there will typically be non-linear identities connecting the variables in the different equations of the system (Fisher 1970). This non-linearity is essential in our study, as we have visualized in Figure 3 a non-linear divergence between the size of the Fed's balance sheet and the case of the S&P 500 index trajectory, and although the functions shown in Figure 4 are originally described as non-linear by Krugman and Obstfeld (2006), a linear adaptation has been made to fit the empirical model broken down by the different moments of intervention.

In order to calculate the estimations of the proposed instrumental variables system of simultaneous equations, we begin by employing the 3SLS for time series strategy on the S&P 500 index as a case analysis, and then replicate this method on the remaining indices.

4. Empirical Results

4.1. Correlations Results

From the results displayed in Table 2, it is possible to verify our expectations about a high negative correlation between the levels of the Fed's balance sheet and the treasury yields, as well as the high positive correlation of the balance sheet with the value of the foreign exchange rate and inflation. This is in line with the fact that the higher demand from the central bank for treasuries lowers their yield, while weakening its currency and increasing the value of the CPI. Note in the fifth column the high correlation between the balance sheet instrument *Fed_BalSht,* and the *t_yield* (-0.6140), the *usd_eur* (0.5391), and the us_cpi_t (0.5439). Moreover, the results confirm the significant negative correlations between the yields and the currency prices, and the latter with the oil prices of -0.4978 and -0.6676, respectively. Another key finding in this table is the high positive correlations of the balance sheet with the four indices, ranging from 0.8830 in the case of the DJIA to 0.9342 for the NASDAQ, as displayed in the fourth row. Also note that, since the open market purchases are reported weekly, lags in the balance sheet level series have been calculated for one-day and one-week delays (*lag1d_Bal_Sh* and *lag1w_Bal_Sh*), showing similar correlation results with the index. Moreover, the high positive correlations of the indices with the currency value and the CPI (ranging from 0.5551 to 0.6318, and from 0.5450 to 0.5742, respectively) imply that a weakening of the currency, as well as increases in the price of the products sold, may drive the index up.

Finally, although there is a lower negative correlation (ranging from -0.2483 to -0.3043) between the indices and the oil prices, all the above-mentioned results suggest that, for the data used in this study, this set of variables are relevant as instruments for our estimations. In contrast, although the volatility index *vix* displays a negative correlation with all the indices, these are weak correlations, ranging from -0.0639 in the case of the NASDAQ and -0.2800 for the SMLCAP 2000, with this last a logical result as small capitalization companies are more sensitive to market instability.

4.2. Regressions Results

The regression results, estimated by the three stage least squares approach for the S&P 500 index, as a case analysis, are shown in Table 3. In this model, the variable *Fed_BalSht* was used as instrument in the first equation for the endogeneity of the treasury yield variable, *t_yield*. In turn, the treasury yield variable, *t_yield*, was used as instrument in the second equation for the endogeneity of the currency variable, *usd_eur*. The regression results of the simultaneous equations show high statistical significance for most variables. Then, using the coefficients in this table, it is possible to conclude that the Fed's intervention by expanding its balance sheet through the purchase of treasury securities causes the treasury yields to drop while weakening its currency, which supports the high negative correlation between the currency price and the treasury yields shown in the ninth column of Table 2, and in Krugman and Obstfeld's diagram in Figure 4.

As for the principal equation, the results show that the S&P 500 index increases are associated with raises in the Federal Funds Rate, *Fed_FRate,* as shown by its positive coefficient, and drops in the index are associated with cuts in this rate. Intuitively, this tells us that increases in the *Fed_FRate* usually happen when the economy is booming, and cuts of this rate usually happen when the firms that compose the index are underperforming, which in turn corresponds to corrections in the index. Moreover, the coefficients of the oil prices, *wti_spot,* and price index, *us_cpi,* coincide with our expectations that increases in the oil prices and in the price levels in the economy drive the index to drop and rise, respectively, with the former via the weakening of the currency.

Table 2. Correlation results (from 16 December 2008 to 29 April 2022).

	SP500	DJIA	NASDAQ	SMLCAP2000	Fed_ BalSht	lag1d_ Bal_Sh	lag1w_ Bal_Sh	Fed_ FRate	t_yield	usd_eur	wti_spot	us_cpi	vix
SP500	1												
DJIA	0.9925 *	1											
	0.0000												
NASDAQ	0.9893 *	0.9731 *	1										
	0.0000	0.0000											
SMLCAP2000	0.9771 *	0.9803 *	0.9546 *	1									
	0.0000	0.0000	0.0000										
Fed_BalSht	0.9255 *	0.8830 *	0.9342 *	0.8857 *	1								
	0.0000	0.0000	0.0000	0.0000									
lag1d_Bal_Sh	0.9257 *	0.8832 *	0.9343 *	0.8860 *	0.9999 *	1							
	0.0000	0.0000	0.0000	0.0000	0.0000								
lag1w_Bal_Sh	0.9262 *	0.8838 *	0.9345 *	0.8875 *	0.9996 *	0.9997 *	1						
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							
Fed_FRate	0.3128 *	0.4120 *	0.2373 *	0.3602 *	−0.0184	−0.0178	−0.0156	1					
	0.0000	0.0000	0.0000	0.0000	0.2866	0.3014	0.3672						
t_yield	−0.5405 *	−0.5189 *	−0.5578 *	−0.4742 *	−0.6140 *	−0.6134 *	−0.6111 *	0.0951 *	1				
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000					
usd_eur	0.6167 *	0.6318 *	0.5551 *	0.6078 *	0.5391 *	0.5390 *	0.5388 *	0.4339 *	−0.4978 *	1			
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000				
wti_spot	−0.2946 *	−0.3043 *	−0.2948 *	−0.2483 *	−0.2748 *	−0.2750 *	−0.2760 *	−0.2653 *	0.4104 *	−0.6676 *	1		
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000			
us_cpi	0.5742 *	0.5522 *	0.5703 *	0.5450 *	0.5439 *	0.5440 *	0.5446 *	0.0587 *	−0.1449 *	0.1221 *	0.3675 *	1	
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0007	0.0000	0.0000	0.0000		
vix	−0.1522 *	−0.1887 *	−0.0639 *	−0.2800 *	−0.0488	−0.0493	−0.0511	−0.2569 *	−0.0962 *	−0.1629 *	−0.2224 *	−0.0715 *	1
	0.0000	0.0000	0.0002	0.0000	0.0046	0.0042	0.0031	0.0000	0.0000	0.0000	0.0000	0.0000	

Note(s): * denotes coefficients are significant at 0.1%. Source: author's calculations.

Table 3. Regression results for the S&P 500 Index (from 16 December 2008 to 29 April 2022).

Three-stage least-squares regressions						
Panel A: Composition of effects *without* balance sheet weekly lag						
Equation	Obs	Parms	RMSE	R-sq	chi2	P
SP500	3366	2	754.896	0.4077	2411.66	0.0000
t_yield	3366	1	0.57864	0.3744	1778.33	0.0000
usd_eur	3366	2	0.05447	0.4767	4490.07	0.0000
	Coef.	Std.Err.	z	P>|z|	[95% Conf. Interval]	
SP500						
Fed_FRate	384.9307	18.65331	20.64	0.0000	348.3709	421.4906
us_cpi	333.8543	7.72019	43.24	0.0000	318.7230	348.9856
_cons	1327.1010	22.51226	58.95	0.0000	1282.9780	1371.2240
t_yield						
Fed_BalSht	−0.2337	0.00554	−42.17	0.0000	−0.24458	−0.22286
lag1w_Bal_Sh	-	-	-	-	-	-
_cons	3.2618	0.02560	127.42	0.0000	3.21166	3.31201
usd_eur						
t_yield	−0.0450	0.00232	−19.35	0.0000	−0.04954	−0.04043
wti_spot	−0.0018	0.00005	−39.31	0.0000	−0.00193	−0.00174
_cons	1.0480	0.00430	243.84	0.0000	1.03955	1.05640
Endogenous variables:	SP500 t_yield usd_eur					
Exogenous variables:	Fed_FRate us_cpi Fed_BalSht wti_spot					
Panel B: Composition of effects *with* balance sheet weekly lag						
Equation	Obs	Parms	RMSE	R-sq	chi2	P
SP500	3361	2	754.981	0.4068	2385.72	0.0000
t_yield	3361	2	0.57194	0.3897	1862.02	0.0000
usd_eur	3361	2	0.05369	0.4907	4345.55	0.0000
	Coef.	Std.Err.	z	P>|z|	[95% Conf. Interval]	
SP500						
Fed_FRate	382.3947	18.67625	20.47	0.0000	345.7899	418.9995
us_cpi	332.7607	7.72852	43.06	0.0000	317.6131	347.9084
_cons	1331.8390	22.55758	59.04	0.0000	1287.6270	1376.0510
t_yield						
Fed_BalSht	−1.4081	0.18828	−7.48	0.0000	−1.7772	−1.0391
lag1w_Bal_Sh	1.1790	0.18893	6.24	0.0000	0.8087	1.5493
_cons	3.2549	0.02532	128.56	0.0000	3.2053	3.3046
usd_eur						
t_yield	−0.0422	0.00227	−18.6	0.0000	−0.0467	−0.0378
wti_spot	−0.0018	0.00005	−39.52	0.0000	−0.0019	−0.0018
_cons	1.0427	0.00423	246.52	0.0000	1.0344	1.0510
Endogenous variables:	SP500 t_yield usd_eur					
Exogenous variables:	Fed_FRate us_cpi lag1w_Bal_Sh Fed_BalSht wti_spot					

Note(s): This table displays the coefficients of the variables in the models proposed for the S&P 500 index. The models considered are the instrumental variables three stage least squares (IV3SLS) for time series *with* and *without* one week lag in the central bank balance sheet size tested for the entire data period (16 December 2008–29 April 2022). Both models use the size of the Fed's balance sheet as control variables. Source: own estimations.

Panels A and B of Table 3 show the composition of the effects of the balance sheet growth on the treasury yields without and with a weekly lag. That is, although we have established that an increase in the Fed's balance sheet explains the drop in the yields, this

change is about 23.37 basis points (bps) for each trillion added to the Fed's balance sheet, as shown in Panel A. This, however, is a result of netting a sharp drop of about 140.81 (Panel B) bps in the yields as the purchases are executed in the current week (*Fed_BalSht*), but subsequently the yields rise through the week as the liquidity is absorbed by the market in about 117.90 (Panel B) bps (*lag1w_BalSht*), for a net drop of about 22.91 bps per trillion. From these findings, Equation (2) has been re-specified to derive the results on Panel B as:

$$\text{Stage 1': } t\_yield_t = \pi_0 + \pi_1 Fed\_BalSht_t + \pi_2 lag1w\_BalSht_t + \Sigma\pi_i Z_{i,t} + v_t \quad (5)$$

The regression results help identify the magnitudes and changes in the main instrumental variable per week and how the effects are distributed. That is, the expansion of the Fed's balance sheet seems to shave a cumulative portion of the yields that gets transmitted into the index, meaning that as the treasury yields drop slightly further each week while the central bank is executing the securities purchase, the index does not adapt in the same manner, continuing its trend instead. This effect is also noticeable in the other indices, per the results displayed in Appendix B, where all coefficients and equation significances coincide with those for the S&P 500.

Finally, the R-squares for each of the three equations are displayed in the first section of Table 3. Since the simultaneous equations approach is being used in this research, we do not aim to maximize the R-squares in any of the simultaneous equations (Fisher 1970). However, the results register plausible enough R-squares in each equation, as well as high chi-square values.

Appendix B also shows the equation significances for the other indices in line with those for the S&P 500. Although the estimates from the 3SLS are assumed to be robust, they can be verified by the results obtained via the generalized method of moments (GMM) for the S&P 500 case provided in Appendix C.

To assess the validity of the specified equations of the system, we performed the Breusch–Pagan test of independence of errors using the seemingly unrelated regression (SUR) approach introduced by Zellner (1962). The Breusch and Pagan (1980) for the SUR is a Lagrange Multiplier (LM) statistic calculated as:

$$\lambda = T \sum_{m=1}^{M} \sum_{n=1}^{m-1} r_{mn}^2$$

where T is the number of observations and r_{mn} is the estimated correlation between the residuals of the M equations. The LM is distributed as χ^2 with $M\,(M-1)/2$ degrees of freedom. Table 4 displays the correlation matrix of errors across the three equations and the Breusch–Pagan test of independence of the errors.

Table 4. Test of independence of errors for the S&P 500 Index (from 16 December 2008 to 29 April 2022).

Panel A: Correlation Matrix of Residuals (*Without* Balance Sheet Weekly Lag):				Panel B: Correlation Matrix of Residuals (*With* Balance Sheet Weekly Lag):			
	SP500	t_yield	usd_eur		SP500	t_yield	usd_eur
SP500	1			SP500	1		
t_yield	−0.1666	1		t_yield	−0.1631	1	
usd_eur	0.1094	0.2443	1	usd_eur	0.1042	0.2207	1
Breusch–Pagan test of independence: chi2(3) = 334.467,			Pr = 0.0000	Breusch–Pagan test of independence: chi2(3) = 289.651,			Pr = 0.0000

Note(s): This table displays the correlation matrix of errors across the three equations and the Breusch–Pagan test of independence of errors. High $\chi 2$ indicate that the three correlation coefficients are jointly significant. Source: own estimations.

The results of the Breusch–Pagan test of independence, displayed in Table 4, indicate that the three correlation coefficients are jointly significant with χ^2 of 334.467 and 289.651 for the S&P 500 without and with the one-week balance sheet lag equations, respectively. As the results of these tests indicate, the pricing in both the treasury yields and the currency is highly influenced by the central bank balance sheet, and this affects the pricing of equity securities, supporting H2 and H3. The LM results for the remaining indices are provided in Appendix D. Furthermore, Appendix E summarizes the 3SLS, SUR, and 2-step GMM for 3SLS estimators for all indices without and with one-week lag balance sheet size.

4.3. Correlation Analysis of Intervention Effects

The correlation results during the interventions under analysis, displayed in Sections F and G, are somewhat mixed. For instance, in the first intervention, the high negative correlation between the size of the Fed's balance sheet and the treasury yields still holds (−0.4962), while for the second intervention this correlation turns highly positive (0.8121). This last result is explained by the extremely low level (near the zero bound) of the treasury yields at the time of the implementation of the second intervention. That is, in March of 2020, the treasury yields were quoting just below 0.5 percent as these assets became the top global safe haven destination for investors shifting out of risky assets during the global financial downturn caused by the COVID-19 pandemic, while back in 2008 the treasury yields were quoting above 2%, with a high pressure to increase as expectations of further deterioration of the economy increased, driving the yields to almost 4% in the spring of 2009. Hence, even meager increases in the treasury yields during the second intervention would be considered high, for which a rise of 50 bps would double the yield rate, while it would be a rise of a much lesser proportion in the first intervention.

A correlation switching also happens between the balance sheet size and the value of the foreign exchange rate. This correlation, although rather low at 0.1938 in the first intervention, turned negative (−0.0833) during the second intervention, transitorily strengthening the currency as a side effect of the above-described process, in which the demand for dollars increased to purchase the world's safest treasuries. However, there is an increase in the positive correlation of the balance sheet with inflation, passing from 0.4016 in the first intervention to a shocking 0.8838 in the second intervention.

Despite the mixed results in the interventions correlations, the strong correlations of the balance sheet with the four indices also hold, maintaining the highest positive correlation of all four indices in both periods consistently (ranging from 0.9322 to 0.9427, and from 0.8818 to 0.9395 in the first and second interventions, respectively), as well as the lagged balance sheet size variable. Moreover, the high positive correlations of the indices with the CPI accelerated from the first intervention to the second (from a range of 0.3866 to 0.4392 to a startling range of 0.6746 to 0.8725), implying a pronounced upward drive in the indices. Finally, although a low negative correlation of −0.2946 between the S&P 500 and the oil prices was stated from the results of Table 2, this correlation is specially high during both intervention periods (0.8186 to 0.8385 and 0.8231 to 0.9011), leading us to determine that the index performance, although ignored the 2014–2016 oil crisis (where there was no government intervention), was highly sensitive to the oil prices during times of interventionism due to added risks in the financial markets, in agreement with Degiannakis et al. (2018).

4.4. Results of Regression Analysis by Interventions

The next step consists of running the same methods on the data solely in the periods under the intervention by the central bank in order to estimate the changes in the coefficients of the equations presented. In turn, after running the specified 3SLS model for the period from 16 December 2008 to 31 December 2013 for the first intervention, and for the period from 18 March 2020 to 29 March 2022 for the second intervention, yielded the sets of coefficients for the S& P500 case presented in Table 5.

Table 5. Coefficients of regression results by interventions for the S&P 500 Index.

Three-stage least-squares regressions by government intervention						
Intervention	(2008–2013)		(2020–2022)		(2008–2022)	
Variable	SP5003SLS	SP5003SLSlg	SP5003SLS	SP5003SLSlg	SP5003SLS	SP5003SLSlg
SP500						
Fed_FRate	(omitted)	(omitted)	−899.4386 ***	−934.4934 ***	384.9307 ***	382.3947 ***
us_cpi	71.7047 ***	70.8901 ***	209.6201 ***	198.2083 ***	333.8543 ***	332.7607 ***
_cons	1159.469 ***	1161.948 ***	3379.689 ***	3440.396 ***	1327.101 ***	1331.839 ***
t_yield						
Fed_BalSht	−0.79619 ***	2.22881 ***	0.40251 ***	1.47007 ***	−0.23372 ***	−1.40813 ***
lag1w_Bal_Sh	–	−3.06200 ***	–	−0.97657 ***	–	1.17898 ***
_cons	4.80692 ***	4.88872 ***	−1.87952 ***	−2.63439 ***	3.26183 ***	3.25493 ***
usd_eur						
t_yield	−0.03082 ***	−0.03388 ***	0.29521 ***	0.11085 ***	−0.04498 ***	−0.04222 ***
wti_spot	−0.00047 ***	−0.00056 ***	−0.00382 ***	−0.00107 ***	−0.00184 ***	−0.00185 ***
_cons	0.86651 ***	0.88257 ***	0.71070 ***	0.78379 ***	1.04797 ***	1.04269 ***
note: Fed_FRate omitted because of collinearity					legend: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$	

Note(s): This table displays the coefficients of the variables in the models proposed for the S&P 500 index during the two interventions and the entire period under analysis. The models are the Instrumental Variables Three Stage Least Squares (IV3SLS) for time series with and without one-week lag (labeled SP5003SLSlg and SP5003SLS) in the central bank balance sheet size tested during the great recession (2008–2013) and the COVID-19 (2020–2022) intervention periods, and the entire data period (2008–2022). All approaches use the size of the Fed's balance sheet as control variables. ***, **, * Coefficients are significant at the 1%, 5%, and 10% levels. Source: own estimations.

The first two columns of Table 5 display the coefficients under the first intervention, while the next two columns are the resulting coefficients under the second intervention. Furthermore, the last two columns in Table 5 include the coefficients for the entire period, per the results in Table 3, to facilitate the analysis that follows.

First, the coefficients under the first intervention suggest that the Fed's intervention via the expansion of its balance sheet through the purchase of treasury securities leads the treasury yields to drop, and this drop is followed by a weakening of the currency, in line with the results obtained for the entire 2008–2022 period. However, the opposite happens to the yields during the second intervention, turning the yield-to-balance-sheet coefficient positive (0.4025) in the first equation of the system. That is, although the balance sheet size increased abruptly in the spring of 2020, the treasury yields did not continue to drop as they were already at their historically lowest levels, instead moderately rising to levels below those before the start of the first intervention. Moreover, its one-week lagging adaptability inverted. For instance, the yields did, indeed, drop in the week prior to each purchase, yet rose higher in the week of the purchase, acting as though the investment public had identified an opportunity to sell to the Fed at much lower yields each time they anticipated the Fed's purchases. In other words, the Fed fell into a liquidity trap, turning the second intervention rather ineffective in its goal of keeping the yields at least lower than at the start of its intervention. This switching is confirmed by the −0.9766 and 1.4700 coefficients for the one-week lagged (*lag1w_Bal_Sh*) and the actual (*Fed_BalSht*) balance sheet size in the fourth column of Table 5.

Note also that the currency-to-yields coefficient has also switched in the second equation of the second intervention, explained by the foreign flight-to-quality inflows (among other possible factors), hence strengthening the currency while the yields went up. These results indicate that the pricing of the equity index should have adjusted matching the effects of the expansion of the central bank balance sheet on the treasury yields and the currency rate, yet the index continued into an overvaluation trend, in support of H1.

As for the third stage equation, the results show that the S&P 500 index no longer increases by the Federal Funds Rate, *Fed_FRate*. Instead, this rate was omitted by our model in the first intervention, as it stayed constant at the lowest level possible throughout that

intervention. Furthermore, the index fell at the end of the second intervention as the Fed had to raise its rate to tackle the inflation outbreak in early 2021. This is shown by the −899.4386 and −934.4934 coefficients in the third and fourth columns of Table 5. Finally, the coefficients of the price index, *us_cpi*, and the constant terms, both expanded threefold, from 71.70466 and 70.89005 to 209.6201 and 198.2083, and 1159.469 and 1161.948 to 3379.689 and 3440.396, respectively. These results indicate that the inflation component on the index remains the same on both interventions, and that the value of the index tripled in the second intervention from the first one, and so did the size of the Fed's balance sheet. The regression results for all four indices are shown in Appendix H, in which the above findings are confirmed by the two twelve equations systems for each intervention, displayed in panels A and B, for the first and second interventions, respectively.

4.5. Instrumental Variables Tests

In order to verify whether there are endogeneity concerns between the value of the indices and the variables included in the models, the Durbin-Wu-Hausman test was performed for each model in each intervention period. Table 6 shows the results of the endogenous tests for the S&P 500 index models, while Appendix I shows the test results for the other three indices. Based on the higher efficiency of the 3SLS estimators in comparison to those of the 2SLS modeling proved by Zellner and Theil (1962), the Durwin-Wu-Hausman tests were performed using the more constrained 2SLS approach, only merging the first two equations of the 3SLS models. The results in Table 6 and Appendix I exhibit large chi2, and zero *p*-values in all periods, being the largest for the longer period models. Hence, these results strongly reject the null hypothesis that all independent variables are exogenous for the models in the intervention periods under analysis.

Table 6. Instrumental variables tests by interventions for the S&P 500 Index.

Durwin-Wu-Hausman Test			
Tests of endogeneity Ho: variables are exogenous			
Intervention Period:		(2008–2013)	
SP5002SLS	Durwin (score) Wu-Hausman	chi2(1) = 302.04 F(1,1265) = 395.136	(p = 0.0000) (p = 0.0000)
SP5002SLS1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 303.938 F(1,260) = 398.892	(p = 0.0000) (p = 0.0000)
Intervention Period:		(2020–2022)	
SP5002SLS	Durwin (score) Wu-Hausman	chi2(1) = 71.3761 F(1,508) = 82.104	(p = 0.0000) (p = 0.0000)
SP5002SLS1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 95.9886 F(1,503) = 117.187	(p = 0.0000) (p = 0.0000)
Period:		(2008–2022)	
SP5002SLS	Durwin (score) Wu-Hausman	chi2(1) = 2292.5 F(1,3361) = 7177.51	(p = 0.0000) (p = 0.0000)
SP5002SLS1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 2203.08 F(1,3356) = 6385.18	(p = 0.0000) (p = 0.0000)

Note(s): This table shows the presence of endogeneity in the variables included in the models selected. The null hypothesis that all variables in the models are exogenous is rejected if Chi^2 and F values are large. Zero p-values indicate variables are endogenous. All models use the balance sheet as control variable. Source: own estimations.

4.6. First Stage Regression Results

The explanatory power of the instrumental variables is verifiable by running the correlation test of the first stage regression. Table 7 displays the results of such a test on the S&P 500 case per model by intervention period. The Robust F values in all the models

are sufficiently large to reject the null hypothesis that the coefficients of the instrumental variables are zero. A lower than 10 *F* statistic would suggest weak instruments. In the case of the S&P 500 index these values are much higher than 10 in each intervention period. Appendix J shows identical results for the other three indices with identical first stage equations.

Table 7. First-stage regression summary statistics by interventions for the S&P 500 Index.

Model	Variable	*R*-sq.	Adjusted *R*-sq.	Partial *R*-sq.	Robust *F* Value		Prob > *F*
Intervention Period:				(2008–2013)			
SP5002SLS	*t_yield*	0.4688	0.4671	0.4138	F(3,1264):	330.169	0.0000
SP5002SLS1Wlg	*t_yield*	0.4787	0.4766	0.4236	F(4,1258):	253.755	0.0000
Intervention Period:				(2020–2022)			
SP5002SLS	*t_yield*	0.8623	0.8609	0.4426	F(3,507):	132.534	0.0000
SP5002SLS1Wlg	*t_yield*	0.8677	0.8662	0.4637	F(4,501):	118.595	0.0000
Period:				(2008–2022)			
SP5002SLS	*t_yield*	0.4883	0.4875	0.4715	F(3,3360):	957.066	0.0000
SP5002SLS1Wlg	*t_yield*	0.4987	0.4978	0.4823	F(4,3354):	871.693	0.0000

Note(s): This table shows the Robust F statistic for the significance of the instrument coefficients. If the F statistic is not significant, the instruments have no significant explanatory power for *t_yield* after controlling for the effect of *Fed_BalSht*, *lag1w_Bal_Sh*, *usd_eur*, and *wti_spot*. Source: own estimations.

4.7. The Identification of Instrumental Variables

To determine whether fewer instrumental variables than endogenous ones are being used in these models, the Anderson Lagrangian Multiplier test was performed. Table 8 shows that this statistic is large enough to strongly reject the null hypothesis that the models may be under-identified. Furthermore, the Sargan (1964) test on the right-hand side of this table confirms that there is an overidentification of instruments in the models, as expected from the second aspect previously mentioned about the benefits of the 3SLS estimation.

Table 8. Instrumental variables identification tests by interventions for the S&P 500 Index.

	Underidentification test (Anderson canon. corr. LM statistic): Ho: underidentification of instrumental variables		Sargan statistic (overidentification test of all instruments): Ho: overderidentification of instrumental variables	
Intervention Period:		(2008–2013)		
SP5002SLS	525.118	Chi-sq(3) P-val = 0.0000	639.396	Chi-sq(2) P-val = 0.0000
SP5002SLS1Wlg	535.438	Chi-sq(4) P-val = 0.0000	638.456	Chi-sq(3) P-val = 0.0000
Intervention Period:		(2020–2022)		
SP5002SLS	227.03	Chi-sq(3) P-val = 0.0000	287.492	Chi-sq(2) P-val = 0.0000
SP5002SLS1Wlg	235.56	Chi-sq(4) P-val = 0.0000	242.494	Chi-sq(3) P-val = 0.0000
Period:		(2008–2022)		
SP5002SLS	1586.973	Chi-sq(3) P-val = 0.0000	443.641	Chi-sq(2) P-val = 0.0000
SP5002SLS1Wlg	1620.904	Chi-sq(4) P-val = 0.0000	508.681	Chi-sq(3) P-val = 0.0000

Note(s): This table shows high Chi2 values in the Instrumental Variables Underidentification test. These reject the null hypothesis of less relevant instruments in the models than endogenous variables. The zero *p*-values suggest no underidentification of instruments. In the Overidentification test, large Chi2 values and zero *p*-values detect overidentification of instruments. That is, there is one endogenous variable *t_yield*, but more than one valid instrument in addition to *Fed_BalSht*, which are (2): *usd_eur* and *wti_spot* in the simple models, and (3): plus *lag1w_Bal_Sh*, in the lagged models. Source: own estimations.

The number in brackets next to the Chi2 detect the possibility of more than one instrument for the endogenous variable *t_yield*, which could be the currency (*usd_eur*) and the oil prices (wti_spot), in addition to the balance sheet instruments (Fed_BalSht and lag1w_Bal_Sh) for the simple and lagged models, and in turn the currency (*usd_eur*) may also be endogenous. Hence, recalling Wooldridge (2002), the 3SLS strategy is preferred over the 2SLS approach. Accordingly, inclusion of the Fed's balance sheet variable is plausible according to the first test, however, the other variables may also be valid instruments, according to the results of the second test. Appendix K exhibits identical results by intervention period on the first test and, although not identical, high chi2 values on the second test for the remaining indices.

4.8. Results on the Relevance of Instrumental Variables

Table 9 confirms that none of the instruments used in this study is weak in any of the indices' models in all intervention periods. None of the Stock-Yogo (Stock and Yogo 2005) critical values is near the Cragg-Donald Wald *F* statistic (Cragg and Donald 1993), in line with the correlation results which indicated that the variables included in the models are relevant as instruments. Weak instruments draw low μ^2 values and derive low *F* values, which instead here are large enough for all twenty-four models. Moreover, the results of the Montiel–Pflueger robust weak instrument test (Olea and Pflueger 2013; Pflueger and Wang 2015) show that the TSLS and LIML critical values for $\tau = 5\%$ are still low compared to the C-D Wald *F* statistic.

Table 9. Weak instrumental variables tests by index per intervention.

Weak identification test (Cragg–Donald Wald F statistic):								
Intervention Period	Model				Model			
	SP500	DJIA	NASDAQ	SMCP2K	SP500 1WLg	DJIA 1WLg	NASDAQ 1WLg	SMCP2K 1WLg
2008–2013	297.426	297.426	297.426	297.426	231.134	231.134	231.134	231.134
2020–2022	134.169	134.169	134.169	134.169	108.295	108.295	108.295	108.295
2008–2022	999.091	999.091	999.091	999.091	781.065	781.065	781.065	781.065

Stock–Yogo weak ID test critical values:				
	5% maximal IV relative	13.91	5% maximal IV relative	16.85
	10% maximal IV relative	9.08	10% maximal IV relative	10.27
	20% maximal IV relative	6.46	20% maximal IV relative	6.71
	30% maximal IV relative	5.39	30% maximal IV relative	5.34
	10% maximal IV size	22.3	10% maximal IV size	24.58
	15% maximal IV size	12.83	15% maximal IV size	13.96
	20% maximal IV size	9.54	20% maximal IV size	10.26
	25% maximal IV size	7.8	25% maximal IV size	8.31

Montiel–Pflueger robust weak instrument test					
Critical Values:	TSLS	LIML	Critical Values:	TSLS	LIML
% of Worst Case Bias			% of Worst Case Bias		
tau = 5%	13.253	13.253	tau = 5%	16.720	10.231
tau = 10%	8.525	8.525	tau = 10%	10.231	6.701
tau = 20%	5.898	5.898	tau = 20%	6.701	4.749
tau = 30%	4.930	4.930	tau = 30%	5.421	4.035

Note(s): This table shows lower S–Y weak ID test critical values than the C–D Wald F statistics in all intervention periods. The Montiel–Pflueger robust test for weak instruments also shows that neither the TSLS nor LIML critical values for threshold values $\tau \in (5\%, 10\%, 20\%, 30\%)$ exceed the F statistics in any intervention period, thus, rejecting the null hypothesis that the instruments used in the models are weak. Had any of the S-Y and Montiel–Pflueger TSLS and LIML critical values been larger than the C–D Wald F values, there would have been at least one weak instrument in the models. Source: own estimations.

5. Discussion

Based on the results displayed in Table 3, although there is a positive relation between the value of the SP500 and the size of the Fed balance sheet, there is no evidence from the model used in this research that Central Bank interventions via the expansion of the balance sheet cause inflation. This clarifies the assumption of this variable as exogenous within this model. Moreover, even though there is a positive relationship between the SP&500 index value and the consumer price index, the model system used here had to be re-specified as the R-square results of the second equation turned negative, meaning low significance of that equation in the specification of the model in such a way. This fact is in agreement with what Bernanke (2020) suggested about the effects of the lower bound, in which it would be fair to moderately allow the inflation rate target to increase.

However, from the results in Table 5, it is possible to identify that, as the sources of both financial crises were different, the normal flows of liquidity assumed from the first intervention may be altered. For instance, while during the 2008–2013 intervention period the lack of liquidity from the investment public called for the additional liquidity provided by the Fed and lowered the yields some 0.0796 bps for each billion of securities purchases, in the 2020–2022 intervention massive flows of liquidity from the global investors went directly to the purchase of U.S. treasuries, pushing their yields to extremely low levels never seen before nearing the zero bound, though with the help of the Fed's involvement they would not lower further, and instead rose some 0.0403 bps per billion of purchases as the crisis progressed. Hence, the second intervention proved to be rather ineffective for the Fed's goal of lowering the yields further, for which opposite results were attained, despite the same type of stimulation was implemented, supporting H5.

Special attention is given to the currency-to-yields coefficient switching in the second equation of the second intervention, showing the strengthening of the currency as a key effect of the flight-to-quality flows while the yields caught an upward trend. In agreement with Engel (2016), this particular puzzle goes in contradiction to the foreign exchange premium and interest rate differentials relationship. This outcome also provides proof that, although the same type of stimulation was applied in different periods under crisis, opposite results were achieved.

Additionally, the results show that, in the second intervention, the S&P 500 index no longer increases alongside the Federal Funds Rate, instead the index falls at the end of the second intervention as the Fed had to raise its rate to halt the inflation outbreak of early 2022. This last fact may contradict Cochrane (2018), though only for a short period. Furthermore, regarding the large growth in the coefficients of the inflation and the constant terms of the S&P 500 equation, although the inflation proportion on the index remains constant in both interventions, this suggests long-term growth accumulated during the 2014–2019 dis-intervention period as the value of the index tripled in the second intervention from the first one. This conclusion is made possible as the size of the Fed's balance sheet also tripled as of the end of the second intervention.

6. Implications

The results in this research have important policy implications. First, as the Fed's balance sheet expands during its intervention, a cumulative portion of the effect it has on the treasury yields remains on the valuation of the selected U.S. indices on a weekly basis. Although each week the Fed's balance sheet expands, causing a drop in the yield, then after that drop there is a smooth adjustment of the yields in preparation for the following week's purchases by the Fed. Even though this dynamic is happening in the treasuries market, the equity indices continue their trends for which the weekly adjustment does not materialize. As there is no adjustment in the index, the rise of the index continues, revealing a divergence between the pricing in the equity markets and that of the debt market, supporting H4. That is, while the investors in the stock market make their investment decisions on a long-term basis, the traders in the fixed income market do so on a short-term basis. Moreover,

while stock prices follow random walks (Fama 1965), yields follow a diffusion process (Vasicek 1977).

Figure 5 shows the dynamics in the treasury yields in response to the Fed's weekly purchases based on the results displayed in Table 3. While there is a sharp drop upon each new purchase by the Fed executed each week, there is a smooth rise throughout the prior week in anticipation of the following week's Fed purchases. To better illustrate this effect, the expected drop in the yields for each billion of central bank purchases worth of treasuries would be 0.14081 bps on average, from a prior week rise of 0.11789 bps[3].

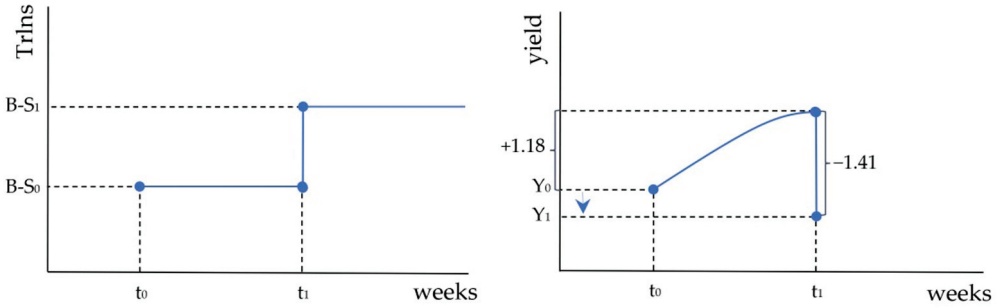

Figure 5. Yield net drops as result of Fed purchases (2008–2022). Source: own calculations.

Figures 6 and 7 show the dynamics in the treasury yields in response to the 2008–2013 and 2020–2022 Fed interventions, per the results shown in Table 5. While there is a confirmation of the yield dynamics in the first intervention displayed in Figure 6, it differs in the second intervention, as shown in Figure 7. That is, while there is a drop in the yields in the week prior to each week's execution of the Fed's purchases, a larger rise in the week of the actual purchases follows, in anticipation of each week's intervention purchases. As the Fed expected the debt markets to behave according to the 2008–2013 intervention, when the effect was a drop of 0.30620 and a rise 0.22288 for a net drop of 0.079 bps per billion dollars, they implemented the same approach to face the COVID-19 crisis of 2020. However, the results in Table 5 proved this policy ineffective, as the yields rose some 0.0403 bps per billion instead, despite an aggressive expansion of the Fed's balance sheet in a shorter period.

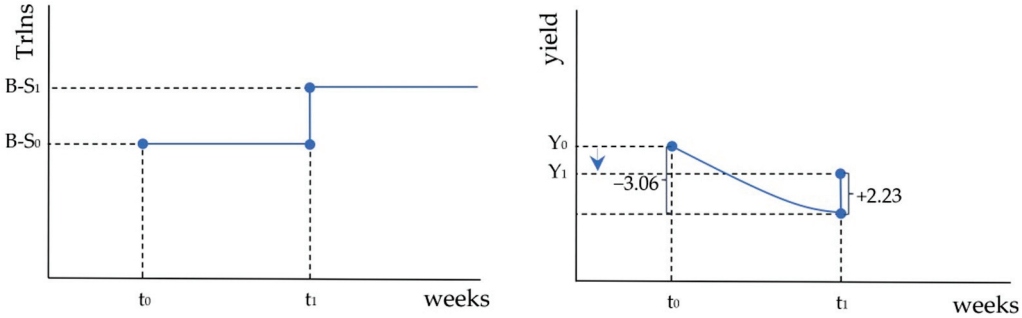

Figure 6. Yield net drops as result of Fed purchases, (2008–2013) intervention. Source: own calculations.

In short, the effects of the size of the central bank's balance sheet on the treasury yields are transmitted into each index valuation equations in different proportions. Hence the level of price distortion on each market is determined by these effects. For instance, while the drop in the yields from the expansion of the balance sheet for the DJIA index is about 0.07390 bps per billion dollars, it is about 0.08747 bps for the Russell index. This explains to some degree why the stocks in the Russell index underperformed in comparison to those in the other indices during the first intervention period. Although the under-valuation would remain for the Russell during the COVID-19 intervention, the S&P 500 would overvalue compared to the other two indices with effects of 0.03774 and 0.04025, respectively.

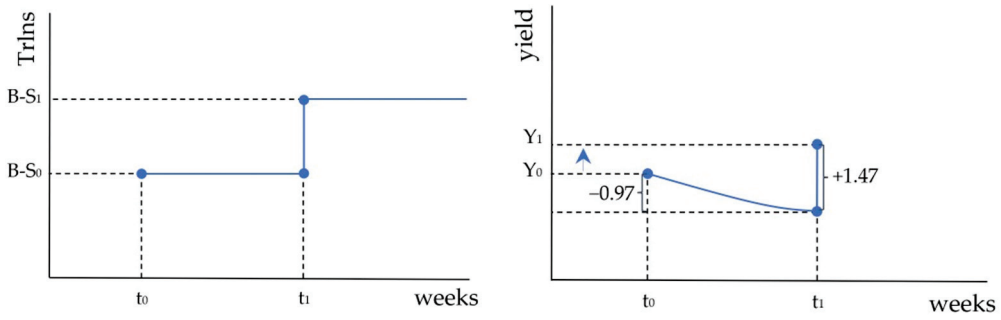

Figure 7. Yield net rises as result of Fed purchases (2020–2022) intervention. Source: own calculations.

In addition to the switching of the balance sheet size against the yields coefficient in the second intervention, the currency-to-yields coefficient has also switched in the second equation, in opposition to Krugman and Obstfeld (2006) premise, accordingly. Figure 8 shows the Figure 4 diagram again, however, in it the demand for treasuries and the expected foreign currency return functions have positive slopes. Nonetheless, the regression results for this intervention estimate a lower elasticity of the expected foreign currency return function compared to that of the demand for treasuries function. In short, for a given amount of Fed purchases in billions of dollars, the rise in the yields is much higher than the strengthening of the dollar against the euro, as a result of the near zero bound yield levels (Doh 2010) and the higher demand for the dollar, respectively, under times of excess liquidity and increased uncertainty. Henceforth, as excess liquidity finds extremely low yields in the debt market and a more costly currency, flows steer into the equity markets in search of much higher returns. Although this effect is identified from the positive performance of the four main indices during the second intervention, it is best described by the different effects, or price distortions, shown in Appendix H for each of the selected indices, once again strongly supporting H5.

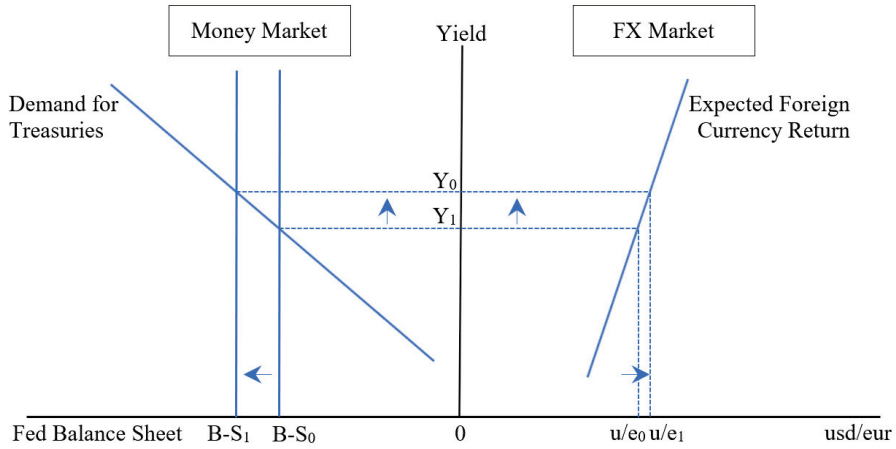

Figure 8. Treasury yields and dollar/euro exchange rate as a function of Fed's balance sheet in 2020–2022 intervention. Source: own estimations.

7. Conclusions

This study uses the interventions of the credit market in the U.S. in response to the credit crisis of 2007 and the response to the COVID-19 crisis as quasi-natural experiments to explore whether interventions in the credit markets such as QE (or tapering) impact some key industry and financial asset prices.

The empirical results show that increases in the Fed's balance sheet, as a consequence of large-scale purchases of treasuries and MBS in the last fourteen years, have impacted the valuation of the four main U.S. equity indices positively. Moreover, this effect seems to add a residual factor that accumulated through the years as the performance of the

equity indices continued its upward trend, even during times of dis-interventions, mostly explained by an adaptability divergence between equity pricing and the debt market pricing. Furthermore, liquidity excesses from interventions in the debt market contribute to the overpricing of equity assets.

Although this research has proved that pricing in the debt market is directly affected by the size of the Fed's balance sheet, it also validates that pricings in the debt and currency markets that may be affected by the Fed's interventions influence the pricing of equity securities in the long run, at least under the simultaneous equations time-series analysis performed on the four most prominent equity markets' benchmarks.

Based on the above conclusions, this study may suggest that if policymakers aim to reduce the relative cost of financing in the capital markets in times of financial distress via market interventions, long-run effects on the pricing of financial assets are to be considered. Such effects include changes in the trends of key macroeconomic series that hint at the over-valuation of financial assets and, thus, inefficient asset valuations in the future. Moreover, the sources of each financial crisis differ, hence different interventions may be implemented. The 2007 crisis originated within the U.S., making it an internal crisis that later spread out to the rest of the world. However, the 2020 crisis originated globally, catching the U.S. as the soundest at that time, to which unprecedented flows of liquidity migrated to help keep the U.S. treasury yields at the lowest historical levels, for which the already known QE mechanism may have been unnecessary for maintaining low yields. The question would be whether the excess liquidity provided by the Fed boosted the valuation of the equity and the consumer price indices at the same time. Moreover, as Cox et al. (1985) mentioned, changes in preferences in the debt market explain the switching in the money and foreign exchange markets' pricing. This may be a limitation of our study as the methods used are unable to capture how the liquidity flows circulate among markets.

Another limitation is the fact that this work focused on identifying the effects on the trends of a particular market such as that of the U.S., for which integration of other relevant markets (e.g., the European and Asian ones) would help break down the effects identified here considerably.

Future research calls for the understanding of the effects on the market as a whole, suggesting the use of panel data modeling that includes the four indices. This may help determine the presence of market segmentations by obtaining fixed effects by index as a result of the interventions studied. Moreover, the different effects shown in Appendix H, which we have referred to as price distortions, may indicate those fixed effects in panel data modeling worth exploring in future research. The methodology may also be useful for estimating the effects by economic sector or by industry.

This research contributes to the understanding of financial asset valuations under particular interventions by central planners in some financial markets.

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Data Availability Statement: The data that support the findings of this study are available from the Federal Reserve Bank of St. Louis (FRED) datasets website https://fred.stlouisfed.org/categories/ (accessed on 29 April 2022) and monetary policy website https://www.federalreserve.gov/monetarypolicy.htm (accessed on 29 April 2022).

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A. Simultaneous Equations by Stages System Index Solution

Given the system:

$$\text{Stage 1: } t\_yield_t = \pi_0 + \pi_1 Fed\_BalSht_t + v_t \quad \text{(A1)}$$

$$\text{Stage 2: } usd\_eur_t = \delta_0 + \delta_1 t\_yield_t + \delta_2 wti\_spot_t + e_t \quad \text{(A2)}$$

$$\text{Stage 3: } Index_t = \beta_0 + \beta_1 t\_yield_t + \beta_2 usd\_eur_t + \beta_3 Fed\_FRate_t + \beta_4 us\_cpi_t + u_t \quad \text{(A3)}$$

By substitution of Equations (2) and (3) into (4):

$$\begin{gathered} Index_t = \beta_0 + \beta_1(\pi_0 + \pi_1 Fed\_BalSht_t + v_t) + \beta_2(\delta_0 + \delta_1(\pi_0 + \pi_1 Fed\_BalSht_t + v_t) + \delta_2 wti\_spot_t + e_t) + \\ \beta_3 Fed\_FRate_t + \beta_4 us\_cpi_t + u_t \\ Index_t = \zeta_0 + \zeta_1 Fed\_BalSht_t + \zeta_2 wti\_spot_t + \zeta_3 Fed\_FRate_t + \zeta_4 us\_cpi_t + \epsilon_t \end{gathered} \quad \text{(A4)}$$

Notice that the variables *t_yield* and *usd_eur* have disappeared from the expression (A4), as they are both the endogenous variables in the system. Hence, the system is finally dependent on the exogenous variables (or instruments) *Fed_BalSht*, *wti_spot*, *Fed_FRate and us_cpi*.

Appendix B. Regression Results by Index (from 16 December 2008 to 29 April 2022)

Three-Stage Least-Squares Regressions by Index

	(1)		(2)		(3)		(4)	
Variable	**SP500**	**SP500 1WLg**	**DJIA**	**DJIA 1WLg**	**NASDAQ**	**NASDAQ 1WLg**	**SMCP2K**	**SMCP2K 1WLg**
Fed_FRate	384.9307	382.3947	4137.8340	4119.3300	1183.6030	1174.2210	208.4120	206.6854
us_cpi	333.8543	332.7607	2469.4850	2462.0310	1292.0510	1289.9160	146.9944	146.2313
_cons	1327.1010	1331.8390	11913.1100	11947.2600	2642.4890	2655.5140	807.1451	810.3717
R^2	0.4077	0.4068	0.4494	0.4486	0.3657	0.3649	0.4044	0.4034
χ	2411.66	2385.72	2903.65	2873.31	2230.06	2210.86	2187.3	2161.54
P-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
t_yield								
Fed_BalSht	−0.233722	−1.408131	−0.228948	−1.372496	−0.233966	−1.360477	−0.253249	−1.543998
lag1w_Bal_Sh	-	1.178981	-	1.147626	-	1.130360	-	1.298019
_cons	3.261833	3.25493	3.241519	3.236392	3.262874	3.258566	3.344931	3.327776
R^2	0.3744	0.3897	0.3731	0.3883	0.3745	0.3895	0.377	0.3929
χ	1778.33	1862.02	1714.78	1800.21	1783.27	1871.68	2060.26	2123.75
P-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
usd_eur								
t_yield	−0.044983	−0.042221	−0.046512	−0.043667	−0.051962	−0.049034	−0.038969	−0.036551
wti_spot	−0.001836	−0.001847	−0.001832	−0.001844	−0.001836	−0.001849	−0.001878	−0.001882
_cons	1.047974	1.042690	1.051195	1.045825	1.063766	1.058340	1.037202	1.032244
R^2	0.4767	0.4907	0.4716	0.4865	0.4490	0.4669	0.4918	0.5026
χ	4490.07	4345.55	4565.02	4419.63	4910.79	4763.24	4309.16	4164.75
P-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Endogenous variables:		SP500 DJIA NASDAQ		SMCP2K t_yield usd_eur				
Exogenous variables:		Fed_FRate us_cpi		lag1w_Bal_Sh Fed_BalSht wti_spot				

Source: own estimations.

Appendix C. Robust Estimates S&P 500 Index (from 16 December 2008 to 29 April 2022)

Two Step GMM Estimation Results

Step 1
Iteration 0: GMM criterion Q (b) = 5828325.5
Iteration 1: GMM criterion Q (b) = 540042.39
Iteration 2: GMM criterion Q (b) = 540042.39
Step 2
Iteration 0: GMM criterion Q (b) = 1.2128526
Iteration 1: GMM criterion Q (b) = 1.1949021
Iteration 2: GMM criterion Q (b) = 1.1949021
GMM estimation
Number of parameters = 9
Number of moments = 18
Initial weight matrix: Unadjusted Number of obs = 3,361
GMM weight matrix: Unadjusted

	Coef.	Std. Err.	z	P > z	[95% Conf.	Interval]
SP500						
Fed_FRate	397.817	18.69296	21.28	0.0000	361.179	434.455
us_cpi	335.843	7.73227	43.43	0.0000	320.688	350.998
_cons	1316.156	22.57053	58.31	0.0000	1271.919	1360.394
t_yield						
lag1w_Bal_Sh	1.536262	0.196165	7.83	0.0000	1.15179	1.920738
Fed_BalSht	−1.752991	0.195403	−8.97	0.0000	−2.135973	−1.370008
_cons	3.20559	0.025438	126.02	0.0000	3.15573	3.255447
usd_eur						
t_yield	−0.043461	0.003145	−13.82	0.0000	−0.049626	−0.037297
wti_spot	−0.001838	0.000067	−27.58	0.0000	−0.001968	−0.001707
_cons	1.04489	0.005873	177.9	0.0000	1.03337	1.056397

Instruments for equation eq1: Fed_FRate us_cpi lag1w_Bal_Sh Fed_BalSht wti_spot _cons
Instruments for equation eq2: Fed_FRate us_cpi lag1w_Bal_Sh Fed_BalSht wti_spot _cons
Instruments for equation eq3: Fed_FRate us_cpi lag1w_Bal_Sh Fed_BalSht wti_spot _cons

Source: own calculations.

Appendix D. Test of Independence of Errors by Index (from 16 December 2008 to 29 April 2022)

Panel A: Correlation matrix of residuals (*without* Balance Sheet Weekly Lag):

	SP500	t_yield	usd_eur
SP500	1		
t_yield	−0.1666	1	
usd_eur	0.1094	0.2443	1

Breusch–Pagan test of independence: chi2(3) = 334.467, Pr = 0.0000

Correlation matrix of residuals:

	DJIA	t_yield	usd_eur
DJIA	1		
t_yield	−0.1859	1	
usd_eur	0.0984	0.2443	1

Breusch–Pagan test of independence: chi2(3) = 349.718, Pr = 0.0000

Correlation matrix of residuals:

	NASDAQ	t_yield	usd_eur
NASDAQ	1		
t_yield	−0.1702	1	
usd_eur	0.029	0.2443	1

Breusch–Pagan test of independence: chi2(3) = 301.150, Pr = 0.0000

Correlation matrix of residuals:

	SMCP2K	t_yield	usd_eur
SMCP2K	1		
t_yield	−0.0943	1	
usd_eur	0.162	0.2443	1

Breusch–Pagan test of independence: chi2(3) = 319.167, Pr = 0.0000

Panel B: Correlation matrix of residuals (*with* Balance Sheet Weekly Lag):

	SP500	t_yield	usd_eur
SP500	1		
t_yield	−0.1631	1	
usd_eur	0.1042	0.2207	1

Breusch–Pagan test of independence: chi2(3) = 289.651, Pr = 0.0000

Correlation matrix of residuals:

	DJIA	t_yield	usd_eur
DJIA	1		
t_yield	−0.1813	1	
usd_eur	0.0931	0.2207	1

Breusch–Pagan test of independence: chi2(3) = 303.367, Pr = 0.0000

Correlation matrix of residuals:

	NASDAQ	t_yield	usd_eur
NASDAQ	1		
t_yield	−0.1649	1	
usd_eur	0.0238	0.2207	1

Breusch–Pagan test of independence: chi2(3) = 257.073, Pr = 0.0000

Correlation matrix of residuals:

	SMCP2K	t_yield	usd_eur
SMCP2K	1		
t_yield	−0.0981	1	
usd_eur	0.1568	0.2207	1

Breusch–Pagan test of independence: chi2(3) = 278.725, Pr = 0.0000

Note(s): This table displays the correlation matrix of errors across the three equations and the Breusch–Pagan test of independence of the errors for each of the indices. High χ^2 indicate that the three correlation coefficients are jointly significant. Source: own estimations.

Appendix E. 3SLS, SUR and 2 Step GMM Estimators for All Indices (2008–2022)

Three-Stage Least-Squares, Seemingly Unrelated, and Two Step GMM Regressions Estimation Results by Index (from 16 December 2008 to 29 April 2022)

Index	S&P500						DJIA					
Model	3SLS	3SLS1Wlg	SUR	SUR1Wlg	Robust	Robust1Wlg	3SLS	3SLS1Wlg	SUR	SUR1Wlg	Robust	Robust1Wlg
Variable												
Fed_FRate	384.9307	382.3947	341.8748	343.2947	404.6229	397.8169	4137.8341	4119.3297	3813.1064	3823.4318	4350.7396	4308.5433
us_cpi	333.8543	332.7608	320.0322	319.9994	337.4309	335.8427	2469.4851	2462.0312	2362.0200	2362.6059	2502.5455	2494.4704
_cons	1327.1010	1331.8388	1380.8500	1381.1001	1307.7838	1316.1561	11913.1050	11947.2620	12324.6550	12325.5320	11715.0120	11765.1700
t_yield												
Fed_BalSht	−0.2337	−1.4081	−0.2225	−1.7064	−0.2202	−1.7530	−0.2289	−1.3725	−0.2182	−1.6731	−0.2067	−2.1008
lag1w_Bal_Sh		1.1790		1.4893		1.5363		1.1476		1.4598		1.9005
_cons	3.2618	3.2549	3.2141	3.2070	3.2042	3.2056	3.2415	3.2364	3.1956	3.1901	3.1468	3.1391
usd_eur												
t_yield	−0.0450	−0.0422	−0.0391	−0.0375	−0.0472	−0.0435	−0.0465	−0.0437	−0.0393	−0.0377	−0.0502	−0.0461
wti_spot	−0.0018	−0.0018	−0.0017	−0.0017	−0.0018	−0.0018	−0.0018	−0.0018	−0.0017	−0.0017	−0.0018	−0.0018
_cons	1.0480	1.0427	1.0234	1.0217	1.0519	1.0449	1.0512	1.0458	1.0248	1.0231	1.0576	1.0500
Index	NASDAQ						SMCP2K					
Model	3SLS	3SLS1Wlg	SUR	SUR1Wlg	Robust	Robust1Wlg	3SLS	3SLS1Wlg	SUR	SUR1Wlg	Robust	Robust1Wlg
Variable												
Fed_FRate	1183.6028	1174.2210	1026.3398	1031.1730	1164.4119	1145.8599	208.4120	206.6854	186.2845	186.9564	212.6758	209.6973
us_cpi	1292.0513	1289.9159	1243.1496	1244.3260	1275.7923	1272.5377	146.9944	146.2313	140.5160	140.3782	148.0706	147.0385
_cons	2642.4893	2655.5136	2835.7710	2833.6290	2685.8162	2706.8413	807.1451	810.3717	833.5691	834.1026	802.3836	806.9149
t_yield												
Fed_BalSht	−0.2340	−1.3605	−0.2260	−1.6988	−0.2122	−2.0778	−0.2532	−1.5440	−0.2403	−1.8271	−0.2490	−1.6239
lag1w_Bal_Sh		1.1304		1.4781		1.8716		1.2980		1.5945		1.3810
_cons	3.2629	3.2586	3.2289	3.2219	3.1702	3.1642	3.3449	3.3278	3.2897	3.2735	3.3270	3.3154
usd_eur												
t_yield	−0.0520	−0.0490	−0.0411	−0.0395	−0.0555	−0.0513	−0.0390	−0.0366	−0.0374	−0.0359	−0.0397	−0.0369
wti_spot	−0.0018	−0.0018	−0.0017	−0.0018	−0.0018	−0.0018	−0.0019	−0.0019	−0.0017	−0.0017	−0.0019	−0.0019
_cons	1.0638	1.0583	1.0324	1.0308	1.0699	1.0623	1.0372	1.0322	1.0200	1.0182	1.0384	1.0328

Endogenous variables: SP500 DJIA NASDAQ SMCP2K t_yield usd_eur
Exogenous variables: Fed_FRate us_cpi Fed_BalSht lag1w_Bal_Sh wti_spot

Source: Own Estimations.

Appendix F. Correlation Results (2008–2013)

	SP500	DJIA	NASDAQ	SMLCAP2000	Fed_ BalSht	lag1d_ Bal_Sh	lag1w_ Bal_Sh	Fed_ FRate	t_yield	usd_eur	wti_spot	us_cpi	vix
SP500	1												
DJIA	0.9956 *	1											
	0.0000												
NASDAQ	0.9950 *	0.9900 *	1										
	0.0000	0.0000											
SMLCAP2000	0.9914 *	0.9844 *	0.9896 *	1									
	0.0000	0.0000	0.0000										
Fed_BalSht	0.9391 *	0.9391 *	0.9427 *	0.9322 *	1								
	0.0000	0.0000	0.0000	0.0000									
lag1d_Bal_Sh	0.9386 *	0.9388 *	0.9425 *	0.9316 *	0.9996 *	1							
	0.0000	0.0000	0.0000	0.0000	0.0000								
lag1w_Bal_Sh	0.9368 *	0.9374 *	0.9418 *	0.9293 *	0.9982 *	0.9986 *	1						
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							
Fed_FRate	.	.	.	.	.	.	.	.					
t_yield	−0.4187 *	−0.4707 *	−0.4211 *	−0.3546 *	−0.4962 *	−0.4979 *	−0.5067 *	.	1				
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.					
usd_eur	0.1716 *	0.1940 *	0.1821 *	0.1411 *	0.1938 *	0.1946 *	0.1976 *	.	−0.5324 *	1			
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.	0.0000				
wti_spot	0.8186 *	0.8385 *	0.8342 *	0.8335 *	0.7295 *	0.7291 *	0.7290 *	.	−0.2902 *	0.0066	1		
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.	0.0000	0.8146			
us_cpi	0.3866 *	0.4392 *	0.4068 *	0.4032 *	0.4016 *	0.4016 *	0.4017 *	.	−0.3064 *	0.0608	0.6168 *	1	
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.	0.0000	0.0304	0.0000		
vix	−0.7913 *	−0.7824 *	−0.7808 *	−0.7846 *	−0.5779 *	−0.5768 *	−0.5706 *	.	0.1325 *	−0.0258	−0.7765 *	−0.2480 *	1
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	.	0.0000	0.3578	0.0000	0.0000	

(*) denotes coefficients significant at the 10% level. Source: Own calculations.

Appendix G. Correlation Results (2020–2022)

	SP500	DJIA	NASDAQ	SMLCAP 2000	Fed_ BalSht	lag1d_ Bal_Sh	lag1w_ Bal_Sh	Fed_ FRate	t_yield	usd_eur	wti_spot	us_cpi	vix
SP500	1												
DJIA	0.9909 *	1											
	0.0000												
NASDAQ	0.9783 *	0.9762 *	1										
	0.0000	0.0000											
SMLCAP2000	0.9176 *	0.9454 *	0.9530 *	1									
	0.0000	0.0000	0.0000										
Fed_BalSht	0.9395 *	0.9169 *	0.8818 *	0.7923 *	1								
	0.0000	0.0000	0.0000	0.0000									
lag1d_Bal_Sh	0.9387 *	0.9156 *	0.8808 *	0.7897 *	0.9985 *	1							
	0.0000	0.0000	0.0000	0.0000	0.0000								
lag1w_Bal_Sh	0.9329 *	0.9074 *	0.8758 *	0.7799 *	0.9942 *	0.9952 *	1						
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000							
Fed_FRate	0.137	0.1129	0.0779	0.0518	0.1998 *	0.2005 *	0.2003 *	1					
	0.0019	0.0105	0.0778	0.2416	0.0000	0.0000	0.0000						
t_yield	0.8249 *	0.8272 *	0.7448 *	0.7776 *	0.8121 *	0.8190 *	0.8280 *	0.3310 *	1				
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000					
usd_eur	−0.2720 *	−0.3581 *	−0.4108 *	−0.5149 *	−0.0833	−0.0792	−0.0457	0.2030 *	−0.048	1			
	0.0000	0.0000	0.0000	0.0000	0.0594	0.0736	0.3043	0.0000	0.2774				
wti_spot	0.9011 *	0.8884 *	0.8441 *	0.8231 *	0.8783 *	0.8786 *	0.8812 *	0.2782 *	0.9232 *	−0.1361	1		
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0020			
us_cpi	0.8725 *	0.8317 *	0.7680 *	0.6746 *	0.8822 *	0.8838 *	0.8902 *	0.2509 *	0.8595 *	0.1269	0.9073 *	1	
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0040	0.0000		
vix	−0.7263 *	−0.7686 *	−0.7784 *	−0.7670 *	−0.6650 *	−0.6608 *	−0.6358 *	−0.0351	−0.4254 *	0.5730 *	−0.4900 *	−0.3888 *	1
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4280	0.0000	0.0000	0.0000	0.0000	

(*) denotes coeficients signifcant at the 10% level. Source: Own calculations.

Appendix H. Regression Results by Index per Intervention

Three-Stage Least-Squares Regressions by Index per Intervention								
Panel A: Regressions Results 1st Intervention (2008–2013)								
Variable	SP500	SP500 1WLg	DJIA	DJIA 1WLg	NASDAQ	NASDAQ 1WLg	SMCP2K	SMCP2K 1WLg
Index	(1)		(2)		(3)		(4)	
Fed_FRate	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)
us_cpi	71.7047	70.8900	707.6381	700.8915	185.9111	183.6030	52.0364	51.4864
_cons	1159.4691	1161.9480	10754.6280	10774.7960	2373.3875	2380.5885	671.6842	673.4021
P-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
t_yield	(5)		(6)		(7)		(8)	
Fed_BalSht	−0.7962	2.2288	−0.7390	2.3320	−0.7995	2.2430	−0.8747	2.0488
lag1w_Bal_Sh	-	−3.0620	-	−3.1103	-	−3.0796	-	−2.9574
_cons	4.8069	4.8887	4.6529	4.7403	4.8159	4.8980	5.0185	5.0925
P-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
usd_eur	(9)		(10)		(11)		(12)	
t_yield	−0.0308	−0.0339	−0.0311	−0.0342	−0.0304	−0.0334	−0.0303	−0.0332
wti_spot	−0.0005	−0.0006	−0.0005	−0.0006	−0.0005	−0.0006	−0.0005	−0.0006
_cons	0.8665	0.8826	0.8673	0.8833	0.8665	0.8825	0.8663	0.8823
P-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Panel B: Regressions Results 2nd Intervention (2020–2022)								
Variable	SP500	SP500 1WLg	DJIA	DJIA 1WLg	NASDAQ	NASDAQ 1WLg	SMCP2K	SMCP2K 1WLg
Index	(13)		(14)		(15)		(16)	
Fed_FRate	−899.4386	−934.4934	−8372.9004	−9421.7857	−5603.9925	−5440.0177	−1481.5871	−1570.1119
us_cpi	209.6201	198.2083	1343.0482	1263.4306	682.0166	631.6812	94.3413	89.6114
_cons	3379.6891	3440.3962	28658.1660	29297.2660	11841.9870	12023.1460	1979.4897	2026.0396
P-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
t_yield	(17)		(18)		(19)		(20)	
Fed_BalSht	0.4025	1.4701	0.3935	1.5285	0.3993	1.5056	0.3774	1.6158
lag1w_Bal_Sh	-	−0.9766	-	−1.0390	-	−1.0100	-	−1.1297
_cons	−1.8795	−2.6344	−1.8098	−2.6064	−1.8549	−2.6521	−1.6859	−2.5842
P-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
usd_eur	(21)		(22)		(23)		(24)	
t_yield	0.2952	0.1108	0.2637	0.0964	0.3541	0.1165	0.3205	0.1128
wti_spot	−0.0038	−0.0011	−0.0032	−0.0008	−0.0048	−0.0012	−0.0041	−0.0011
_cons	0.7107	0.7838	0.7175	0.7862	0.6925	0.7836	0.6966	0.7802
P-Value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Endogenous variables:		SMCP2K t_yield usd_eur						
Exogenous variables:		lag1w_Bal_Sh wti_spot						

Source: own calculations.

Appendix I. Instrumental Variables Tests by Index per Intervention

Durwin-Wu-Hausman Test			
Tests of endogeneity			
Ho: variables are exogenous			
Intervention Period:		(2008–2013)	
DJIA2SLS	Durwin (score) Wu-Hausman	chi2(1) = 287.229 F(1,1265) = 370.091	(p = 0.0000) (p = 0.0000)
DJIA2SLS_1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 290.807 F(1,260) = 376.51	(p = 0.0000) (p = 0.0000)
NASDAQ2SLS	Durwin (score) Wu-Hausman	chi2(1) = 317.109 F(1,1265) = 421.417	(p = 0.0000) (p = 0.0000)
NASDAQ2SLS_1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 320.922 F(1,260) = 428.768	(p = 0.0000) (p = 0.0000)
SMCP2K2SLS	Durwin (score) Wu-Hausman	chi2(1) = 287.229 F(1,1265) = 370.091	(p = 0.0000) (p = 0.0000)
SMCP2K2SLS_1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 315.581 F(1,260) = 418.713	(p = 0.0000) (p = 0.0000)
Intervention Period:		(2020–2022)	
DJIA2SLS	Durwin (score) Wu-Hausman	chi2(1) = 62.7963 F(1,508) = 70.858	(p = 0.0000) (p = 0.0000)
DJIA2SLS_1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 80.1503 F(1,503) = 94.2284	(p = 0.0000) (p = 0.0000)
NASDAQ2SLS	Durwin (score) Wu-Hausman	chi2(1) = 95.4257 F(1,508) = 116.09	(p = 0.0000) (p = 0.0000)
NASDAQ2SLS_1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 121.784 F(1,503) = 158.609	(p = 0.0000) (p = 0.0000)
SMCP2K2SLS	Durwin (score) Wu-Hausman	chi2(1) = 100.157 F(1,508) = 123.242	(p = 0.0000) (p = 0.0000)
SMCP2K2SLS_1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 120.088 F(1,503) = 155.717	(p = 0.0000) (p = 0.0000)
Period:		(2008–2022)	
DJIA2SLS	Durwin (score) Wu-Hausman	chi2(1) = 2157.66 F(1,3361) = 6001.52	(p = 0.0000) (p = 0.0000)
DJIA2SLS_1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 2083.34 F(1,3356) = 5472.27	(p = 0.0000) (p = 0.0000)
NASDAQ2SLS	Durwin (score) Wu-Hausman	chi2(1) = 2001.14 F(1,3361) = 4927.87	(p = 0.0000) (p = 0.0000)
NASDAQ2SLS_1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 1920.89 F(1,3356) = 4476.4	(p = 0.0000) (p = 0.0000)
SMCP2K2SLS	Durwin (score) Wu-Hausman	chi2(1) = 1971.55 F(1,3361) = 4751.98	(p = 0.0000) (p = 0.0000)
SMCP2K2SLS_1Wlg	Durwin (score) Wu-Hausman	chi2(1) = 1863.77 F(1,3356) = 4177.57	(p = 0.0000) (p = 0.0000)

Note(s): This table shows presence of endogeneity in the variables included in the models selected. The null hypothesis that all variables in the models are exogenous is rejected if Chi^2 and F values are large. Zero p-values indicate variables are endogenous. All models use the balance sheet as a control variable. Source: own estimations.

Appendix J. First-Stage Regression Summary Statistics by Index per Intervention

Model	Variable	*R*-sq.	Adjusted *R*-sq.	Partial *R*-sq.	Robust *F* Value		Prob > *F*
Intervention Period:			(2008–2013)				
DJIA2SLS	*t_yield*	0.4688	0.4671	0.4138	F(3,1264):	330.169	0.0000
DJIA2SLS_1Wlg	*t_yield*	0.4787	0.4766	0.4236	F(4,1258):	253.755	0.0000
NASDAQ2SLS	*t_yield*	0.4688	0.4671	0.4138	F(3,1264):	330.169	0.0000
NASDAQ2SLS_1Wlg	*t_yield*	0.4787	0.4766	0.4236	F(4,1258):	253.755	0.0000
SMCP2K2SLS	*t_yield*	0.4688	0.4671	0.4138	F(3,1264):	330.169	0.0000
SMCP2K2SLS_1Wlg	*t_yield*	0.4787	0.4766	0.4236	F(4,1258):	253.755	0.0000
Intervention Period:			(2020–2022)				
DJIA2SLS	*t_yield*	0.8623	0.8609	0.4426	F(3,507):	132.534	0.0000
DJIA2SLS_1Wlg	*t_yield*	0.8677	0.8662	0.4637	F(4,501):	118.595	0.0000
NASDAQ2SLS	*t_yield*	0.8623	0.8609	0.4426	F(3,507):	132.534	0.0000
NASDAQ2SLS_1Wlg	*t_yield*	0.8677	0.8662	0.4637	F(4,501):	118.595	0.0000
SMCP2K2SLS	*t_yield*	0.8623	0.8609	0.4426	F(3,507):	132.534	0.0000
SMCP2K2SLS_1Wlg	*t_yield*	0.8677	0.8662	0.4637	F(4,501):	118.595	0.0000
Period:			(2008–2022)				
DJIA2SLS	*t_yield*	0.4883	0.4875	0.4715	F(3,3360):	957.066	0.0000
DJIA2SLS_1Wlg	*t_yield*	0.4987	0.4978	0.4823	F(4,3354):	871.693	0.0000
NASDAQ2SLS	*t_yield*	0.4883	0.4875	0.4715	F(3,3360):	957.066	0.0000
NASDAQ2SLS_1Wlg	*t_yield*	0.4987	0.4978	0.4823	F(4,3354):	871.693	0.0000
SMCP2K2SLS	*t_yield*	0.4883	0.4875	0.4715	F(3,3360):	957.066	0.0000
SMCP2K2SLS_1Wlg	*t_yield*	0.4987	0.4978	0.4823	F(4,3354):	871.693	0.0000

Note(s): This table shows the Robust F statistic for the significance of the instrument coefficients. If the F statistic is not significant, the instruments have no significant explanatory power for *t_yield* after controlling for the effect of *Fed_BalSht*, *lag1w_Bal_Sh*, *usd_eur*, and *wti_spot*. Source: own estimations.

Appendix K. Instrumental Variables Identification Tests by Index per Intervention

	Underidentification test (Anderson canon. corr. LM statistic): Ho: underidentification of instrumental variables		Sargan statistic (overidentification test of all instruments): Ho: overderidentification of instrumental variables	
Intervention Period:		(2008–2013)		
DJIA2SLS	525.118	Chi-sq(3) P-val = 0.0000	658.841	Chi-sq(2) P-val = 0.0000
DJIA2SLS1Wlg	535.438	Chi-sq(4) P-val = 0.0000	655.72	Chi-sq(3) P-val = 0.0000
NASDAQ2SLS	525.118	Chi-sq(3) P-val = 0.0000	636.342	Chi-sq(2) P-val = 0.0000
NASDAQ2SLS1Wlg	535.438	Chi-sq(4) P-val = 0.0000	633.039	Chi-sq(3) P-val = 0.0000
SMCP2K2SLS	525.118	Chi-sq(3) P-val = 0.0000	631.205	Chi-sq(2) P-val = 0.0000
SMCP2K2SLS1Wlg	535.438	Chi-sq(4) P-val = 0.0000	630.598	Chi-sq(3) P-val = 0.0000
Intervention Period:		(2020–2022)		
DJIA2SLS	227.03	Chi-sq(3) P-val = 0.0000	317.99	Chi-sq(2) P-val = 0.0000
DJIA2SLS1Wlg	235.56	Chi-sq(4) P-val = 0.0000	277.335	Chi-sq(3) P-val = 0.0000
NASDAQ2SLS	227.03	Chi-sq(3) P-val = 0.0000	236.747	Chi-sq(2) P-val = 0.0000
NASDAQ2SLS1Wlg	235.56	Chi-sq(4) P-val = 0.0000	202.537	Chi-sq(3) P-val = 0.0000
SMCP2K2SLS	227.03	Chi-sq(3) P-val = 0.0000	212.14	Chi-sq(2) P-val = 0.0000
SMCP2K2SLS1Wlg	235.56	Chi-sq(4) P-val = 0.0000	186.43	Chi-sq(3) P-val = 0.0000
Period:		(2008–2022)		
DJIA2SLS	1586.973	Chi-sq(3) P-val = 0.0000	510.89	Chi-sq(2) P-val = 0.0000
DJIA2SLS1Wlg	1620.904	Chi-sq(4) P-val = 0.0000	569.035	Chi-sq(3) P-val = 0.0000
NASDAQ2SLS	1586.973	Chi-sq(3) P-val = 0.0000	553.352	Chi-sq(2) P-val = 0.0000
NASDAQ2SLS1Wlg	1620.904	Chi-sq(4) P-val = 0.0000	618.657	Chi-sq(3) P-val = 0.0000

SMCP2K2SLS	1586.973	Chi-sq(3) P-val = 0.0000	537.662	Chi-sq(2) P-val = 0.0000
SMCP2K2SLS1Wlg	1620.904	Chi-sq(4) P-val = 0.0000	624.028	Chi-sq(3) P-val = 0.0000

Note(s): This table shows high Chi2 values in the Instrumental Variables Underidentification test. These reject the null hypothesis of less relevant instruments in the models as endogenous variables. The zero *p*-values suggest no underidentification of instruments. In the Overidentification test, large Chi2 values and zero *p*-values detect overidentification of instruments. That is, there is one endogenous variable *t_yield*, but more than one valid instrument in addition to *Fed_BalSht,* which are (2): *usd_eur* and *wti_spot* in the simple models and (3): plus *lag1w_Bal_Sh,* in the lagged models. Source: own estimations.

Notes

1 Quantitative Easing (QE) is a form of monetary policy used by central banks as a method of increasing the domestic money supply and stimulating economic activity. QEs consist of large-scale purchases of long-term government bond and other types of financial assets.

2 Note that variable vix_t has been omitted from the system due to its low significance in the model estimations.

3 As of December 2013, the Fed monthly treasury and government backed MBS purchases were USD 45 and USD 40 billion. Should these amounts be multiplied by 0.00141 and 0.00118, the average expected monthly drop and rise of prior week in the yields would be 11.985 bps and 10.021 bps, respectively. Multiplying the difference of these amounts times 60 months (of intervention), the average expected net drop in the yields would be 117.84 bps for the entire first intervention.

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The Stability of the Financial Cycle: Insights from a Markov Switching Regression in South Africa

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Abstract: The stability of the financial cycle is paramount for the effective formulation and implementation of macroprudential policy in South Africa. The South African Reserve Bank (SARB) and the Prudential Authority strive to mitigate excessive fluctuations in the financial cycle, recognising that a stable cycle provides more reliable signals for financial sector activity and anchors macroprudential policy decisions. However, the tightening of macroprudential policy by the SARB and the Prudential Authority during the post-2009 recovery period, despite mild signs of recovery from the global financial crisis, raises concerns about the stability of the South African financial cycle. This study aims to construct a financial cycle volatility index to assess its stability and identify the key macroeconomic drivers of financial instability in South Africa. Employing monthly data from 1970 to 2024, the study utilises a dynamic conditional correlation model and a Markov switching regression model to analyse the relationship between macroeconomic variables and financial stability. The findings reveal heightened financial cycle volatility around crisis periods and demonstrate that macroeconomic variables such as exchange rate fluctuations, price level changes, and implementing monetary and macroprudential policies can significantly increase financial instability. These results suggest a need for proactive and aggressive macroprudential policy measures in the years preceding potential crises. Moreover, the study's findings emphasise the importance of considering macroeconomic conditions when calibrating financial cycle policies.

Keywords: financial cycle; financial stability; macroprudential policy; Markov switching regression

JEL Classification: E32; E44; E52; E58

1. Introduction

A stable financial cycle is pivotal for maintaining financial stability and is essential for formulating and implementing effective macroprudential policy. The financial cycle measures systemic risk over time (Jing et al., 2022; O'Brien & Velasco, 2025). When the financial cycle is stable and authorities have successfully managed it, systemic risk is mitigated, which in turn contributes to a stable financial environment (Meuleman & Vander Vennet, 2020). A stable financial cycle ensures that shifts in macroprudential policy accurately reflect underlying developments within the financial system, which in turn increases the credibility of prudential authorities (Zhang et al., 2020). Conversely, an unstable financial cycle can lead to misleading signals about financial sector conditions, making macroprudential policy adjustments less reliable as indicators of actual financial sector developments (Nyati et al., 2021). Due to its critical role, many authorities consider the financial cycle a primary anchor for financial stability and macroprudential policy. This

study is motivated by the above critical roles of the financial cycle in maintaining financial stability and shaping macroprudential policies. A thorough examination of the financial cycle's stability is essential to identify potential vulnerabilities, mitigate systemic risks, and enhance the effectiveness of policy measures to safeguard the financial system.

Economic theory suggests that systemic risk accumulates during the expansion phase of the financial cycle and materialises into financial crises during downturns (Borio et al., 2020a; Das et al., 2022; Danthine, 2012). During expansions, financial agents often become overly optimistic, leading to increased borrowing, lending, and investment in riskier assets, which appear less dangerous in a booming economy. In downturns, however, heightened debt levels result in higher default rates, and investments in riskier assets frequently lead to substantial losses, potentially triggering financial crises. Recognising these dynamics, the South African Reserve Bank (SARB) and the Prudential Authority (PA) aim to stabilise the financial cycle to enhance financial stability by mitigating excessive credit and asset price growth (Nyati et al., 2024). In line with this approach, the Committee on the Global Financial System (CGFS) suggests that macroprudential policy should respond to changes in the financial cycle (Forbes, 2021). Specifically, it recommends tightening macroprudential measures during a financial boom in a strong real economy, unchanging macroprudential measures during a downturn without a crisis, and releasing policy buffers during a financial expansion in a weak economy (Mishra, 2019). Similarly, macroprudential buffers should also be released in a downturn coupled with a weak economy, particularly during a crisis.

Theoretical and policy perspectives assume that each financial expansion foreshadows a potential crisis in the subsequent downturn. Moreover, following the CGFS guidelines, one would expect macroprudential policy adjustments to align with financial cycle developments. However, not all financial cycle booms pose a threat (Borio et al., 2018, 2020b), and not all macroprudential policy changes correspond to phases of the financial cycle. In South Africa, for example, between 2002 and 2007, South African banks' credit extension increased at an average annual rate of 19.2%, a sharp contrast to the late 1990s, when credit growth hovered around 0% before reaching approximately 15% by the end of 2007 (*see* Figure 1). This period of rapid credit expansion coincided with favourable economic conditions, with output growing at an annual average of 4.5% and inflation remaining within the target range of 3% to 6%. Notably, no internal financial crisis occurred in South Africa during this period. Absent the global financial crisis originating in the United States, credit and economic growth would likely have continued, improving the living standards for many South Africans (Hollander & Havemann, 2021).

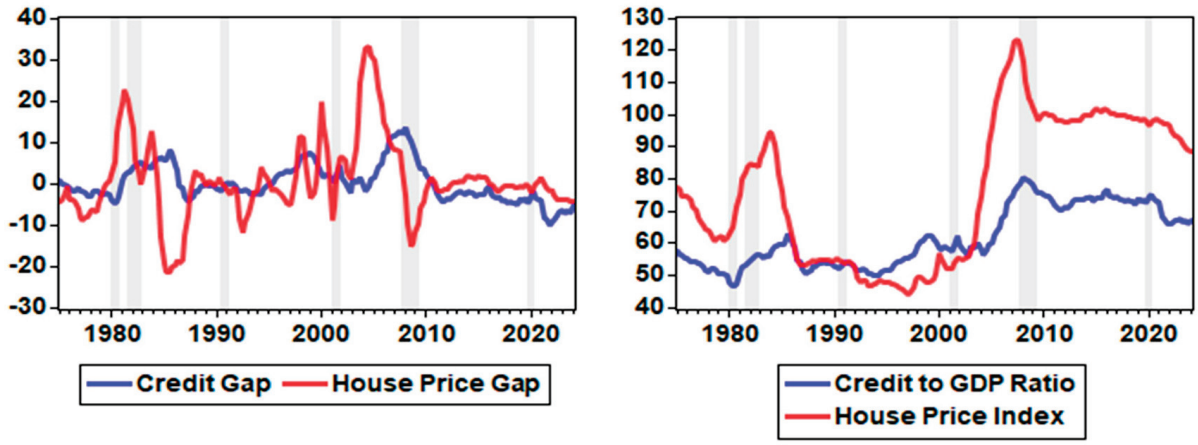

Figure 1. Evolution of credit and housing markets in South Africa. *Source:* own estimates.

Another example is the 2007–2009 global financial crisis to 2019, during which South Africa's financial cycle showed only mild signs of recovery without a discernible boom (*see* Figure 1). Economic conditions suggested that macroprudential policy should have been relaxed or, at the very least, left unchanged. However, the SARB and PA continued to tighten macroprudential policy tools, such as the countercyclical capital buffer (CCyB), capital conservation buffer (CCB), and capital requirements. For instance, CCyB requirements were introduced in January 2016, and the CCB progressively increased from 0.625% in 2017 to 1.25% in 2018 and 2.5% in 2019 (Magubane, 2024a). Additionally, even as the financial cycle had yet to recover from the impacts of the COVID-19 pandemic, the Pillar 2A minimum capital requirement was reinstated to 1% from 0% in January 2022 (Magubane, 2024a).

This phenomenon, where not all financial cycle booms are detrimental, implies that the financial cycle can exhibit stability even during expansion phases. However, strict actions taken by the SARB and the PA in South Africa between 2018 and 2022 reflect an assumption of inherent instability within the financial cycle. This creates a notable contradiction where macroprudential policy tightening does not always align with financial cycle expansion. This raises critical research questions: How stable is the financial cycle across its various phases? What are the key determinants of this stability? To address these questions, this study's objective is to construct a dynamic conditional correlation (DCC) model to develop the financial cycle volatility index (FCVIX), which is used to measure the stability of the financial cycle over time. However, the point of departure for the study is to apply a Markov Switching Autoregression (MSAR) model to examine the drivers of the FCVIX. The financial cycle is represented through the total domestic credit, the house price index, and the all-share price index, with monthly data from 1970-M1 to 2023-M4. Explanatory variables include the macroprudential policy index (MPI), policy rate (PR), real GDP (Y), consumer price index (CPI), and the real effective exchange rate (ER).

2. Literature Review

The stability of the financial cycle is essential for two reasons. The financial cycle traces systemic risk's evolution over time and signals when to activate and deactivate macroprudential policy. The financial cycle often reflects the accumulation of systemic risk as credit grows rapidly and asset prices inflate beyond sustainable levels, followed by market corrections that usually manifest as crises (Adarov, 2023). Risk in this context refers to systemic risk, which is the risk of threats to financial stability that can impair the functioning of a significant portion of the financial system, resulting in adverse effects on the broader economy (Agénor & Pereira da Silva, 2023; Freixas, 2018; Galati & Moessner, 2018). This type of risk comprises two distinct aspects: the cross-sectional and time-varying dimensions (Mieg, 2022). The cross-sectional dimension focuses on the distribution of risks across different institutions or sectors at a given time, highlighting systemic vulnerabilities due to interconnectedness or exposure concentrations. In contrast, the time-varying dimension examines how risks evolve, emphasising cyclical patterns and the impact of macroeconomic conditions on the overall risk profile. The financial cycle is primarily concerned with the time-varying aspect of systemic risk. In this dimension, systemic risk often appears as cyclical deviations in credit, asset prices, and leverage from long-term trends, leading to financial imbalances (Adarov, 2022; Sato et al., 2019). On the other hand, the financial cycle is measured as the co-movement of cyclical fluctuations in the growth of credit and asset prices (Tian, 2024). The definition of the financial cycle and systemic risk shows that these concepts are closely interconnected.

For example, the debt-deflation theory proposed by Fisher (1933) and the general theory proposed by Keynes (1936) were the first theoretical frameworks to emphasise that

activity in financial markets could be characterised by financial booms followed by busts (Ma et al., 2019). Fisher (1933) argued that this behaviour of financial markets affected the real economy through debt deflation. During a business cycle boom, financial markets are flooded with liquidity, searching for yield, which in turn triggers a rise in investments into riskier assets that seem safe during good times (Dimand, 2019). The increased investment in assets initiates a surge in asset prices, which, in turn, improves the net worth of businesses and enables them to acquire more debt to fund additional investments (Hryhoriev, 2024). The increased investments in riskier assets and rising debt levels build financial imbalances. The higher levels of debt, in turn, reduce currency deposits and the rate at which they occur due to an inflow of bank loan repayments. The contraction in currency deposits causes a slowdown in the velocity of money, reducing aggregate spending and shrinking the price level (Metrah, 2017). Furthermore, the fall in the price level will trigger an appreciation of debt in real terms, thereby causing a further fall in aggregate spending and further reducing the price level (Metrah, 2017).

Keynes (1936), on the other hand, argued that financial markets could affect real economic activity through the 'State of Credit', which is influenced by how much confidence lenders have in financing borrowers (Thakor & Merton, 2024). Lenders' confidence depends on their perceptions of how well borrowers' incentives are aligned with their own and, subsequently, how well secured borrowers' liabilities are. Keynes contended that a collapse in the confidence of either borrowers or lenders is enough to induce a downturn (Carlsson Hauff & Nilsson, 2020). A fall in either lenders' or borrowers' confidence reduces the amount of credit available in the economy, thereby reducing spending and, consequently, reducing aggregate output (Herreno, 2020; Angeletos & Lian, 2022). Indeed, recent evidence suggests that credit can either spur or retard aggregate spending (Kim & Mehrotra, 2022). In addition, evidence suggests that credit and output tend to move pro-cyclical with each other (Leroy & Lucotte, 2019). Put simply, credit and output rise and fall together. The predictions of the debt-deflation theory and the general theory were helpful in explaining the Great Depression; they became popular with scholars such as Gurley and Shaw (1955), Kindleberger (1978), Goldsmith (1969), McKinnon (1973), and Minsky (1977).

For instance, Minsky (1977) argued that the pro-cyclical nature of credit supply creates fragile financial systems and leads to financial crises. This is because, during credit expansion, economic agents accumulate more risk, which then becomes an ingredient for financial disruption (see Herrera et al., 2020). Kindleberger (1978), on the other hand, provided a historical account of how the mismanagement of money and credit creates financial fragility and causes financial disruptions, while Gurley and Shaw (1955) linked economic development and finance. According to economies could grow by accumulating more debt, provided proper debt management is in place. These scholars provided insight into how the strength or weakness of the financial system can affect economic conditions. However, these studies are theoretical and were overshadowed by the 'irrelevance theorem' of d.

Nevertheless, financial cycles lost favour for most postwar periods (Adarov, 2022). The main factor behind the decline in the popularity of financial cycles was the irrelevance theorem proposed by Modigliani and Miller (1958). The irrelevance theorem posited that capital financing did not affect a firm's value, which could bear on its ability to accumulate more capital and invest more (Modigliani & Miller, 1958). In contrast, a firm's value is determined by what the firm does with its profits (Al-Kahtani & Al-Eraij, 2018). This is because, according to Modigliani and Miller, when firms acquire debt to fund more investment, the value of outstanding equity falls as the selling of cash flows to debtholders lowers equity value. This implies that the gains from acquiring finance are offset by the cost of finance (Al-Kahtani & Al-Eraij, 2018). Hence, firms do not base their investment decisions

on capital financing. Based on these arguments, it was accepted that since finance did not matter in a firm's decision to invest, it also did not affect the macroeconomy (Gersbach & Papageorgiou, 2024). Consequently, scholars became less concerned with studying financial factors and financial cycles. Financial cycles progressively disappeared from the macroeconomists' radar screen and became a sideshow to macroeconomic fluctuations (Drehmann et al., 2012).

In the late 1990s, other mature theories of financial cycles emerged from large macroeconomic models. For instance, Bernanke (1999) and Gertler and Karadi (2011) developed the financial–economic cycle theory, which stipulated that the macroeconomy depends on credit conditions. When credit conditions deteriorate, there may be substantial increases in bankruptcies, debt burdens, and bank failures, including a severe fall in asset prices. This sequence of events works to depress economic activity. Furthermore, Bernanke (1999) and Gertler and Karadi (2011) argued that the macroeconomy depends on the interaction of credit shocks with credit interventions. A financial crisis emerges during a disturbance in credit, which depresses the whole economy. In reaction to a financial crisis, central banks tightened monetary policy, causing banks to raise their lending standards, thereby improving credit conditions. As credit conditions improve, the economy is rescued from the crisis and enters an upward phase. These interactions offer a mechanism for how credit conditions cause business fluctuations.

Consistent with Bernanke (1999), Kiyotaki and Moore (1997) developed the credit cycle theory. In this framework, lenders cannot force borrowers to repay their debt; instead, lenders rely on several assets, such as land or buildings, to secure debt. Hence, assets have a dual role: (i) they affect credit constraints through variations in their prices; (ii) assets are part of the factors of production. Kiyotaki and Moore (1997) postulated that the dual role of assets implies that an increase in asset prices eases credit constraints and triggers an expansion in investment and production. Put differently, an increase in asset prices improves the net worth of companies, thereby causing them to acquire more credit, invest more, and produce more. Furthermore, the rise in production and investment stimulates demand for assets and further puts upward pressure on asset prices, accelerating credit accumulation, investment, and production (Bordalo et al., 2018). The conclusions of Kiyotaki and Moore (1997) suggest that the interaction between asset prices and credit constraints can amplify macroeconomic fluctuations and lead to large business cycles. Krishnamurthy and Muir (2017) reached a similar conclusion and found that credit constraints and asset prices can lead to large swings in the business cycle. These advances by Kiyotaki and Moore (1997) and Bernanke (1999) support the arguments of Keynes (1936) and Fisher (1933) by identifying channels through which financial cycles could affect the real sector.

The credit cycle and the financial–economic cycle theories had significant flaws. Borio et al. (2015) argued that these theories reduced the importance of financial cycles to nominal frictions that only marginally affect the speed of real activity adjustments to equilibrium in an otherwise stable economy. This has proved limiting as it ignored the role of financial cycles as instigators and drivers of fluctuations in real activity. Not surprisingly, as a result of the global financial crises of 2007/09 and the failure of the above theories to foresee it, research has emerged focusing on analysing financial cycles as "self-reinforcing interactions between perceptions of value and risk, attitudes towards risk, and financing constraints, which translate into booms followed by busts" (Borio, 2014). These studies include Schüler et al. (2020), Aldasoro et al. (2020), Coimbra and Rey (2024), Jordà et al. (2018), Bai et al. (2019), Strohsal et al. (2019), Potjagailo and Wolters (2023), and Qin et al. (2021), amongst others.

These studies focus on estimating financial cycles and analysing their stylised facts. They rarely examine the association between the financial cycle and systemic risk. Some

studies have focused on advanced economies. For instance, Drehmann et al. (2012), Jordà et al. (2018), Strohsal et al. (2019), and Schüler et al. (2020) have examined the United States, United Kingdom, and Germany. Strohsal et al. (2019) found that the length of the financial cycle phases is roughly 15 years. Moreover, financial cycles in these economies are characterised by high amplitude, indicating sharp and volatile turning points. Indeed, financial cycles in advanced economies have been the primary source of global financial instability in recent years. International financial crises, such as the Asian Financial Crisis, Black Monday, the Dot-com Bubble Burst, the Global Financial Crisis, and the Euro-Zone Debt Crisis, among others, were triggered by peak turning points in these cycles. According to Borio (2014), a few years before each crisis, these financial cycles tend to enter zones of unsustainable development. Jordà et al. (2018) focused on 17 advanced economies and estimated that financial cycles last 2 to 32 years. However, the main contribution of their study was to show that U.S. monetary shocks drove variations in risk appetite along the financial cycle. Drehmann et al. (2012), focusing on the G7 countries, found that from 1990 onwards, financial cycles typically last up to 20 years but have sharp amplitude around turning points. These findings imply that financial cycle peaks tend to occur at or around times of financial crisis. Moreover, the study found that business cycle recessions coinciding with financial downturns tend to be deeper and longer-lasting. These findings suggest that financial cycles in advanced economies are characterised by instability, though the evolution of this instability takes time to manifest.

Some studies have focused on global financial cycles, combining both advanced and emerging market economies (see Bai et al., 2019; Adarov, 2022; Aldasoro et al., 2020; Ha et al., 2020; Claessens et al., 2011). Bai et al. (2019) concentrated on the United States and 23 emerging market economies. The main aim of their study was to examine the influence of variations in financial cycles, measured by spreads and stock prices. The study found that the duration of financial cycles was longer than that of business cycles. However, the study's point of departure was to show that the standard deviation of financial cycles in emerging market economies was more significant compared to the United States, indicating that financial cycles are more volatile in emerging market economies. The study also highlighted that emerging market economies depend on the U.S. for financial resources, which creates uncertainty and instability in these financial systems as these markets lack complete control over financial developments. Aldasoro et al. (2020), focusing on both emerging and advanced economies, found no significant difference in the duration of financial cycles, suggesting that the time it takes for systemic risk to evolve is similar in both advanced and emerging market economies. Adarov (2022) found that financial cycles in advanced and developing economies last up to 15 years and are driven by the volatility index (VIX) and U.S. Treasury bills.

These results suggest that although there may be differences in the stability of financial cycles between advanced and emerging market economies, these differences are minor. As a result, the sources of instability can be expected to be similar across these economies. However, it is essential to note that there is a gap in studies focusing solely on emerging market economies and individual countries in particular. Therefore, the above findings are generalisations and must be applied to individual countries with caution. For instance, Prabheesh et al. (2021) found that the Indian financial cycle is more volatile than global financial cycles, whereas the Indonesian financial cycle is more stable. Krznar and Matheson (2017) found that the financial cycle in New Zealand lasts up to 20 years, while the financial cycle in South Africa is approximately 17 years (Bosch & Koch, 2020). These differences merit investigations that focus on individual economies, which is the focus of this study.

This study makes significant contributions to the existing theoretical and empirical literature on the financial cycle and systemic risk. Theoretically, the study expands the

understanding of the factors that drive systemic risk within the financial cycle, mainly focusing on exchange rates, price levels, the business cycle, the repo rate, and macroprudential policy. Economic theory suggests that exchange rates play a crucial role in systemic risk, especially in open economies, as they influence capital flows and external debt, thereby impacting financial stability (Ali, 2022). Fluctuations in the exchange rate can lead to capital flight or sudden shifts in investor sentiment, increasing volatility and systemic risk. On the other hand, the price level is an essential factor in understanding inflationary pressures and their effects on the economy. According to the Quantity Theory of Money, rising prices can lead to higher interest rates, which may trigger financial instability if there are imbalances in debt (Benati, 2021).

The business cycle is another critical driver of systemic risk, as economic expansions and contractions affect the availability of credit and overall economic growth. During boom periods, excessive borrowing can lead to financial bubbles, while credit becomes more constrained during recessions, amplifying systemic risk (Minsky, 1977). The repo rate, set by central banks, serves as a tool to control inflation and stabilise the economy. Changes in the repo rate can influence borrowing costs and liquidity in financial markets, thus impacting financial stability (Taylor, 1993). Finally, macroprudential policy, which aims to mitigate risks to the financial system, is essential in regulating systemic risk. Central banks aim to reduce the likelihood of financial crises by imposing capital buffers and other financial stability measures.

Empirically, the study contributes to the literature by constructing a financial cycle volatility index, which allows the study to track and quantify the systemic risk present at different phases of the financial cycle. This index integrates the aforementioned factors and provides a comprehensive tool to measure the fluctuations in systemic risk over time. Applying this index can help us better understand how these theoretical factors interact to shape financial stability and assess the potential for crisis in emerging market economies. This study, therefore, not only advances theoretical insights but also provides empirical evidence to support the role of these factors in driving systemic risk within the financial cycle.

3. Econometric Methods

The study sample is from the first month of 1970 to the ninth month of 2024. This is a sufficient period to capture any changes in the stability of the financial cycle and changes in variables that might affect the stability of the financial cycle. To address the objective of the study, two variables must be constructed. The first is the financial cycle, and the second is the FCVIX. According to the existing literature, the financial cycle can be represented by a common factor between credit, house prices, and share prices (Farrell & Kemp, 2020; De Wet, 2020; Adarov, 2022; Pahla, 2019; Menden & Proaño, 2017). The primary motivation for choosing these variables is that they are the primary sources of systemic risk, which the financial cycle aims to trace over time (Borio, 2014). In the credit market, over-indebtedness and defaulting on debt repayments of households and government debt repayments contribute to instability. In the asset markets, price volatility creates uncertainty about the housing and equity markets in South Africa (Magubane, 2024b). Besides this motivation, credit, house, and share prices represent the most significant financial markets in South Africa, which account for a significant share of the financial system's resources and developments (Magubane, 2024b). Hence, in this study, the variables total domestic credit, house price index, and all-share price index were used.

The study utilised principal component analysis (PCA) to combine these variables into a financial cycle. One significant benefit of using PCA over dynamic factor models is its capability to manage large datasets like those utilised in this research (Jawadi et al., 2021).

Conversely, dynamic factor models become less effective as the number of variables grows (Khoo et al., 2024). Another reason for selecting PCA is that it possesses time-varying parameters, unlike simple correlation (Lever et al., 2017). This characteristic enables the study to follow and depict the progression of financial cycles over time. The initial step is to find a linear function $\theta 1' z$ of the elements of $z = n$ financial indicators that have the maximum variance. $\theta 1$ is a vector of m variables θ_{11}, θ_{12}, …, $\theta 1$ m, and $'$ denotes transpose such that

$$\theta_1' x = \theta_{11} z_1 + \theta_{12} z_2 + \ldots + \theta x_m = \sum_{j=1}^{m} \theta z_j. \quad (1)$$

Subsequently, a linear function, denoted as $\alpha_2' x$ should be sought, which is uncorrelated with $\alpha_1' x$, and exhibits maximum variance. At the kth stage, it is necessary to identify a linear function of $\alpha_k' x$ that also has maximum variance and remains uncorrelated with $\theta_1' z, \theta_2' z \ldots, \theta_{k-1} z$. The variable derived at the kth stage is referred to as $a_k x$, and is among the principal components that account for variations in financial variables. This study is conducted with eigenvalues exceeding one to identify financial cycles from financial indicators. As demonstrated by Brave et al. (2019), the derived principal components will serve as the financial cycle index, which can then be used to construct the financial cycle.

Constructing the financial cycle involves removing the principal trend of the principal component, leaving only the cyclical component indicative of the financial cycle. The literature offers several filtering techniques, each with unique characteristics. For the sake of comparability, the study uses the Hodrick–Prescott filter (HP filter), which is extensively utilised in the financial cycle literature (Bosch & Koch, 2020; Adarov, 2022). The HP filter was selected because it is the favoured method for estimating financial cycles, and it is more effective than other techniques at predicting financial expansions and contractions (Hamilton, 2020). Additionally, as shown in Bosch and Koch (2020), it has produced dependable financial cycles in South Africa's context. For the scope of the study, presume that the principal components from the first equation can be depicted in the following manner:

$$z_t = v_t + w_t l = 1, 2 \ldots, T \quad (2)$$

In this context, z_t represents the observed principal component, with v_t and $w_t l$ denoting the cyclical and trend components of the observed series, respectively. Additionally, it is assumed that the secular component is difference stationary, while the cyclical component is level stationary. The trend is estimated by minimising Equation (4).

$$\min_{[g_t]_{t-1}^{T}} \sum_{t=1}^{T} c_t^2 + \lambda \sum_{t=1}^{T} [(g_{t+1} - g_t) - (g_{t-1} - g)]^2 \quad (3)$$

Assume, z_t represents the observed principal component of the data, while v_t and w_{tl} denote the cyclical and trend components, respectively. A key assumption underlying the HP filter is that the trend component w_{tl} is difference stationary, implying that changes in the trend follow a predictable, smooth path. In contrast, the cyclical component, v_t, is assumed to be level stationary, which allows for short-term deviations around the trend that revert to a long-run mean over time. These assumptions ensure that the HP filter captures both the persistent, long-term dynamics and the transient fluctuations characteristic of financial cycles.

The HP filter estimates the trend by minimising a loss function, as represented in Equation (3). This loss function balances the trade-off between the smoothness of the trend component and the fidelity of the cyclical component to the observed series. The first term, $\sum_{t=1}^{T} c_t^2$, penalises deviations of the cyclical component, c_t, from zero, while the second term, $\lambda \sum_{t=1}^{T} [(g_{t+1} - g_t) - (g_{t-1} - g)]^2$, penalises variations in the second difference in the trend

component, g_t. The penalty parameter λ plays a crucial role in determining the smoothness of the estimated trend, with higher values of λ yielding a smoother trend and lower values allowing for more pronounced short-term fluctuations.

For financial cycle analysis, the choice of λ is critical, as it governs the temporal resolution of the decomposition. According to Drehmann et al. (2012) and Bosch and Koch (2020), for quarterly financial cycles, λ is set to 400,000. If the trend component is removed, Equation (3) can be reformulated as a financial cycle equation as seen in Equation (4)

$$FC_t = q_t \tag{4}$$

In order to construct the FCVIX, Equation (4) is re-estimated as a DCC model in order to extract time-varying conditional variance between the financial cycle and its lags. The DCC is chosen because studies such as Engle (2002) demonstrated the versatility of the DCC model in capturing correlations, volatility dynamics, and systemic risk in modern financial markets. In particular, the choice of the DCC is influenced by its ability to estimate time-varying correlation and volatility (Kovacic & Vilotic, 2017). Firstly, the DCC model, proposed by Engle (2002), offers a flexible and computationally efficient framework for modelling time-varying correlations while maintaining a parsimonious structure. It allows for the estimation of dynamic correlations between multiple time series without requiring the estimation of a large number of parameters, as is the case with BEKK models (Bollerslev et al., 1988). This makes the DCC model particularly advantageous in studies with large datasets or when the number of variables is relatively high, as it mitigates issues related to overfitting and computational complexity.

Secondly, while the BEKK model provides a more detailed specification by modelling the full conditional covariance matrix, it can be computationally intensive, especially with multiple variables, due to the need for estimating a large number of parameters (Bollerslev & Engle, 1993). In contrast, the DCC model offers a simpler structure that still captures time-varying correlations effectively, making it a preferred choice for our study. Furthermore, Copula-GARCH models, while useful in capturing non-linear dependencies and tail risk, can be difficult to estimate and require assumptions about the joint distribution of the data (Patton, 2006). The DCC model, on the other hand, allows for a more straightforward estimation of time-varying correlations without relying heavily on distributional assumptions, making it more suitable for our study's objectives.

The study estimates the following model:

$$y_t = Cx_t + \epsilon_t \tag{5}$$

$$\epsilon_t = H_t^{\frac{1}{2}} v_t \tag{6}$$

$$H_t = D_t^{\frac{1}{2}} R_t \tag{7}$$

$$R_t = diag(Q_t)^{-\frac{1}{2}} Q_t diag(Q_t)^{-\frac{1}{2}} \tag{8}$$

$$Q_t = (1 - \lambda_1 - \lambda_2)R_t + \lambda_1 \widetilde{\epsilon_{t-1}} \widetilde{\epsilon'_{t-1}} + \lambda_2 Q_{t-1} \tag{9}$$

where y_t is the financial cycle; x_t is the lags of dependent variables; $H_t^{\frac{1}{2}}$ is the Cholesky factor of the time-varying conditional covariance matrix H_t; v_t is an $(m\ x\ 1)$ vector of (*iid*) innovations; and D_t is a diagonal matrix consisting of conditional variances:

$$D_t = \begin{pmatrix} \sigma_{1,t}^2 & 0 & \cdots & 0 \\ 0 & \sigma_{2,t}^2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \sigma_{m,t}^2 \end{pmatrix} \tag{10}$$

In which $\sigma_{i,t}^2$ evolves according to a univariate GARCH model of the form $\sigma_{i,t}^2 = s_i + \sum_{j=1}^{p_i} \alpha_j \epsilon_{i,t-j}^2 + \sum_{j=1}^{q_i} \beta_j \sigma_{i,t-j}^2$ by default, where α_j and β_j are the ARCH and GARCH parameters, respectively.

R_t is a matric of conditional quasicorrelation,

$$R_t = \begin{pmatrix} 1 & \rho_{12,t} & \cdots & \rho_{1m,t} \\ \rho_{12,t} & 1 & \cdots & \rho_{2m,t} \\ \vdots & \vdots & \ddots & \vdots \\ \rho_{1m,t} & \rho_{2m,t} & \cdots & 1 \end{pmatrix} \tag{11}$$

$\widetilde{\epsilon_t}$ is an m x 1 vector of standardised residuals, $D_t^{-\frac{1}{2}}\epsilon_t$, and λ_1 and λ_2 are non-negative parameters that govern the dynamics of conditional quasicorrelation and satisfy $0 \leq \lambda_1 + \lambda_2 < 1$. If Q_t is stationary, the R matrix in Equation (11) is a weighted average of the unconditional covariance matrix of the standardised residuals $\epsilon^{\sim}$, denoted by $\overline{R}$, and the unconditional mean of Q_t, denoted by $\overline{Q}$. Since $\overline{R} \neq \overline{Q}$, as shown by Aielli (2013), R is neither the unconditional matrix nor the unconditional mean of Q_t. For this reason, the parameters in R are known as quasicorrelation (Aielli, 2013; Engle, 2002). The study is interested in the estimated time-varying conditional covariance used to represent the FCVIX.

In order to assess which variables drive the stability of the financial cycle, the following variables were used in the study: the ER, CPI, Y, PR, and MPI. We considered Equation (12) which expresses the FCVIX in an MSAR:

$$Y_t = \mu_{s_t} + X_t \beta_{s_t} + \delta_{i,s_t}\left(Y_{t-i} - \mu_{s_{t-i}} - K_{t-i} B_{s_{t-i}}\right) + \epsilon_{s_{t-i}} \tag{12}$$

where Y_t is the growth of the FCVIX, X_t is a vector of covariates containing the explanatory variables with state-dependent parameters β_{s_t}, δ_{i,s_t} is the ith autoregressive term in state s_t, and ϵ_{s_t} is the normal, independent, and identically distributed normal error term with mean zero and state-dependent variance, σ^2. $\mu_{s_{t-i}}$ is the state-dependent mean at time $t-i$. The MSAR is used in this study in analysing the stability of financial cycles because it effectively captures the non-linear and regime-dependent dynamics inherent in financial data (Hamilton, 1989; Krolzig, 1997). Financial cycles often exhibit distinct phases, such as expansions and contractions, corresponding to underlying structural regimes (Claessens et al., 2011). Unlike threshold autoregressive models, which require the a priori specification of the transition threshold, the MSAR model probabilistically determines regime transitions based on the data, thus reducing model specification bias and enhancing its robustness for analysing complex financial systems (Ang & Timmermann, 2011). Additionally, MSAR models accommodate the potential persistence of states and the asymmetric effects of shocks across regimes, features that are critical for understanding financial cycle dynamics (Borio, 2014). Empirical studies have demonstrated that MSAR models outperform other regime-switching approaches, such as smooth transition autoregressive models, in

capturing the abrupt regime changes typical of financial cycles. Using monthly data, the MSAR framework also enables the identification of short-term fluctuations and long-term trends, ensuring a comprehensive understanding of the factors affecting financial cycle stability, such as macroeconomic policies and external shocks (Gadea Rivas & Perez-Quiros, 2015). Hence, the MSAR model's flexibility and suitability for regime-dependent financial analysis justify its application in this study.

The MSAR model is predicated on several key assumptions that enable it to analyse the regime-dependent dynamics of financial cycles effectively. At its core, the MSAR framework assumes that the observed time series, Y_t, in this case representing the growth of the FCVIX, is governed by latent regimes, denoted by s_t, which follow a discrete-time Markov process. This assumption underpins the probabilistic nature of regime transitions, where a state transition matrix determines the probability of transitioning from one state to another. Such a framework allows the model to capture the non-linear and regime-switching behaviour typical of financial cycles, such as expansions and contractions, without requiring an explicit threshold specification for regime changes (Hamilton, 1989; Krolzig, 1997).

The model further assumes that Y_t is influenced by a vector of covariates, X_t, with state-dependent parameters, β_{s_t}, reflecting how explanatory variables vary across different regimes. Additionally, the autoregressive structure of the model, encapsulated by δ_{is_t}, allows for state-dependent dynamics, where the influence of lagged values of Y_t changes according to the prevailing regime. This assumption is critical for capturing the persistence and path-dependency of financial cycles, which often exhibit prolonged phases of stability or instability (Claessens et al., 2011). The inclusion of a regime-dependent mean, μ_{s_t-i}, and variance, $\sigma^2_{s_t}$, ensures that both the central tendency and volatility of Y_t adapts to the specific characteristics of each regime. The model also assumes that the error term, ϵ_{s_t}, is normally distributed, independent, and identically distributed, with a mean of zero, providing a robust framework for handling stochastic variations in the data.

These assumptions collectively allow the MSAR model to probabilistically determine regime transitions, minimising model specification bias compared to threshold autoregressive models (Ang & Timmermann, 2011). By accommodating the asymmetric effects of shocks and capturing abrupt regime changes, the MSAR model aligns with empirical observations of financial cycles, which often display sudden shifts in behaviour due to external shocks or policy interventions. The model's capacity to incorporate both short-term fluctuations and long-term trends further enhances its utility in understanding the factors influencing financial cycle stability, including macroeconomic variables and external shocks (Gadea Rivas & Perez-Quiros, 2015). Moreover, the MSAR framework's flexibility and robustness make it particularly well suited for studying the inherently non-linear and regime-dependent nature of financial systems, justifying its application in this study.

Financial cycles are widely recognised to exhibit two distinct phases: expansion and contraction. The expansion phase is characterised by rising credit growth, increased asset prices, and overall economic optimism, while the contraction phase reflects declining credit availability, falling asset prices, and heightened financial distress (Borio, 2014; Drehmann et al., 2012; Schüler et al., 2020; Magubane, 2024b; Nyati et al., 2024). These alternating phases align with the dynamics of financial market behaviour, which often oscillate between risk appetite and risk aversion periods. Given this cyclical nature, the study adopts a two-state MSAR model to effectively capture the financial cycle's non-linear dynamics and regime-dependent properties. The choice of two states is well suited to reflect the inherent dichotomy of expansion and contraction, ensuring that the model provides a parsimonious yet robust framework for analysing shifts in financial conditions while maintaining interpretability (Hamilton, 1989). The study applies a simple two-state FCVIX growth model with state variant variance. It means to estimate the impact of the macroprudential

policy index (MPI), policy rate (PR), real GDP (Y), consumer price index (CPI), and the real effective exchange rate (ER) on the stability of the financial cycle in both the instability and stability states in South Africa as follows:

$$Y_t = \mu_{s_t} + \epsilon_{s_t} \tag{13}$$

where

$$Y_t = \begin{bmatrix} \mu_1 + \epsilon_{1t} \; if \; s_t = 1 \\ \mu_2 + \epsilon_{2t} \; if \; s_t = 2 \end{bmatrix} \tag{14}$$

Before discussing the results of the study, it is important to outline the sources of the variables used. The policy rate, total domestic credit, and house price index were obtained from the Bank for International Settlements (BIS). The Organisation for Economic Co-operation and Development (OECD) sourced the real effective exchange rate and all-share price index. The gross domestic product (GDP) and consumer price index (CPI) variables were retrieved from the South African Reserve Bank (SARB). Finally, the macroprudential policy index (MPI) was obtained from the International Monetary Fund (IMF).

4. Results and Discussion

The following hypotheses are proposed to achieve the study's objectives. First, the study hypothesises that the financial cycle volatility index (FCVIX) effectively captures the stability of the financial cycle in South Africa. The null hypothesis (H_0) asserts that the FCVIX does not provide a reliable measure of financial cycle stability. In contrast, the alternative hypothesis (H_1) contends that the FCVIX is a valid and reliable measure. Furthermore, the study investigates the influence of macroeconomic and policy variables on the FCVIX. For each determinant, the null hypotheses (H_0) state that the variable—such as exchange rate volatility, consumer price index, output, financial cycle dynamics, repo rate, and macroprudential policies—has no significant effect on financial cycle stability, while the alternative hypotheses (H_1) propose that each variable significantly impacts the FCVIX. Finally, the overarching null hypothesis (H_0) posits that macroeconomic and policy variables do not collectively or interactively influence financial cycle stability. In contrast, the alternative hypothesis (H_1) suggests that these factors play a significant and interactive role in shaping the stability of the financial cycle in South Africa. This results and discussion section delves into the study's empirical findings, addressing these hypotheses and shedding light on the key determinants and dynamics of financial cycle stability.

Figure 2 plots the FCVIX against the financial cycle. The FCVIX is derived as the conditional standard deviation of the financial cycle, calculated using the DCC model. Since the index is based on standard deviation, a commonly used rule of thumb is that a standard deviation more significant than one signifies higher volatility, while a standard deviation below one indicates lower volatility (Ahmed et al., 2020). A visual inspection of Figure 2 reveals that the FCVIX exceeds the value of one around financial crisis periods. During these times, the FCVIX displays sharp spikes, signalling elevated levels of volatility. In terms of financial cycle stability, this suggests that the financial cycle tends to exhibit greater instability during crisis events. In contrast, the financial cycle shows more stability when no crises exist.

Figure 2 highlights several significant financial turmoil events that coincide with moments of instability in the financial cycle. These include the financial crash caused by the COVID-19 pandemic in 2019/20, the Euro-debt crisis in 2010, the global financial crisis from 2007 to 2009, the Dotcom bubble burst in 2002, and the Asian financial crisis in 1997. Most of these crises originated internationally; South Africa, a smaller economy highly dependent on the international financial system, is particularly vulnerable to external

adverse shocks (De Waal & Van Eyden, 2016; Gumata & Ndou, 2019). However, some crises were domestic, such as the Banking Crisis of 2002 (Hollander & Havemann, 2021). This observation indicates that instability in the financial cycle reflects vulnerabilities within the country and captures external shocks, demonstrating the interconnectedness of the global and local financial systems.

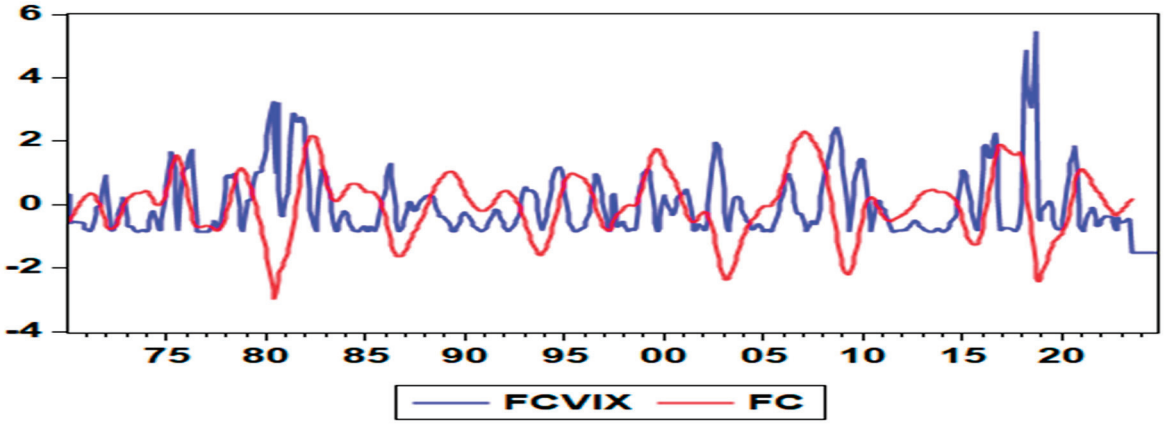

Figure 2. Evolution of the South African financial cycle and the FCVIX (1970–2023). *Source:* own estimates.

Economic theory posits that systemic risk develops during the expansion phase of the financial cycle, implying that we should expect greater instability in the financial cycle during this phase (Ma et al., 2019; Dimand, 2019). However, some of the study's results contradict this theory. The findings suggest that between the 1970s and 1980s, the financial cycle exhibited more instability during its expansionary phases. This is reflected in the FCVIX, which experienced sharper spikes during the expansion phases of this period. In contrast, from the late 1990s to the present, findings indicate that the financial cycle exhibits more instability during its downturn phases. Sharper spikes in the FCVIX have been observed during downturns in recent years. In other words, the study finds that in recent years, the financial cycle has shown more stability during its expansionary phase and greater instability during its downturn phase. This pattern, however, can only be observed from a time-line graph, and formal testing is necessary to verify these findings.

To further investigate this, we conducted a crosscorrelation analysis between the financial cycle and the FCVIX, as presented in Figure 3. A visual inspection of Figure 3 indicates that maximum correlation occurs at a positive lag 5. This suggests that the FC volatility index and the financial cycle are leading each other, but the sign of the maximum correlation is negative, indicating that these variables move countercyclically. In simpler terms, during a financial cycle expansion, the FCVIX tends to decline, while it rises during an economic cycle downturn. These results align with the observations made in Figure 2, further supporting our findings.

Before presenting the study's primary results, a model fit test was conducted to validate the results of the DCC model and assess the reliability of the FCVIX. The Ljung–Box Q test was employed to determine whether the residuals exhibited heteroscedasticity or homoscedasticity. The model's residuals are normally distributed with a slight left tail (*see* the bell-shaped histogram in Figure A1A in Appendix A). The null hypothesis of the test Ljung–Box Q is that the residuals are heteroscedastic, while the alternative hypothesis posits homoscedasticity. A key advantage of the Ljung–Box Q test is its ability to evaluate dependencies across multiple lags rather than a single lag. Following the approach of Ramsey (1999), the test was performed at lags 6, 12, 18, 24, 30, and 36. The results, presented in Table 1, reveal that the autocorrelation (AC) and partial autocorrelation (PAC) parameters

are statistically significant at all the tested levels (as indicated by the Prob* values). This significance suggests that the null hypothesis of heteroscedasticity is rejected in favour of the alternative hypothesis of homoscedasticity. These findings indicate that the DCC model and FCVIX results are reliable.

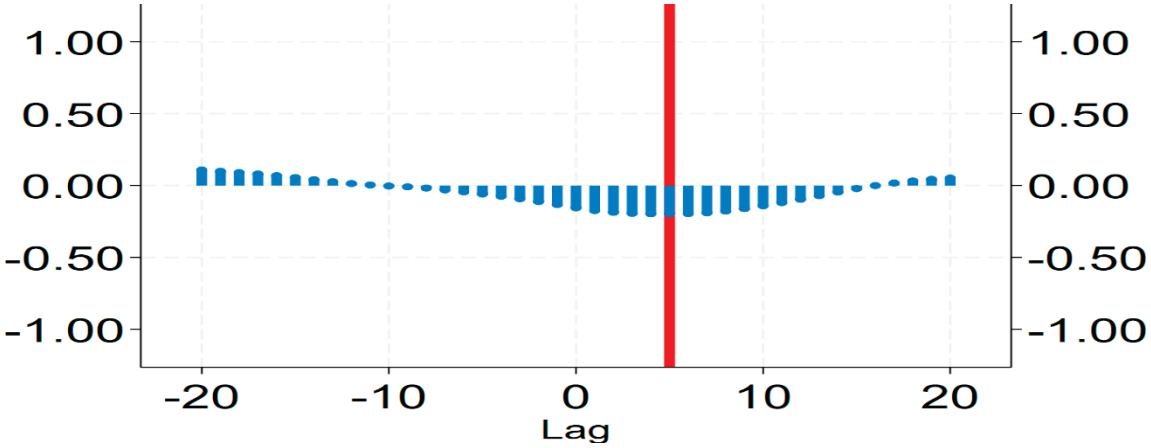

Figure 3. Cross-correlogram of the South African financial cycle and the FCVIX. *Source:* own estimates.

Table 1. Ljung–Box Q autocorrelation test—DCC.

Lag	AC	PAC	Q-Stat	Prob*
6	0.215	0.123	260.04	0.000
12	0.175	0.096	298.03	0.000
18	0.171	0.092	351.49	0.000
24	0.185	0.098	395.67	0.000
30	−0.002	−0.030	415.13	0.000
36	0.091	0.055	421.99	0.000

Sources: own estimates.

The study next applied the Augmented Dickey–Fuller (ADF) unit root test to evaluate the stationarity of the variables used in the MSAR model. Additionally, the Phillips–Perron (PP) unit root test was conducted to confirm the findings of the ADF test. This step is critical to ensure that all variables are of the same order of integration before estimating the MSAR model (Hall et al., 1999). Table 2 presents the test results. For both the ADF and PP tests, the null hypothesis posits that the series contains a unit root (non-stationary), while the alternative hypothesis suggests that the series is stationary. The results in Table 2 demonstrate that in almost all the cases, the null hypothesis is rejected at all the significance levels for both the level and first difference versions of the variables. The only exceptions are the ADF test results at the level, where the null hypothesis fails to be rejected for FCVIX, CPI, and MPI.

When variables are stationary at both levels and first differences as in the study, using the first differences is often preferred in econometric models like MSAR due to considerations of stability and interpretability. Econometric theory suggests that differencing stationary variables can mitigate potential overfitting issues in models designed to capture regime-switching behaviour (Hamilton, 1989). Since the MSAR model focuses on identifying shifts in underlying states or regimes, using first differences minimises the risk of spurious state transitions caused by level-based fluctuations unrelated to regime dynamics (Krolzig, 1997). Moreover, differencing adheres to the principle of parsimony, which advocates for simpler models that effectively capture the data's structural properties (Lütkepohl, 2005). Empirical evidence demonstrates that this approach improves the

model's ability to identify structural shifts, particularly in financial and economic time series with high-frequency variations (Kim & Nelson, 1999). Given these considerations, the study proceeded to estimate the MSAR model using the differenced variables to ensure clearer inferences and more robust regime identification.

Table 2. ADF and PP unit roots test.

UNIT ROOT TEST TABLE (PP)							
At Level							
	FCVIX	ER	CPI	Y	FC	MPI	PR
t-Statistic	−6.534	−9.208	−15.675	−9.487	−4.799	−1.212	−3.538
Prob.	0.000	0.000	0.0000	0.000	0.000	0.000	0.000
	***	***	***	***	***	***	***
At First Difference							
	d(FCVIX)	d(ER)	d(CPI)	d(Y)	d(FC)	d(MPI)	d(PR)
t-Statistic	−7.983	−4.645	−14.417	−8.693	−5.893	−7.345	−9.057
Prob.	0.000	0.000	0.000	0.000	0.000	0.000	0.000
UNIT ROOT TEST TABLE (ADF)							
At Level							
	FCVIX	ER	CPI	Y	FC	MPI	PR
t-Statistic	−1.445	−1.731	−1.364	−1.981	−7.054	−1.602	−1.836
Prob.	0.138	0.079	0.160	0.045	0.000	0.102	0.063
	no	*	no	**	***	no	*
At First Difference							
	d(FCVIX)	d(ER)	d(CPI)	d(Y)	d(FC)	d(MPI)	d(PR)
t-Statistic	−9.925	−10.811	−9.080	−10.098	−8.474	−8.179	−9.494
Prob.	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Sources: own estimates. *Notes:* (*) significant at the 10%; (**) significant at the 5%; (***) significant at the 1%; and (no) not significant; lag length based on SIC; probability based on MacKinnon (1996) one-sided *p*-values.

Next, the study discusses the main results of the MSAR. Table 3 below displays the results. The results of this study reveal important dynamics that drive financial stability and instability in South Africa. These findings provide a nuanced understanding of how various macroeconomic and financial variables interact with the FCVIX. The high persistence of changes in the FCVIX, evidenced by autoregressive parameters ($\delta_1 = 0.974$ and $\delta_2 = 0.822$) being close to 1, suggests that fluctuations in financial stability (instability) are deeply embedded in the system. Economic theory posits that high persistence in financial volatility often stems from structural weaknesses or entrenched cyclical behaviours within the financial system (Jain, 2007; Caporale et al., 2018; James, 2021). For South Africa, this persistence reflects an economic landscape shaped by recurring crises, such as the prolonged impacts of the global financial crisis of 2008, the sovereign credit rating downgrades in 2017 and 2020, and the economic disruptions caused by the COVID-19 pandemic (Bond, 2018). This also reflects a system that is vulnerable to the excessive debt of households and the government, rapid loadshedding, and high price levels (Mothibi & Mncayi, 2019). Each of these events introduces systemic shocks that heighten financial instability, amplifying the volatility observed in the financial cycle.

The exchange rate and price levels contribute significantly and positively to the FCVIX in both the states of stability and instability, underscoring their pivotal role in influencing financial cycle dynamics. This is indicated by the positive sign in parameters corresponding to ER and CPI. This finding is similar to Moyo and Tursoy (2020), Trecy et al. (2024), and Olamide et al. (2022) who also found the exchange rate and the price level to be significant drivers of financial market behaviour in South Africa. In the context of South Africa, the

exchange rate is particularly volatile, reflecting the country's susceptibility to global capital flows, commodity price fluctuations, and domestic political risks. The depreciation of the rand, such as the sharp decline observed during the political turmoil surrounding the "Nenegate" crisis in 2015, has historically been linked to periods of heightened financial instability (Potgieter, 2021). From a theoretical perspective, the Mundell–Fleming model suggests that exchange rate volatility transmits external shocks into the domestic economy, thereby destabilising financial markets (Okotori & Ayunku, 2020; Egilsson, 2024). Moreover, inflationary pressures, as captured by the price level, exacerbate this instability. During episodes of high inflation, such as the energy-driven price hikes in 2022, financial markets react adversely, with increased uncertainty feeding into greater volatility (Miyajima, 2020).

Table 3. MSAR main results.

	Instability State		**Stability State**	
	Coefficient	**P > z**	**Coefficient**	**P > z**
ER	0.013	0.004	0.155	0.000
CPI	0.009	0.000	−0.010	0.281
Y	−0.029	0.159	0.753	0.001
FC	−0.008	0.168	−0.011	0.056
PR	0.008	0.020	0.059	0.128
MPI	0.019	0.082	0.250	0.002
μ	0.015	0.000	0.010	0.000
δ_1	0.974	0.000		
δ_2	0.822	0.000		

Source: own estimates. *Notes:* P > z refers to *p*-values.

Interestingly, the financial cycle's contribution to the FCVIX is negative in both the states of instability and stability, though the effects are statistically insignificant. Put differently, the financial cycle reduces volatility. The negative impact of the financial cycle is because credit and asset price growth contribute to economic development in South Africa. Borio (2014) argues that financial cycles often act as stabilising mechanisms, dampening volatility during expansions and contractions. However, in South Africa, inefficiencies in credit markets—such as limited access to credit for marginalised groups—may weaken the stabilising role of financial cycles. This is further supported by the SARB's Financial Stability Review (2023), which highlights structural barriers within South Africa's financial sector, such as high levels of inequality and limited financial inclusion. These challenges may explain the weak and statistically insignificant impact of the financial cycle on volatility.

The business cycle exhibits contrasting effects on the FCVIX, contributing negatively during instability and positively during stability. This dichotomy reflects the dual role of economic activity in shaping financial stability. In periods of instability, economic downturns suppress financial volatility by reducing speculative activities and dampening risk appetite, consistent with Minsky's (1977) financial instability hypothesis. Conversely, in stable periods, economic growth fosters increased risk-taking and financial market activity, amplifying volatility. This dynamic is particularly evident in South Africa, where periods of economic recovery, such as the post-2020 rebound from COVID-19 lockdowns, have been accompanied by heightened credit extensions and asset price inflation (Fotso et al., 2022; van Seventer et al., 2021). The statistically significant positive effect of the business cycle during stability highlights the pro-cyclicality of South Africa's financial system, a feature commonly observed by studies such as Bergman and Hutchison (2020), Rothert (2020), and Saini et al. (2024), in emerging markets.

Both the repo rate and the macroprudential policy index contribute positively and significantly to the FCVIX in both states of stability and instability, highlighting their strong

influence on financial volatility. Studies such as Martinez-Miera and Repullo (2019), Laeven et al. (2022), and Agur and Demertzis (2019) have already demonstrated that the contractionary effects of monetary and macroprudential policy can heighten financial risk by dampening the growth of credit and asset prices below the accepted levels. The positive effect of the repo rate reflects the cost-of-credit channel, wherein higher interest rates increase borrowing costs, reduce liquidity, and heighten financial market volatility. For instance, the SARB's aggressive interest rate hikes in 2022 to combat inflation significantly strained household and corporate balance sheets, contributing to increased financial instability. Similarly, the macroprudential policy index's positive contribution underscores the impact of regulatory measures on market behaviour. While these policies are designed to enhance stability, their implementation can initially increase volatility by restricting credit growth and curbing speculative activities. Recent research by Nyati et al. (2024) demonstrates the trade-offs associated with macroprudential policies, particularly in contexts like South Africa's, where financial inclusion remains a challenge.

Next, the study discusses the regime features of the FCVIX in different states. Table 4 presents the results. The variance results, which show slow growth in the FCVIX during instability and high growth during stability, reflect the fundamental behaviour of financial markets in response to different economic conditions. Instability often results in risk aversion, characterised by reduced speculative activity, constrained credit markets, and suppressed financial transactions. This dynamic aligns with Minsky's (1977) financial instability hypothesis, which posits that during crises, market participants retreat into defensive postures to preserve capital. For instance, during the apartheid era, South Africa faced international sanctions that severely restricted access to global financial markets (Davis, 2018). The instability induced by these sanctions forced the financial system to adopt cautious strategies, resulting in subdued volatility growth (Davis, 2018). In contrast, the high growth of the FCVIX during stable periods reflects heightened financial activity fuelled by optimism and increased risk-taking. Theoretically, this dynamic aligns with Borio's (2014) argument that stability often fosters conditions that sow the seeds of future instability. For example, following the end of apartheid in 1994, South Africa entered a period of relative political and economic stability. This newfound optimism drove significant foreign investment inflows, boosting financial market activity and volatility. However, unchecked growth in financial activity also contributed to subsequent vulnerabilities, exemplified by the 2002 banking crisis, during which smaller banks like Saambou and Regal Bank collapsed under the weight of poor risk management and overexposure to unsecured lending (Hollander & Havemann, 2021).

Table 4. Features of the FCVIX in different states.

	Instability	**Stability**
σ	0.001	0.013
θ	28.113	19.837
ρ_1	0.964	0.739
ρ_2	0.036	0.261

Source: own estimates. *Notes:* ρ_1 and ρ_2 refer to the probability of remaining and switching between states, respectively. θ refers to the duration of each state whereas σ is the variance of each state.

The finding that instability lasts up to 28 months, compared to 19 months of stability, underscores the entrenched nature of financial volatility in South Africa. The prolonged periods of instability reflect deep-rooted structural challenges, such as persistent unemployment, inequality, and political uncertainty. Reinhart and Rogoff (2009) argue that emerging markets often experience extended instability due to their reliance on external financing and vulnerability to global shocks. In South Africa, this dynamic has been observed during

events like the 1998 Asian Financial Crisis, which triggered capital outflows and currency depreciation, prolonging instability in the domestic financial system. The relatively shorter duration of stability reflects the fragility of South Africa's financial system, where stable periods are often disrupted by exogenous or domestic shocks (Pretorius & De Beer, 2014). For instance, the optimism that followed the democratic transition in 1994 was cut short by fiscal crises and governance failures in the subsequent decades (Sachs, 2021; Gumata, 2022). Recent examples include the economic stagnation caused by rolling blackouts (load-shedding) since 2007, exacerbated by operational inefficiencies at Eskom, and the sharp depreciation of the rand in 2015 due to a sudden change in finance ministers, colloquially referred to as "Nenegate" (Naidoo, 2023; Walsh et al., 2021).

The strong likelihood of the FCVIX remaining in its current state, whether stability or instability, underscores the inertia present in South Africa's financial system. However, the finding that the likelihood of remaining in the instability state is higher than in the stability state signals a systemic bias toward prolonged financial instability. This persistence can be explained through Hamilton's (1989) regime-switching theory, which posits that structural and cyclical factors reinforce the continuity of a given state. In South Africa, factors such as weak economic growth, high public debt levels, and policy uncertainty act as anchors, preventing transitions to stability. Historical events support this interpretation. During the apartheid era, sanctions and exclusion from global markets entrenched financial instability, as the economy relied heavily on domestic financing and faced constrained capital flows. Similarly, the 2002 banking crisis, though isolated to smaller banks, reflected systemic issues such as weak regulatory oversight and limited financial inclusion, which perpetuated instability in the broader financial system. More recently, the COVID-19 pandemic reinforced the persistence of instability by exacerbating structural weaknesses, such as high unemployment and limited fiscal space for stimulus.

The transition probabilities also reflect the challenges policymakers face in shifting the economy toward stability. The SARB has historically employed monetary policy tools, such as adjustments to the repo rate, to stabilise the financial system. For example, during the 2020 pandemic, the SARB cut the repo rate by 300 basis points to support liquidity and financial stability. However, such measures often have limited effectiveness in addressing the underlying structural issues, such as governance failures and inadequate infrastructure investment, which perpetuate financial instability. These findings underscore the need for a multifaceted policy approach to address the drivers of financial volatility in South Africa. The slow growth of the FCVIX during instability suggests that policymakers must prioritise structural reforms to enhance resilience and reduce systemic vulnerabilities. This includes improving governance at state-owned enterprises, increasing investment in infrastructure, and fostering financial inclusion. For example, addressing Eskom's operational inefficiencies and stabilising the energy supply could reduce the economic uncertainty that fuels financial instability. The high growth of the FCVIX during stability highlights the importance of counter-cyclical policies to prevent overheating and mitigate the risks of excessive financial activity. Strengthening macroprudential regulations, such as capital buffers and loan–value ratios, could curb excessive risk-taking during stable periods, reducing the likelihood of subsequent instability. Empirical studies, such as those by Aikman et al. (2015), have shown that robust macroprudential frameworks can mitigate the pro-cyclical effects of financial activity, particularly in emerging markets.

As with the DCC model, the Ljung–Box Q test was used to assess the validity of the MSAR results. The findings are presented in Table 5. According to the table, there is no evidence of heteroscedasticity in the residuals of the MSAR, indicating that the model is well specified. Moreover, the results are normally distributed as indicated by

the bell-shaped histogram in Figure A1B in Appendix A. Therefore, the results can be considered reliable.

Table 5. Ljung–BOX Q autocorrelation test—MSAR.

Lag	AC	PAC	Q-Stat	Prob*
6	0.148	0.109	134.42	0.000
12	0.134	0.070	162.48	0.000
18	0.116	0.093	176.60	0.000
24	0.168	0.078	203.79	0.000
30	0.129	0.091	227.55	0.000
36	0.054	0.021	256.97	0.000

Source: own estimates.

In addition to the Ljung–Box Q test, the variance inflation factor (VIF) test was conducted to determine whether multicollinearity could have affected the results of the MSAR. Addressing multicollinearity is crucial in regression analysis, as it can distort the reliability of coefficient estimates and weaken the interpretability of the model. Multicollinearity inflates standard errors, making it difficult to determine the unique contribution of each explanatory variable, which can lead to misleading inferences about the relationships between variables (Gujarati, 2021). VIF is widely used as a diagnostic tool to detect and quantify multicollinearity due to its simplicity, interpretability, and robustness in empirical research (Mansfield & Helms, 1982; Kutner et al., 2005; Hair et al., 2012; Montgomery et al., 2021). A VIF of 1 indicates no multicollinearity, values between 1 and 5 suggest moderate multicollinearity, and a VIF exceeding 10 is widely regarded as a strong indication of high multicollinearity that requires intervention (Gujarati, 2021; O'Brien, 2007).

Table 6 presents the findings of the VIF analysis. According to the table, the VIF parameters ($\log\sigma = 1.030$ and $\log\sigma = 1.024$) for all the variables combined are closer to one, suggesting that overall, the parameters of the MSAR model are not significantly inflated. This indicates that when the variables are considered as a group, there is no multicollinearity in the model. However, Table 5 shows that for each individual variable, the VIF values range between 1 and 5, suggesting moderate inflation. This indicates the presence of a small level of multicollinearity in the model.

A small level of multicollinearity is unavoidable when analysing variables such as the repo rate, macroprudential policy, exchange rate, consumer price index, output, and the financial cycle due to the inherent interdependence of these economic indicators. The economic literature consistently highlights that such variables are structurally and dynamically linked as a part of the broader macroeconomic and financial systems. For instance, the repo rate, which represents the central bank's monetary policy stance, directly influences borrowing costs, aggregate demand, and inflation. Similarly, macroprudential policy measures are designed to stabilise the financial system and often respond to shifts in output and financial cycles, further linking these variables (Borio, 2014). The exchange rate is also intertwined with monetary policy and inflation dynamics, as changes in interest rates affect capital flows and currency values. Likewise, the consumer price index, which measures inflation, is closely linked to both the exchange rate (through import prices) and monetary policy (via inflation targeting frameworks). Output, as a measure of economic activity, is influenced by all the aforementioned variables, including the financial cycle, which captures fluctuations in credit growth and asset prices that feed into aggregate demand (Drehmann et al., 2012). These interconnections are a natural feature of macroeconomic systems and reflect their co-movement in response to shocks or policy interventions.

Table 6. Variance inflation factor test.

Variable	Coefficient Variance	Uncentered VIF	Cantered VIF
Regime 1			
ER	0.000	1.348	1.309
CPI	0.001	3.497	1.949
Y	0.121	4.030	1.880
FC	0.002	5.176	1.666
PR	0.006	5.931	2.169
MPI	0.024	5.148	2.577
Regime 2			
ER	0.024	1.079	1.079
CPI	0.013	3.125	3.123
Y	0.022	3.804	3.773
FC	0.003	5.857	5.828
PR	0.017	4.336	4.329
MPI	0.004	5.421	5.365
Common			
Log(σ)	0.001	1.030	1.024
Probability Parameters			
P1-C	0.039	1.272	1.164

Source: own estimates.

In our study, the VIF results for all the variables combined were close to 1, suggesting that there is no significant multicollinearity at the aggregate level. When the variables were considered individually, the VIF parameters ranged from 1 to 5, indicating a small level of multicollinearity. However, as emphasised in the literature, a small degree of multicollinearity within this range is generally considered acceptable and does not undermine the validity of the model (Gujarati, 2021). These interconnections between the variables are not only expected but also necessary for reflecting the real-world complexity of economic systems. Therefore, the small level of multicollinearity in our model is inherent to the nature of the economic variables being studied and does not detract from the reliability of the MSAR results. Given these theoretical and empirical justifications, we conclude that the MSAR results are robust and valid for analysing the dynamics of the financial cycle and related economic indicators.

Next, the threshold autoregressive model (TAR) was estimated as an additional test to corroborate the findings of the MSAR. Table 7 presents the findings. In the table, there are three states identified by the model. The three states represent different levels of financial cycle volatility. State 1 corresponds to a period of stability, where the FCVIX is low, indicating a more stable financial environment. State 2 is an intermediate state, where the FCVIX is moderate, reflecting a transitional period between stability and instability. State 3 represents instability, with high FCVIX indicating a more volatile financial environment.

In state 1, where the FCVIX is low, CPI and PR are statistically significant with positive coefficients, indicating that higher inflation and stronger macroprudential policies are associated with higher financial cycle volatility. Y is also significant, with a positive coefficient, suggesting that stronger economic activity is linked to increased financial cycle volatility. On the other hand, FC and MPI are not statistically significant, indicating their limited impact in this state.

In state 2, where the FCVIX is in an intermediate range, ER, CPI, and Y remain significant and positive, suggesting that higher exchange rates, inflation, and economic activity are associated with higher volatility in the financial cycle. FC, PR, and MPI continue

to show mixed results, with FC and MPI being non-significant, and PR showing marginal significance at a higher threshold.

Table 7. Threshold autoregression results.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
FCVIX < 0.014 -- 339 obs				
ER	0.053	0.032	1.667	0.096
CPI	0.069	0.026	2.645	0.008
Y	0.583	0.258	2.252	0.024
FC	−0.386	0.001	−0.023	0.981
PR	0.101	0.037	2.683	0.007
MPI	0.039	0.051	0.769	0.441
0.014 <= FCVIX < 0.027 -- 202 obs				
ER	0.055	0.019	2.848	0.004
CPI	0.044	0.016	2.680	0.007
Y	0.528	0.166	3.170	0.001
FC	0.153	0.001	0.364	0.716
PR	0.029	0.022	1.337	0.181
MPI	−0.012	0.053	−0.236	0.813
0.027 <= FCVIX -- 101 obs				
ER	0.111	0.013	8.313	0.000
CPI	0.060	0.016	3.694	0.000
Y	0.596	0.150	3.974	0.000
FC	−0.013	0.002	−5.438	0.000
PR	0.124	0.026	4.614	0.000
MPI	0.412	0.111	3.689	0.000

In state 3, where the FCVIX is high, the relationship between the variables and financial cycle volatility becomes even more pronounced. ER, CPI, Y, PR, and MPI are all statistically significant with positive coefficients, indicating strong associations with higher financial cycle volatility. However, FC has a negative coefficient and is highly significant, suggesting that a higher financial cycle might be associated with lower FCVIX in this state. This could reflect a reversal effect where, as the financial cycle becomes more volatile, certain economic measures begin to stabilise or diminish the impact of further volatility on the financial cycle.

The results from the TAR model show both corroboration and contrast with the findings from the MSAR model. A key area of agreement between the two models is the positive relationship between the FCVIX and the ER. The TAR model suggests that the exchange rate is positively associated with the FCVIX across all the states, with the effect being most pronounced in the high volatility state. This finding aligns with the MSAR model, which also demonstrated a positive linear relationship between the FCVIX and ER. Both models support the argument made in the literature, such as by Borio et al. (2016), that external shocks—like exchange rate movements—can drive financial cycle fluctuations. Higher exchange rates can exacerbate financial market volatility, especially in economies such as South Africa, with open capital accounts or those heavily dependent on imported goods and capital flows. The pronounced effect in the high volatility state found in the TAR model emphasises the amplifying role that exchange rate shocks can have during periods of financial instability, corroborating the findings of Chinn and Ito (2007) who discuss the link between exchange rate volatility and economic risk.

Similarly, the relationship between the FCVIX and the PR is consistent across both models. In the TAR model, the repo rate is positively correlated with the FCVIX in both the low and high volatility states. This finding is consistent with the MSAR model, where a

positive linear relationship was also observed. This suggests that stronger financial policies, such as increases in the repo rate, are associated with higher financial cycle volatility. These results support the notion that higher interest rates, intended to stabilise the economy, may have the unintended effect of exacerbating financial volatility, especially in times of heightened uncertainty. This is consistent with Cerutti et al. (2017), who show that monetary policies—while designed to dampen financial cycle fluctuations—can also have counter-cyclical effects that intensify market volatility in certain conditions.

The relationship between the FCVIX and the MPI is another area where the models converge. The TAR model shows a significant positive relationship between the FCVIX and MPI, particularly in the high volatility state. This finding reinforces the idea that more robust macroprudential measures, such as higher capital requirements or counter-cyclical buffers, may be associated with greater financial volatility in certain conditions. Similarly, the MSAR model suggests a positive and linear relationship between the FCVIX and MPI. This corroborates the broader literature, including Borio (2014), which highlights that while macroprudential policies can stabilise financial markets in the long run, they may also lead to unintended consequences in the short term, particularly when financial markets are already in a state of flux.

The relationship between the FCVIX and the FC shows divergence between the two models. The TAR model reveals a negative and highly significant relationship between the FCVIX and FC in the high volatility state, suggesting that as the financial cycle becomes more volatile, it actually contributes to reducing the FCVIX. This contrasts with the MSAR model, which consistently shows a negative relationship between the FCVIX and FC. The reversal effect in the TAR model can be interpreted as a dynamic adjustment mechanism, whereby the heightened volatility of the financial cycle may act as a corrective force that stabilises financial conditions in the long run. This result is in line with the theory of dynamic financial stability (Schinasi, 2010), which suggests that periods of high volatility in financial markets may eventually lead to market corrections and stabilisation. However, the MSAR model does not capture this stabilisation effect and instead implies that a negative relationship between FC and the FCVIX persists regardless of the state of volatility. This highlights the TAR model's ability to account for non-linear relationships and regime-dependent dynamics, a feature that is less prominent in MSAR models.

The results regarding CPI also show both corroboration and contrast. In the TAR model, CPI has a positive and significant impact on the FCVIX in the low-volatility state and a negative impact in the high-volatility state. This suggests that inflation behaves differently depending on the level of financial volatility, supporting the argument made in the literature that inflation's effects on financial instability are state-dependent (see Woodford, 2012). The MSAR model similarly shows that CPI contributes positively to the instability state and negatively to the stability state, which directly corroborates the findings from the TAR model. This result highlights the context-dependent role of inflation in influencing financial cycle volatility, with inflationary pressures potentially amplifying volatility during periods of economic instability, but helping to stabilise financial markets in periods of low volatility.

Finally, the results for Y exhibit some notable contrasts between the two models. The TAR model shows a positive and significant relationship between output and the FCVIX in the low volatility state, but a negative contribution in the high volatility state. In contrast, the MSAR model shows a negative relationship between output and the FCVIX in both the instability and stability states. This discrepancy can be explained by the different assumptions underlying each model. The TAR model, by allowing for state-dependent changes in the relationship between output and the FCVIX, provides a more dynamic view of how economic growth interacts with financial volatility, while the MSAR model imposes

a linear structure that does not account for possible non-linearities. This highlights the potential benefit of the TAR model in capturing the more complex interactions between output and financial cycle volatility in different states of the economy, as discussed by Filardo (2012), who emphasises that output and financial volatility are not always inversely related, especially when financial conditions are at extreme points.

While the TAR model and the MSAR model generally align in their findings about the relationships between the FCVIX and variables like ER, PR, and MPI, they differ in their treatment of CPI and output. The TAR model provides a more nuanced understanding of how these relationships change depending on the level of financial cycle volatility, offering insights into regime-dependent effects. On the other hand, the MSAR model assumes linearity, providing a more straightforward analysis of these relationships. Despite these differences, the overall conclusions about the impact of key macroeconomic variables on financial cycle volatility remain similar across the two models. Therefore, in conclusion, the study accepts the results of the MSAR as robust, since they align with the TAR in most cases.

5. Conclusions

The primary aim of this study was to construct a measure for assessing the stability of the financial cycle (FCVIX) in South Africa and identify the key drivers of its fluctuations. To achieve this, the study utilised the MSAR model to analyse monthly time-series data spanning from 1970 to 2024. Key variables, including exchange rates, inflation, the business cycle, and macroprudential policies, were considered to investigate how these factors interact with the financial cycle volatility index. This method allowed for the identification of distinct phases of financial stability and instability, providing insights into the structural and cyclical dynamics that influence financial volatility in the South African context. By employing this approach, the study aimed to uncover both the persistence and the drivers of financial instability, contributing to a deeper understanding of South Africa's economic resilience.

The results of the study highlight that financial instability in South Africa exhibits significant persistence, primarily driven by exchange rate volatility, inflationary pressures, and the business cycle. The study found that exchange rate fluctuations and inflationary pressures exacerbate financial instability, aligning with the existing literature, such as the work of Aye et al. (2024), which underscores the importance of these variables in emerging markets. The high persistence of financial volatility observed in the study is also consistent with the findings of Reinhart and Rogoff (2009), who argue that emerging markets often experience prolonged instability due to their reliance on external financing and vulnerability to global shocks. Furthermore, the study revealed that while financial cycles could have stabilising effects in certain contexts, such as in the work of Borio (2014), the weak and statistically insignificant relationship between the financial cycle and volatility in South Africa indicates that factors like limited financial inclusion and structural weaknesses undermine the stabilising potential of financial cycles. The results suggest that South Africa's financial system is prone to prolonged periods of instability, with exogenous and domestic shocks often interrupting stable periods. These findings also support the view that financial instability is deeply rooted in South Africa's structural challenges, such as high inequality and political uncertainty, which reinforce the cyclical nature of financial volatility.

The findings from this study have several key implications for South Africa's economic and financial policy. First, the study underscores the importance of aggressively employing macroprudential policies during periods of economic turmoil to maintain the stability of the financial cycle. Given the persistence of financial instability in South Africa, it is

crucial to adopt proactive regulatory measures to contain volatility and mitigate systemic risks. The study's results emphasise that macroprudential policies should not be seen as supplementary, but rather as essential tools for managing financial cycles and reducing the likelihood of prolonged instability. Second, the study highlights the need for better coordination between monetary and macroprudential policies to ensure that the monetary policy does not inadvertently destabilise the financial cycle. In South Africa, the effects of the repo rate and macroprudential policy index on financial volatility illustrate the need for the careful calibration of both policies to avoid exacerbating instability. As seen during the 2020 pandemic, while aggressive interest rate cuts provided immediate liquidity relief, they did little to address the underlying structural weaknesses that contributed to long-term instability. Third, the findings suggest that when calibrating macroprudential policies, real economic factors, such as price levels, exchange rates, and business cycles, must be carefully considered. By accounting for these key variables, policymakers can better align macroprudential interventions with the broader economic context, reducing the risk of policy-induced financial imbalances and fostering a more stable financial environment.

To enhance the stability of the financial cycle in South Africa, several policy recommendations are proposed. First, it is critical to employ macroprudential policy more aggressively during periods of economic turmoil to safeguard the financial system from excessive risk-taking and instability. In times of economic uncertainty, such as during external shocks or domestic crises, the authorities should implement stricter regulations to mitigate credit expansion and speculative activities, thereby reducing the risk of financial instability. Second, a more coordinated approach between monetary and macroprudential policies is essential. While monetary policy typically aims to control inflation and manage interest rates, it can have unintended consequences for the financial cycle if not aligned with macroprudential measures. For example, aggressive interest rate hikes may exacerbate volatility in times of economic instability, as seen in the study. Therefore, a careful balance between both policies is crucial for achieving long-term financial stability. Finally, when formulating and calibrating macroprudential policies, policymakers must give due consideration to real economic factors, including the price level, exchange rate, and business cycle. These variables play a central role in determining financial stability, and their inclusion in policy frameworks can allow for more targeted and effective interventions. By ensuring that macroprudential policies are calibrated with a thorough understanding of these economic dynamics, South Africa can reduce financial volatility and foster a more resilient financial system.

One of the primary limitations of this study lies in its geographical focus on South Africa. By concentrating solely on South Africa, the analysis excludes other countries that may also benefit from an FCVIX-based assessment of financial cycle stability. The findings and implications drawn from the South African context may not be directly generalisable to economies with different financial structures, regulatory frameworks, or levels of economic development. Expanding the scope to include a broader range of countries in future research could provide a more comprehensive understanding of the relationship between financial cycles and stability across diverse economic settings. A cross-country analysis would also allow for comparative insights and a deeper investigation into the varying impacts of macroprudential policies and other factors on financial cycles globally.

Another notable limitation is the relatively narrow selection of financial variables included in the construction of the FCVIX. The financial sector is complex and comprises hundreds of variables, each of which could play a significant role in influencing financial cycle volatility. However, due to data availability and methodological constraints, only a handful of variables were incorporated into the analysis. This limited scope may overlook critical interactions and dynamics within the financial system. Addressing this limitation

would involve broadening the dataset to include additional financial indicators, equity market performance, and banking sector stability metrics. Incorporating a wider range of variables could enhance the robustness of the model and provide a more nuanced understanding of the determinants of financial cycle volatility.

To address these limitations, future research could adopt a multi-country framework that incorporates diverse economic and financial systems to improve the external validity of the findings. Additionally, advances in data collection and computational methods could allow for the integration of a larger number of financial variables without compromising the efficiency and accuracy of the analysis. By addressing these limitations, subsequent studies could strengthen the theoretical and practical contributions of FCVIX analysis and provide policymakers with more robust tools for enhancing financial stability.

Future research could explore innovative methodologies to refine the measurement of financial cycle stability, such as incorporating machine learning techniques to model complex interactions among financial variables. Additionally, future studies could investigate the dynamic interplay between financial cycle stability and non-traditional factors, such as climate risks, technological innovations, and geopolitical shocks, which are increasingly relevant in shaping global financial systems. Research could also delve into the long-term impacts of sustained macroprudential interventions on financial cycle dynamics, providing a more comprehensive understanding of their effectiveness over extended time horizons. Lastly, applying the FCVIX framework in real-time policy simulations could offer valuable insights into the practical application of findings, enabling policymakers to test the efficacy of proposed interventions under varying economic scenarios.

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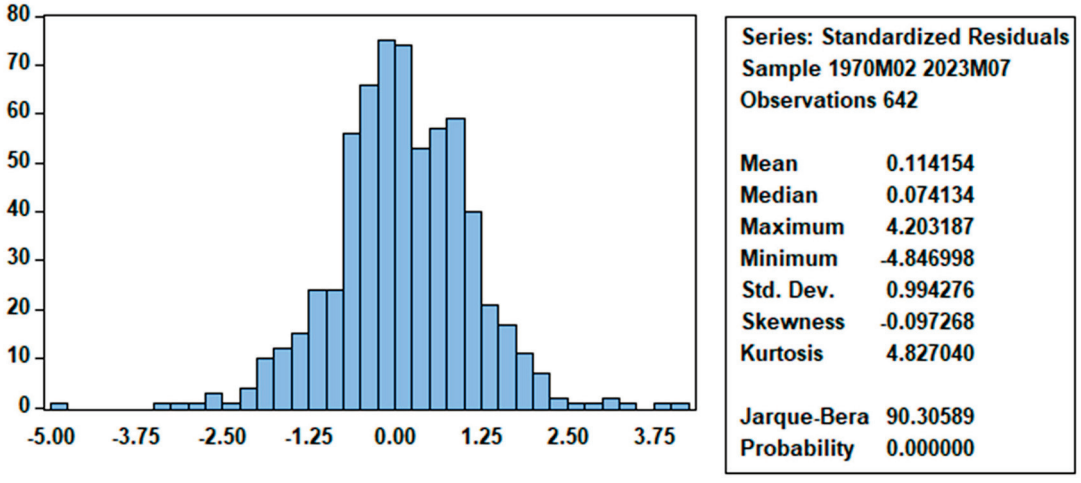
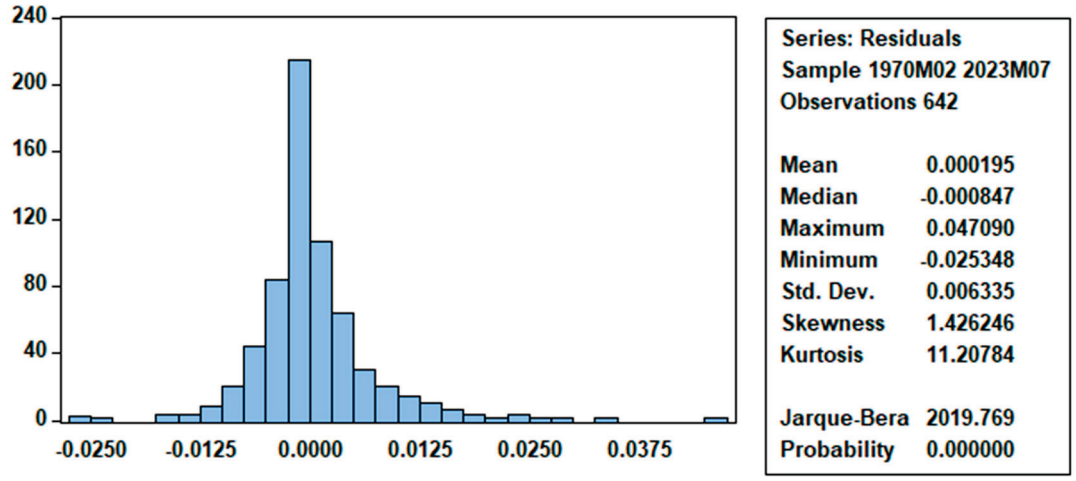
Appendix A



(**A**)

Figure A1. *Cont*.



(**B**)

Figure A1. (**A**) Histogram normality test—DCC model. (**B**) Histogram normality test—MSAR model.

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Corruption Control as a Catalyst for Financial Development: A Global Comparative Study

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Abstract: This study investigates the impact of anti-corruption efforts on financial development across different economies, using G7 and E7 countries as comparative groups. Recognizing corruption as a barrier to economic growth, the research examines how effective corruption control can enhance the efficiency of the financial sector, foreign direct investment (FDI), and capital market development. The methodology includes panel cointegration tests—namely Pedroni, Kao, and Westerlund tests—alongside fully modified ordinary least squares (FMOLS) and dynamic ordinary least squares (DOLS) estimations to assess the long-term relationships between corruption control and financial development. The findings reveal a statistically significant cointegration relationship, suggesting that anti-corruption measures positively influence financial development in both G7 and E7 countries, albeit more strongly in E7 economies. Specifically, the Westerlund test results, which take cross-sectional dependencies into account, reinforce the robustness of the findings. The study underscores the importance of tailoring anti-corruption policies to each country's unique economic framework, highlighting that while G7 countries benefit from advanced institutional structures, E7 countries experience more pronounced effects of corruption control on financial development and FDI. These insights contribute to the policy discourse on sustainable economic development by emphasizing the role of governance quality in fostering robust financial systems and attracting international investment.

Keywords: corruption control; financial development; market regulations; economic growth; panel cointegration

1. Introduction

Central to discussions of economic development and governance is the complex interrelationship between controlling corruption and developing financial systems. The ability to conceptualize this relationship is important for nations negotiating paths to achieve sustainable economic growth. Corruption, defined as the misuse of public power for private gain, erodes trust in institutions, distorts markets, impairs fair competition, and depletes legal and institutional infrastructures (Mauro, 1995; Tanzi, 1998). These effects discourage foreign investments, retard local financial markets' development and lead to inferior resource allocation, high costs of operation for businesses, and severe income distribution problem (Wei, 2000).

Corruption undermines confidence, distorts market dynamics, affects fair competition, and cripples legal and institutional frameworks. Generally, this hampers the flow of foreign investments, constrains the growth of domestic financial markets, and as a result, leads to poor resource allocation, high business costs, and increased income inequality.

Financial development, however, reflects an increase in the effectiveness of financial institutions and markets and the financial system as a whole. It also facilitates economic activities by gathering savings, allocating capital, executing transactions, aiming to mitigate risk, and enhancing technological progress. In this way, an efficiently developed financial system becomes crucial for pooling savings, allocating capital, settling transactions, or managing risk. It plays a key role in the following: promoting economic growth, reducing poverty, and increasing overall wealth.

On the other hand, financial development can be described as an increase in efficiency and effectiveness of the financial institutions and markets that constitute the financial system as a whole (Levine, 1997). It encourages economic activities by mobilizing savings, promoting capital allocation, facilitating smooth transactions between economic agents, reducing risks, and promoting technological progress (Rajan & Zingales, 1998). A well-developed financial system efficiently promotes economic growth, alleviates poverty, and increases overall wealth (Beck et al., 2007).

Corruption control and financial development are interrelated in a complex, bidirectional way. Effective anti-corruption policies support financial development by fostering an investment-friendly environment and promoting fair competition, whereas the level of financial development itself can influence both the extent and the impact of corruption (Aidt, 2009). Well-developed economies, with coherent institutions and high levels of transparency in their financial markets, reduce opportunities for corrupt behavior (Blackburn et al., 2010). Developed financial systems enhance anti-corruption measures through improved tracking of financial transactions and strict enforcement of legal and regulatory provisions (Svensson, 2005).

There are significant differences in corruption levels and financial development observed across the world. For instance, countries such as Singapore and Denmark consistently rank high in financial development indices while ranking low in perceived corruption rankings (Transparency International, 2019). Sound institutional frameworks and openness in governance structures in these countries have created an environment that maximizes financial market development and minimizes corruption. On the other hand, many developing countries from the Sub-Saharan African region and parts of Asia are characterized by high levels of corruption and underdeveloped financial systems (Mbaku, 2007). In these countries, limited legal structures, lack of transparency, and governance issues hinder financial development and economic growth.

It also follows that improving the quality of institutions and governance can have a strong impact on both corruption control and financial development (Kaufmann et al., 2010). Legal institutions that uphold property rights and enforce contracts play a very significant role in reducing corruption and fostering the development of financial markets (La Porta et al., 1998). Increased transparency within the public sector also enhances accountability and diminishes opportunities for corruption, which is significant for the development of a more robust financial system (Islam, 2006).

This research aims to investigate the effects of anti-corruption policy on financial development, and, further, the relationship of these effects with economic welfare. While it is generally recognized in the literature that financial development increases the economic performance of a country, generally, control of corruption exerts influences on financial systems in largely complex ways. This paper examines impacts of anticorruption policies on financial development in the context of developed and developing nations and also

looks at implications regarding economic growth by keeping corruption under control. In this context, the G7 and E7 countries discussed in the study are grouped according to their level of economic development. The G7 group represents the most developed economies in the world and includes the following countries: the United States, Japan, Germany, the United Kingdom, France, Italy and Canada. The E7 group consists of large economies that are rapidly growing and developing; these countries are China, India, Brazil, Mexico, Russia, Indonesia and Turkey. This study predicts that the relationship between corruption control and financial development operates in different ways between these two groups. The underlying hypotheses of the study will be outlined below as follows:

H1. *Strengthening corruption control positively affects financial development.*

H2. *Financial development increases foreign direct investment (FDI) inflows and decreases corruption.*

H3. *The relationship between corruption control and financial development differs between G7 and E7 countries.*

The overall research question of this study can be summarized as follows: how does corruption control affect financial development, and how does this effect change by considering international differences such as G7 versus E7 countries?

This paper focuses on how corruption control in G7 and E7 countries has influenced the long-term association between corruption control and financial development. The effects of such a relationship on capital inflows and economic growth are considered simultaneously. From several viewpoints, this work makes a unique scientific contribution, such as:

- A new perspective on the relationship between corruption and financial development: This study offers an in-depth analysis of the impact of corruption control on financial development, presenting an approach that addresses the long-term relationships, which are often underexplored in the literature.
- Comparative analysis of G7 and E7 countries: This study gives an in-depth review of how dynamics of corruption control and financial development vary between developed and developing nations. This topic is rarely addressed in-depth in the literature.
- Significant implications for policymakers: This study underlines the positive impacts of the anti-corruption policies on the financial sector, thereby bringing forth meaningful policy recommendations to shape economic growth strategies for countries.

This paper contributes to the scientific literature by investigating the relationships between corruption control and financial development from a new point of view and, therefore, in light of international differences, presenting findings that will pave the way both for the academic literature and policymakers' decisions.

2. Literature Review

The theoretical underlying basis for the linkage between anti-corruption efforts and financial development takes root in studies centered on economic development, transparency, and the entrenchment of institutional frameworks. These studies essentially focus on the negative impacts that corruption has imposed on financial systems and the reflections of these impacts on the general health of the economy. Finally, financial development has been analyzed in the literature from the perspective of deepening capital markets, the efficient functioning of the banking systems, and ensuring investor confidence. The

important literature in the chronological review of anti-corruption policies with impacts on financial development and economic growth is presented below (Table 1).

Table 1 presents studies examining the relationship between corruption control and financial development. The literature demonstrates this relationship's complexity by comparing findings obtained from different methodological approaches and geographical regions. In general, it is seen that corruption negatively affects financial development and economic growth, but this effect is less pronounced in countries with strong financial development. Notably, the relationship between corruption control and financial development is more stable in developed economies. In contrast, the positive relationship between corruption control and foreign direct investment (FDI) and economic growth is more pronounced in developing economies. It is frequently emphasized in the literature that corruption control can directly affect financial development and that reducing corruption increases the efficiency of financial markets by increasing financial transparency and ensuring investor confidence. In addition, the indirect effects of corruption control on other economic and social factors, such as energy efficiency, environmental sustainability, and income inequality, have also been addressed in different studies. Therefore, it becomes clear that corruption control should be examined within a broader sustainable development framework, not only in terms of financial development. This literature review underscores the potential of effective corruption control in fostering long-term economic growth and financial development in both developed and developing countries. However, it also highlights the pressing need for more comprehensive studies to unravel the intricate nature of this relationship. Such studies are crucial for gaining a deeper understanding of how corruption control can be effectively leveraged to promote sustainable economic and financial development.

Clearly, corruption control should not be limited to financial development alone but should be addressed within a broader sustainable development framework. This literature review demonstrates the potential of corruption control to promote long-term economic growth and financial development in developed and developing countries. It notes the need for more in-depth studies to fully understand this relationship

Table 1. Literature review summary.

Authors and Year	Research Topic	Key Findings	Methodology
(Karianga, 2024)	State Financial Corruption and its Impact on Development	Corruption negatively impacts individual and community development by eroding trust in the government and creating public apathy. Economically, it slows investment, reduces productivity, and weakens state finances. Politically, it undermines the government's regulatory role and leads to inefficiency in public services.	Normative legal research using an analytical approach
(Ketners & Tsiatkovska, 2024)	Fight against corruption: Analysis of strategies and impact of anti-corruption measures on the social and economic development of society in Ukraine	Since the 2014 Revolution, Ukraine's anti-corruption efforts have intensified with reforms improving economic performance and business conditions. Despite progress, Ukraine remains a country still battling corruption, requiring ongoing efforts.	General scientific methods of analysis and synthesis, comparative method, generalization, dialectical method, and statistical method
(Trabelsi, 2023)	The Impact of Corruption on Economic Growth: A Nonlinear Evidence	The study finds that corruption's impact on growth is nonlinear. Moderate corruption can boost growth, but excessive or minimal corruption hinders it.	Panel data analysis
(Prasetyani et al., 2023)	Do Corruption and Institutions Contribute to the Economic Growth in ASEAN Countries During 2000–2018?	The study shows that corruption perception does not boost growth, but institutional factors like accountability and regulation quality do. Strengthening anti-corruption efforts is crucial for economic growth in ASEAN countries.	Static panel data analysis and panel-vector autoregression (VAR)
(Adebisi & Guermat, 2022)	Comparative Analysis of The Impact of Big Data on Corruption in Selected Developing and Developed Countries	The study shows that big data, internet usage, and technology investments significantly reduce corruption in developing countries, but have no notable impact in developed countries.	Random effects regression models
(Lestari et al., 2022)	Financial development and FDI in developing countries	Financial development positively impacts FDI, but corruption does not significantly affect FDI.	Panel data analysis
(Chebab et al., 2022)	Natural resource abundance and financial development in MENA countries	Natural resource abundance hinders financial development; reducing corruption in the financial sector mitigates this effect.	Panel data analysis

Table 1. *Cont.*

Authors and Year	Research Topic	Key Findings	Methodology
(Krifa-Schneider et al., 2022)	Corruption and FDI in advanced and emerging economies	Less corruption attracts more FDI in advanced economies; corruption level is less critical in emerging economies.	Panel data analysis
(Usman et al., 2022)	Corruption control and income level in Africa	Renewable energy consumption and FDI play a significant role in reducing carbon emissions.	Panel data analysis
(Refakar, 2021)	Corruption Distance and US Foreign Direct Investment Outflows	The study shows that US investors avoid countries with high corruption, and greater corruption distance between the US and the host country leads to decreased US foreign direct investment.	Multivariate regressions
(Alsagr & Hemmen, 2021)	Corruption and financial development in BRICS economies	Corruption has a significant long-term negative impact on financial development.	Panel data analysis
(Ziernhold & Jung-Ivannikova, 2021)	Economic growth and financial development	Economic growth positively impacts financial development, while corruption negatively impacts it.	Panel data analysis
(Mahmood et al., 2021)	Governance indicators and energy consumption in South Asia	Corruption control, economic growth, and sustainable energy balance are crucial.	Panel data analysis
(Odilla & Rodriguez-Olivari, 2021)	Anti-corruption mechanisms in Brazil	Anti-corruption legislative frameworks are ineffective without comprehensive administrative reforms.	Case study
(Pluskota, 2020)	The Impact of Corruption on Economic Growth and Innovation in an Economy in Developed European Countries	The study shows that corruption's impact on innovation and growth is nonlinear, with low levels potentially boosting growth by addressing inefficiencies like bureaucracy. In poorly functioning states, corruption can have a positive economic effect.	Panel data analysis

Table 1. *Cont.*

Authors and Year	Research Topic	Key Findings	Methodology
(Okenna, 2020)	Impact of Corruption on Nigeria's Economic Development	The study shows that corruption severely impedes Nigeria's economic growth and development by diverting resources through practices like bribery, misuse of positions, and tax evasion. It also offers policy recommendations to combat these issues and support the country's progress.	Johansen's cointegration test, ordinary least squares (OLS)
(Sharma & Paramati, 2020)	Financial development and corruption control	Financial development plays a key role in controlling corruption.	Panel data analysis
(Tran et al., 2020)	Credit registries and financial development	Public and private credit registries positively impact financial development and reduce the negative effects of corruption.	Panel data analysis
(Yahaya et al., 2020)	Corruption, financial development, and environmental degradation in Sub-Saharan Africa	Positive relationship between corruption, financial development, and environmental degradation.	Panel data analysis
(Pham, 2020)	Corruption control and economic growth	Corruption control significantly impacts stock market and trade openness; stronger measures enhance market efficiency.	Panel data analysis
(Drápalová & Di Mascio, 2020)	Corruption control in Spanish cities	Administrative reorganization and professional management effectively control corruption.	Case study
(Leite et al., 2019)	Corruption control and economic freedom	Both have positive and significant long-term effects on economic growth.	Panel data analysis
(Christos et al., 2018)	Corruption Perception Index (CPI), as an Index of Economic Growth for European Countries	The study shows that higher corruption leads to lower per capita GDP in most European countries, except for non-EU countries like Turkey. Additionally, reducing corruption is linked to faster GDP growth across all European regions.	Econometric analysis
(Nnyanzi et al., 2018)	Financial development and tax revenues	Financial development enhances tax revenues; corruption control strengthens this relationship.	Panel data analysis

Table 1. *Cont.*

Authors and Year	Research Topic	Key Findings	Methodology
(Choi, 2018)	Corruption control in South Korea	South Korea is successful in controlling low-level corruption but struggles with high-level corruption.	Case study
(Efobi et al., 2018)	Foreign aid and terrorism	Foreign aid reduces the negative effects of terrorism on FDI in high corruption control countries.	Panel data analysis
(Adedeji et al., 2018)	Corruption control in Nigeria's public sector	Effective control depends on honest personnel and robust internal control systems.	Case study
(Huang et al., 2018)	Corruption control in hierarchical societies	Asymmetric punishment fosters public cooperation and improves social welfare.	Theoretical modeling
(F. Wei & Kong, 2017)	Corruption and financial development in China	Both significantly influence company bank loans; financial development does not increase loans in more corrupt areas.	Panel data analysis
(Adams & Mensah Klobodu, 2016)	Financial development and income inequality in Sub-Saharan Africa	Financial development increases income inequality; controlling corruption and enhancing transparency reduce it.	Panel data analysis
(Kunieda et al., 2016)	Corruption, financial development, and economic growth	Corruption negatively impacts economic growth directly and indirectly through financial development.	Panel data analysis
(Batabyal & Chowdhury, 2015)	Corruption and income inequality in Commonwealth countries	Reducing corruption and promoting financial development simultaneously can effectively reduce income inequality.	Panel data analysis
(Asongu & Nwachukwu, 2015)	Political stability and corruption control in Africa	Positive correlation between political stability and corruption control.	Panel data analysis

Table 1. *Cont.*

Authors and Year	Research Topic	Key Findings	Methodology
(Acemoglu & Robinson, 2013)	Why nations fail: The origins of power, prosperity, and poverty	"Why Nations Fail" by Acemoglu and Robinson argues that a nation's economic success hinges on its institutions: inclusive institutions promote prosperity by encouraging participation and protecting rights, while extractive institutions lead to failure by concentrating power among a few. They assert that institutions, rather than geography or culture, determine economic outcomes.	Econometric analysis
(Blackburn & Forgues-Puccio, 2010)	Financial liberalization, bureaucratic corruption and economic development	Blackburn and Forgues-Puccio (2010) conclude that bureaucratic corruption negates the positive effects of financial liberalization on economic development. Thus, combating corruption is essential for realizing the benefits of liberalization.	Dynamic general equilibrium (DGE)
(Mauro, 1995)	Corruption and Growth	Paolo Mauro (1995) finds that corruption adversely affects economic growth and investment. Higher corruption levels lead to lower GDP (Gross Domestic Product) growth rates and reduced private investment, underscoring the need to combat corruption to promote economic development.	Cross-country regression analysis

3. Data and Research Methodology

In this study, potential long-term relationships between variables were examined using panel data analysis methods. Firstly, second-generation cointegration tests, specifically the (Westerlund & Edgerton, 2007) (2007) cointegration test, were applied to account for cross-sectional dependence and to test the cointegration relationships between the variables more robustly. Additionally, Pedroni (1999) and Kao (1999) cointegration tests were also utilized for comparison purposes. If the test results indicate the presence of a cointegration relationship between the series, the coefficients of this relationship were estimated using both the Fully Modified OLS (FMOLS) and Dynamic OLS (DOLS) methods. The FMOLS method provides unbiased coefficient estimates by correcting for endogeneity and autocorrelation, while the DOLS method includes lagged and lead differences of the independent variables to improve estimation accuracy.

3.1. Data

Our study uses annual data from 2002–2021 for E7 and G7 countries, obtained from reliable international institutions such as the World Bank and the International Monetary Fund (IMF). Summary statistics for the sample are provided in Table 2.

Corruption Control (Cor): This variable is an indicator that measures how much corruption is under control in countries. Corruption refers to the abuse of public power for private gain, and this variable expresses how effectively governments and institutions prevent corruption. A positive value indicates corruption is effectively controlled, while a negative value suggests corruption is widespread. A high level of corruption control supports economic and financial development by increasing investor confidence.

E7: Average −0.47 indicates that corruption control is weak in these countries.
G7: An average of 1.40 indicates that corruption is more effectively controlled in these countries.

Table 2. Descriptive statistics.

Variables	Shortening		Mean	Std. Dev.	Minimum	Maximum
Control of Corruption: Estimate	Cor	E7	−0.47	0.33	−1.14	0.16
		G7	1.40	0.52	0.00	2.06
Foreign direct investment, net outflows (% of GDP)	For	E7	0.91	0.87	−1.24	3.73
		G7	2.70	2.09	−3.71	12.17
Financial Development Index	Fdi	E7	0.48	0.09	0.27	0.67
		G7	0.82	0.07	0.67	0.96

Foreign direct investment, net outflows (% of GDP): This variable shows the foreign direct investment made from a country to other countries. The outward portion of the investments made by foreign investors in that country is expressed as a ratio to GDP. A positive value indicates a net outflow of investment from the country, while a negative value indicates that the country attracts net investment (i.e., receives more investment from abroad). This variable is an important indicator for understanding how reliable and attractive the country is to investors. Expressing this variable as a ratio to GDP allows for a clearer view of the impact of different economic sizes across countries on direct investment levels. The percentage values associated with GDP reveal the relative importance of foreign direct investment according to the economic capacity of each country. Thus, it becomes possible to compare the relationship between investment outflows and economic size more consistently between E7 and G7 countries.

E7: Average 0.91, outward investments are limited and sometimes negative.
G7: Average 2.70, investment outflows are higher, and countries have a large variation.

Financial Development Index (Fdi): This variable measures the level of development of a country's financial markets and institutions. Economic development includes elements such as depth, accessibility and efficiency of markets. A high financial development index indicates that capital accumulation in that country is more effective, access to financial services is wide, and markets are more liquid and dynamic. Financial development is one of the main factors supporting economic growth.

E7: An average of 0.48 indicates that financial systems in these countries are in the development stage.
G7: Average 0.82 indicates they have more mature and advanced financial systems.

The variable with the highest standard deviation is GDP in both country groups, indicating a heterogeneous distribution among the countries. When examining the Control of Corruption variable, it is observed that G7 countries have a higher average corruption control. Additionally, G7 countries exhibit a wider distribution in terms of the foreign direct investment and net outflows (% of GDP), while E7 countries show a more homogeneous distribution. It is also noted that the financial development levels of G7 countries, which are higher, vary within a more limited range whereas the economic development levels of E7 countries span a broader range.

The main method used to analyze variables is FMOLS, suitable for examining long-term relationships. The FMOLS method was chosen to estimate the cointegration relationships between corruption control, FDI and financial development in panel data analysis. The FMOLS method detects long-term relationships between variables and is robust against cointegration problems. FMOLS eliminates autocorrelation and endogeny problems between independent variables and error terms. This method is particularly effective in small sample sizes and heterogeneous panel data sets. It is a recommended estimation method after the cointegration tests of Pedroni (2000) and Kao (1999).

3.2. Panel Cointegration Tests

The cointegration relationship refers to a situation where the long-term equilibrium relationship between variables can be maintained despite persistent external shocks. Non-stationary time series are typically analyzed by taking their first differences; however, this process risks losing the long-term information contained in the series. Therefore, the levels of variable series are preferred in cointegration analyses. Common methods such as Engle–Granger and Johansen–Juselius are often used in cointegration analyses, but these tests can be insufficient due to the short-term cross sections of panel data.

In Pedroni cointegration tests, a total of seven test statistics are proposed and are divided into two separate categories. The "Within" category includes four different tests, while the "Between" category includes three tests (Pedroni, 1999, p. 660; Asteriou & Hall, 2007, p. 374; Baltagi et al., 2000, p. 13). The "Within" category takes into account the changes over time in the variables within the panel data set to determine the cointegration relationship between the variables. The "Between" category analyzes the differences between variables to determine the cointegration relationship within the panel data set.

Y_{it} : Dependent variable (e.g., foreign direct investment)
X_t : Independent variable (e.g., corruption control or financial development)
α_i : Constant term (may be different for each country)
δ_i : Time trend
ε_t : Error term (represents the part that cannot explain the relationship between variables);

$$Y_{it} = \alpha_i + \delta_i t + \beta_i X_t + \varepsilon_t \quad (1)$$

In Equation (1), where Y and X are stationary variables at the $I(1)$ level, and α_i, δ_i, parameters represent the effects of panel units; in Pedroni's cointegration test analyzes, the existence of a cointegration relationship between the Y and X variables is analyzed through the stationarity of the error terms.

ε_{t-1} : Error term of the previous period
ρ_i : Dependence of error term on previous period
$\Delta\varepsilon_{i-j}$: Differences from previous periods
u_t : Random error (shocks);

$$\varepsilon_{it} = \rho_i \varepsilon_{t-1} + u_t \quad (2)$$

$$\varepsilon_{it} = \rho_i \varepsilon_{t-1} + \sum_{j=1}^{p_i} \omega_j \Delta\varepsilon_{i-j} + u_t \quad (3)$$

The ρ_i coefficients in Equations (2) and (3) are tested under the null hypothesis that there is no cointegration relationship between the Y and X variables. In this case, it is assumed that the ρ_i coefficients are homogeneous for all units, and the cointegration analysis examines the within dimension or panel as a whole (Equation (2)). In the other case, it is assumed that some of the panel units are heterogeneous, and the cointegration analysis examines the between dimension or the panel as a whole (Equation (3)).

Unlike Pedroni's cointegration test, which assesses whether the relationship between variables is homogeneous by considering both fixed and variable effects, the Kao (1999) cointegration test, which comprehensively addresses the dynamics in cointegration analysis, is also included in the study.

Y_{it} : Dependent variable
$X'_{it}\beta$: Independent variable and coefficients (e.g., corruption control, economic growth)
$Z'_{it}\gamma$: Other explanatory variables and coefficients
ε_{it} : Error term

$$Y_{it} = X'_{it}\beta + Z'_{it}\gamma + \varepsilon_{it} \quad (4)$$

In Equation (1), Y and X are $I(1)$ level stationary variables. Under the assumption of no cointegration relationship, the cointegration relationship between the series is investigated using Dickey–Fuller (DF) and Augmented Dickey–Fuller (ADF) unit root tests on the ε_{it} series, with the equality $Z_{it} = \{\mu_i\}$ as advocated by (Kao, 1999; Lau et al., 2011, p. 148). Under the null hypothesis of no cointegration relationship between the variables, the relevant test statistics are calculated (Kao, 1999, pp. 6–16).

As in the Kao (1999) method, Pedroni and other first-generation panel cointegration tests were developed to test long-term relationships between series, but these can ignore cross-dependencies that may be encountered in the panel data structure. This can lead to misleading results, especially in cases where variables are interdependent. Second-generation cointegration tests have overcome this problem and obtain more reliable results by taking cross-dependency into account. In this study, Westerlund's (2007) cointegration test was also used to address cases where panel units are not independent of each other. The Westerlund test adopts the error correction mechanism approach, tests the existence of long-term relationships in each panel unit, and gives more sensitive results in cases of cross-dependency. This method allows the cointegration relationship between series to be directly analyzed and allows the long-term balance relationship to be examined

separately for each section in the panel. In this context, the Westerlund test is used as an alternative that takes into account the cross-sectional dependence of panel data and reveals long-term relationships more strongly compared to traditional first-generation cointegration tests. Westerlund's (2007) cointegration test is also used to address possible cross-sectional dependence and provide a more robust cointegration analysis in panel data settings. Unlike Pedroni's test, Westerlund's method directly tests the null hypothesis of no cointegration by focusing on the error correction mechanism, making it more reliable when cross-sectional dependence is present. Westerlund's approach includes four main test statistics that test both the panel as a whole and each cross-sectional unit separately for cointegration, providing a more detailed perspective on cointegration dynamics in various panel structures.

This test, proposed by Westerlund (2007), is based on an error correction model (ECM)-based approach to test for long-term relationships between variables and is sensitive to cross-sectional dependence. The Westerlund test uses the following error correction model to investigate the long-term relationship between the dependent and independent variables (Equation (5)).

Y_{it} : Dependent variable
X_{it} : Independent variables
α_i : Constant term
$Z'_{it}\gamma$: Other explanatory variables and coefficients
$\delta_i t$: Trend
$\rho_i Y_{i,t-1}$: Error correction term from the previous period
θ_{ij} : Coefficients of past differences of Y
$\varnothing_{ij}$: Coefficients of lagged differences of X
u_{it}: Error term

$$\Delta Y_{it} = \alpha_i + \delta_i t + \rho_i Y_{i,t-1} + \sum_{j=1}^{p_i} \theta_{ij} \Delta Y_{i,t-j} + \sum_{j=0}^{q_i} \varnothing_{ij} \Delta X_{i,t-j} + u_{it} \quad (5)$$

In this model, Westerlund test statistics are calculated in four different ways as P_a, P_t, G_a, G_t. These statistics are used to test the existence of a long-term relationship between the series. P_a, P_t statistics test whether the error correction mechanism exists for all panel units. The null hypothesis is that there is no cointegration relationship in the entire panel. G_a, G_t statistics are calculated using the average of the error correction terms in each panel unit. The null hypothesis is that there is no cointegration relationship in some of the panel units. According to the test results, rejection of the null hypothesis reveals the existence of a long-term cointegration relationship between the series (Westerlund, 2007; Aytun & Akın, 2014).

3.3. FMOLS and DOLS (Dynamic Ordinary Least Square) Estimators

When a cointegration relationship is determined between the variables, the coefficients of this relationship can be estimated. The FMOLS method is used to estimate the unbiased coefficients of this relationship (Pedroni, 2000). The FMOLS method allows for heterogeneity across units and considers potential correlations among the independent variables, the constant term, and the error term (Yardımcıoğlu, 2012, p. 39).

This technique represents a method to estimate non-stationary cointegration relationships in panel data. This approach is innovative, as it overcomes the limitations of traditional techniques for non-stationarity cointegration analysis and provides a practical solution for panel data. Adjusted for use in panel data structures, Pedroni (2000) defined the FMOLS estimator as a semiparametric adjustment procedure that was designed to address estimation problems that might arise from long-term correlations between cointegrated

equations and also stochastic disturbances. The methodology prevents biases arising from endogeneity and provides corrections for possible autocorrelation. The FMOLS methodology was developed by Kao and Chiang in 2000 to estimate the long-term cointegration vector for non-stationary panel data.

$$\beta_{FM} = \left[\sum_{i=1}^{N}\sum_{t=1}^{T}(x_{it}-\overline{x}_i)(x_{it}-\overline{x}_i)\prime\right]^{-1}\left[\sum_{i=1}^{N}\sum_{t=1}^{T}(x_{it}-\overline{x}_i)\,\hat{y}_{it}^{*}+T\hat{\Delta}_{EM}^{*}\right] \quad (6)$$

β_{FM}: Coefficient estimated by FMOLS method
x_{it} : Value of independent variable in countryii and time t
$\overline{x}_i$: Average value of independent variable in country i
$\hat{y}_{it}^{*}$: Dependent variable corrected for endogenous dependence. This is a transformed version of y_{it} and is defined as $y_{it}-\hat{\Omega}_{EM}\hat{\Omega}_{E}^{-1}\Delta x_{it}$.

In Equation (1), FM means fully modified, EM is error correction mechanism and E is the meaning of error term. $\hat{y}_{it}^{*}$ represents the transformed version of y_{it} to obtain the endogeneity correction and is defined as $\hat{y}_{it}^{*}=y_{it}-\hat{\Omega}_{EM}\hat{\Omega}_{E}^{-1}\Delta x_{it}$ and $\hat{\Delta}_{EM}^{*}$ ($\hat{\Omega}_{EM}$: Error correction mechanism and Δx_{it} : Represents the change in the independent variable over time) represents the autocorrelation correction term and is defined as $\hat{\Delta}_{EM}^{*}=\hat{\Delta}_{EM}-\hat{\Delta}_{E}\hat{\Omega}_{E}^{-1}\hat{\Omega}_{EM}$ (Dritsaki & Dritsaki, 2014, p. 132). This method corrects the autocorrelation and endogeneity problems between the independent variables and the error terms, thus providing more accurate and unbiased estimates. As a result, the FMOLS method allows the precise estimation of long-term relationships by eliminating the endogeneity and autocorrelation problems in cointegration analyses. This is a powerful method used especially in panel data analyses. Similar to the FMOLS method, the DOLS method aims to more accurately estimate the long-term relationships between dependent and independent variables. In this method, endogeneity and autocorrelation problems are corrected by adding lagged and forward values of independent variables to the model (Stock & Watson, 1993). Thus, DOLS provides more consistent forecasts by reducing possible biases. Developed as an alternative to Pedroni's (2000) FMOLS method, DOLS is frequently preferred to examine long-term relationships in panel data analyses. This method generates forecasts by taking into account the heterogeneity in the data structure and possible correlations between the independent variables and the error term. Unlike the FMOLS method, the DOLS method takes a semi-parametric approach to parameter estimation and minimizes bias problems by including the difference terms of the independent variables in the equation. Thus, the DOLS method, as an effective method used in cointegration analysis in panel data sets, helps to solve the problems of autocorrelation and endogeneity between independent variables and error terms in long-term relationships (Mark & Sul, 2003).

$$\beta_{DOLS} = \left[\sum_{i=1}^{N}\sum_{t=1}^{T}(x_{it}-\overline{x}_i)(x_{it}-\overline{x}_i)\prime\right]^{-1}\left[\sum_{i=1}^{N}\sum_{t=1}^{T}(x_{it}-\overline{x}_i)\,\widetilde{y}_{it}\right] \quad (7)$$

β_{DOLS}: Coefficient estimated by DOLS method
x_{it} : Value of independent variable in country i and time t
$\overline{x}_i$: Average value of independent variable in country i
$\widetilde{y}_{it}$: This expression expresses the value of $\widetilde{y}_{it}$ corrected for autocorrelation and endogeny and is defined as in Equation (7)

$$\widetilde{y}_{it} = y_{it} - \sum_{j=-k}^{k}\delta_j \Delta x_{i,t+j} \quad (8)$$

Here, $\Delta x_{i,t+j}$ represents the j lagged or forward differences of the independent variable at time t, and δ_j represents the estimated coefficients for these differences.

4. Results

This section introduces the data to be analyzed, performs stationarity tests, provides brief information about the tests and methods, and evaluates the findings from panel data analysis.

4.1. Correlation Analysis

To test the basic assumptions of the linear least squares method used in panel data analysis, econometric assumption tests must be performed on the variables and estimated regression residuals. First, the correlation matrix, which shows the relationship and direction of the variables across the panel a priori, is provided in Table 3.

According to the correlation matrix findings and coefficient signs of the panel data set, it has been determined that statistically significant relationships between variables vary. The highest positive relationship within the scope of G7 countries is between control of corruption and foreign direct investment (FDI), net outflows (% of GDP) variables, while the lowest positive relationship is between FDI, net outflows (% of GDP) and GDP growth (annual %) variables. For the E7 countries, the highest positive relationship is between Financial Development Index and FDI, net outflows (% of GDP) variables, whereas the highest negative relationship is between FDI, net outflows (% of GDP) and control of corruption variables.

Table 3. Correlation matrix.

Correlation Matrix		COR	GDP	FOR	FDI
COR	E7	1.00			
	G7	1.00			
GDP	E7	0.12	1.00		
		(0.15)			
	G7	0.19 *	1.00		
		(0.02)			
FOR	E7	−0.46	−0.01	1.00	
		(0.00)	(0.90)		
	G7	0.31 *	0.23 *	1.00	
		(0.00)	(0.00)		
FDI	E7	0.18 *	−0.09	0.24 *	1.00
		(0.03)	(0.28)	(0.00)	
	G7	0.26 *	0.09	0.10	1.00
		(0.00)	(0.25)	(0.23)	

Note: The * symbol indicates a statistically significant relationship at a 5% level.

4.2. Panel Regression Analysis

Before determining the stationarity of the series, the cross-sectional dependency status should be examined. If there is a correlation between the sections, analyses that take this dependency structure into account should be used in the regression coefficient estimates. One of the tests used to assess cross-sectional dependency in panel data sets is the Breusch–Pagan (1980-CD_{LM1}) (Breusch & Pagan, 1980) test; it is used in the case of $T > N$. The cross-sectional dependency of the series is examined, and the results are given in Table 4.

Table 4. Cross-sectional dependency.

Variables		Statistic	*p*-Value	Decision
Cor	E7	145.41	0.00	H_0 is rejected
	G7	85.49	0.00	H_0 is rejected
Gdp	E7	134.46	0.00	H_0 is rejected
	G7	303.74	0.00	H_0 is rejected
For	E7	32.02	0.05	H_0 is not rejected
	G7	56.14	0.00	H_0 is rejected
Fdi	E7	175.86	0.00	H_0 is rejected
	G7	95.18	0.00	H_0 is rejected

Note: Horizontal units are independent of each other CD~N (0,1).

According to the results obtained from the CD_{LM1} cross-sectional dependency test, it was observed that the null hypothesis could not be rejected in the FDI, net outflows (% of GDP) variable in E7 countries. As a result of the rejection of the null hypothesis in other variables, it was determined that there was a correlation, i.e., cross-sectional dependency, between the countries forming the data set. Cross-sectional dependency was determined in all variables within the scope of G7 countries. For the series with cross-sectional dependency, the second-generation unit root analysis Pesaran (2007) CADF test, which can be used in this problem, was applied. For the series without cross-sectional dependency, the first-generation unit root test, Hadri (2000)'s unit root test, was used because the $T > N$ situation was considered. It should also be noted that since the Hadri (2000) panel unit root test is an adapted version of the KPSS test in time series, the null hypothesis of the test is assumed to be "all units are stationary".

According to Table 5, the stationarity analysis of the variables within the scope of E7 and G7 countries determined that all variables were stationary of the first order.

Table 5. Unit root test results.

Variable		Constant + Trend (Second Generation)			Constant + Trend (First Generation)		Decision	Result
		t-bar	Z[t-bar]	*p*-Value	z-Statistic	*p*-Value		
Cor	E7	−2.19	0.22	0.59			H_0 is rejected	$I(1)$
ΔCor		−3.77	−5.25	0.00				
Cor	G7	−2.39	−0.29	0.38			H_0 is rejected	$I(1)$
ΔCor		−5.27	−9.09	0.00				
Gdp	E7	−2.71	−1.14	0.12			H_0 is rejected	$I(1)$
ΔGdp		−2.54	−2.08	0.01				
Gdp	G7	−2.29	−0.02	0.48			H_0 is rejected	$I(1)$
ΔGdp		−5.46	−9.60	0.00				
For	E7	−2.39	−0.29	0.38	14.57	0.00	H_0 is not rejected	$I(1)$
ΔFor		−5.27	−9.09	0.00	1.58	0.05		
For	G7	−2.00	−0.71	0.23			H_0 is rejected	$I(1)$
ΔFor		−5.57	−9.86	0.00				
Fdi	E7	−2.01	0.69	0.75			H_0 is rejected	$I(1)$
ΔFdi		−4.70	−7.63	0.00				
Fdi	G7	−2.37	−0.25	0.39			H_0 is rejected	$I(1)$
ΔFdi		−5.02	−8.45	0.00				

4.3. Panel Cointegration Test

Pedroni and Kao cointegration analysis methods were used after unit root tests to determine a long-term mutual relationship between the variables. The result of the test is presented in Table 6.

According to the Pedroni cointegration test, in which we examine the long-term relationship between the variables considered, it has been determined that the H_0 hypothesis (no cointegration between the series) has been rejected for both G7 and E7 countries. When the panel statistics and group statistics are examined according to the test results, it is seen that there is a strong cointegration relationship between the series, with five out of seven tests of the Pedroni cointegration test showing significant results. According to the Kao cointegration test findings, it has been determined that the H_0 hypothesis (there is no cointegration between the series) has been rejected. Therefore, there is a joint movement between the variables considered within the 2002–2021 period, and the cointegration test results indicate a long-term relationship between the variables.

Table 6. Cointegration test results.

(Within-Dimension)		***t*-Statistic**	***p*-Value**	**Weighted *t*-STATISTIC**	***p*-Value**
Panel v-Statistic	E7	−2.30	0.98	−3.11	0.99
	G7	−3.45	0.99	−3.74	0.99
Panel rho-Statistic	E7	−0.75	0.22	−0.57	0.28
	G7	−1.17	0.11	−1.42	0.07
Panel PP-Statistic	E7	−5.80	0.00	−5.14	0.00 *
	G7	−10.43	0.00	−12.34	0.00 *
Panel ADF-Statistic	E7	−5.84	0.00	−5.14	0.00 *
	G7	−8.83	0.00	−9.85	0.00 *
(Between-Dimension)		*t*-statistic		*p*-value	
Grouprho-Statistic	E7	−2.73		0.00 *	
	G7	−5.72		0.00 *	
Group PP-Statistic	E7	−5.88		0.00 *	
	G7	−14.37		0.00 *	
Group ADF-Statistic	E7	−5.92		0.000 *	
	G7	−12.85		0.000 *	
Kao Panel Cointegration		*t*-statistic		*p*-value	
ADF		E7		0.0002 *	
		G7		0.0162 *	
Residua lvariance	E7	0.01			
	G7	0.00			
HAC variance	E7	0.00			
	G7	0.00			
$For_{it} = \alpha_{it} + \beta_1 Cor_{it} + \beta_2 Gdp_{it} + \beta_3 Fdi_{it} + \varepsilon_{it}$					
Westerlund		Statistics	Value	z-value	*p*-value
For & Cor	E7	P_a	−9.49	−7.74	0.00 *
		P_t	−7.15	−4.97	0.00 *
		G_a	−5.92	−1.23	0.10
		G_t	−1.63	−1.68	0.04 *
	G7	P_a	−11.08	−9.19	0.00 *
		P_t	−8.28	−5.93	0.00 *
		G_a	−8.11	−2.50	0.00 *
		G_t	−2.43	−3.71	0.00 *

Table 6. *Cont.*

(Within-Dimension)		*t*-Statistic	*p*-Value	Weighted *t*-STATISTIC	*p*-Value
For & Gdp	E7	P_a	−4.80	−3.45	0.00 *
		P_t	−5.49	−3.55	0.00 *
		G_a	−6.59	−1.62	0.05
		G_t	−2.37	−3.55	0.00 *
	G7	P_a	−4.37	−3.05	0.00 *
		P_t	−5.12	−3.23	0.00 *
		G_a	−1.54	−1.44	0.07
		G_t	−2.23	−0.91	0.08
For & Fdi	E7	P_a	−12.87	−10.82	0.00 *
		P_t	−9.31	−6.82	0.00 *
		G_a	−9.06	−3.06	0.00 *
		G_t	−2.82	−4.69	0.00 *
	G7	P_a	−8.24	−6.59	0.00 *
		P_t	−6.11	−4.07	0.00 *
		G_a	−6.98	−1.85	0.03
		G_t	−2.10	−2.87	0.00 *

Note: The * symbol indicates a statistically significant relationship at a 5% level. The reported values are the Z test statistics and the robust *p*-values obtained from the 400-repeat bootstrap process, respectively. These probability values were calculated by repeating the bootstrap process 400 times. In our study, the bandwidths were calculated as $4\left(\frac{T}{100}\right)^{2/9} \approx 3$, with the number of periods. The test regression includes a constant, a lead, and a lag.

The homogeneity of the variables in the model was checked with the slope heterogeneity test of Pesaran and Yamagata (2008). According to the test results, the Delta statistic was found to be 0.415 and the corresponding *p*-value was 0.678. The corrected Delta statistic was 0.464 and the corresponding *p*-value was 0.643. These *p*-values mean that the null hypothesis could not be rejected at the 5% significance level. Therefore, it was concluded that the slope coefficients of the variables were homogeneous. The test statistics results are evaluated in two groups according to the assumption of homogeneity and heterogeneity. Under the assumption of homogeneity, the analysis is performed using the panel test statistics P_a and P_t of all cross-sectional units. In our study, since we reached the conclusion that the slope coefficients are homogeneous with the Pesaran and Yamagata (2008) test, we only considered the *p*-values based on the P_a and P_t statistics in the Westerlund test results. When the results are examined, it is seen that the *p*-values of the test statistics are below 0.05. This shows that there is a significant cointegration relationship between the variables under the assumption of a homogeneous structure. Especially, the values of P_a and P_t being close to zero support a strong cointegration relationship at the panel level.

In the study, Pedroni, Kao, and Westerlund cointegration tests were applied to evaluate the long-term relationship between variables in the period 2002–2021. Although all three tests aim to detect cointegration, they differ in terms of assumptions and methodological approaches and provide a comprehensive view of cointegration relationships. The Pedroni cointegration test, which allows for cross-sectional heterogeneity, revealed a strong cointegration relationship between variables for both G7 and E7 countries. This finding shows that there is a robust, long-term relationship between variables in both G7 and E7, and the heterogeneity feature of the test provides insights into differences between countries in each group. Similarly, the Kao test rejected the null hypothesis and showed the existence of a long-term relationship between variables. However, unlike the Pedroni test, the Kao test assumes homogeneity between cross-sectional units, that is, it applies a uniform relationship between all units in the panel. While the Kao test confirms a common movement among the variables, its restrictive assumption of homogeneity may limit its

ability to capture country-specific variation. The Westerlund test differs from both the Pedroni and Kao tests by including a bootstrap approach that provides robust *p*-values and increases the reliability of cointegration findings. The Westerlund test results further support the existence of a long-term relationship among the variables with significant results in the primary panel statistics. Given that we determined homogeneity across cross sections, the focus on panel statistics in Westerlund strengthens the cointegration relationship under the assumption of homogeneity. In summary, all three tests consistently show a long-term relationship among the variables.

4.4. Cointegration Testing with Fully Modified Ordinary Least Square (FMOLS) and Dynamic Ordinary Least Square (DOLS)

After the cointegration tests, the FMOLS method developed by Pedroni (2001) was used to estimate the unbiased coefficients of this relationship and to evaluate the estimators' conformity to our expectations. Additionally, Pedroni (2000) examined the effectiveness of the FMOLS method in small samples and stated that Monte Carlo simulations supported the performance of the *t*-statistic in these samples.

As seen in Table 7, when the magnitudes and impact strengths of the coefficients are examined, it is seen that the effect of GDP on foreign direct investments is high for G7 countries in the FMOLS method (0.19). This shows that FMOLS provides accurate results by considering the long-term correlations between independent variables and error terms. However, the fact that the effect of GDP on the same relationship is encountered with a larger coefficient value (0.57) in the DOLS method reveals that DOLS can increase the coefficient size by addressing the endogenous problem more comprehensively. It is also noteworthy that the DOLS method provides stronger results regarding *t*-statistics and significance. For example, the *t*-statistic (10.41) of the effect of GDP on foreign direct investments in G7 countries in the DOLS estimation is quite high and statistically significant. In the FMOLS method, the *t*-statistic (5.90) for the same relationship is lower but remains at a substantial level. This situation shows that the DOLS method allows for stronger significance by adding lagged differences. When the model's fit strength is examined, the DOLS method increases the explanatory power of the dependent variable by providing higher R^2 values. While the R^2 value of the corruption control variable for E7 countries was 0.45 in the FMOLS estimation, the DOLS method increased this value to 0.68. Similarly, the DOLS estimates for G7 countries also provided higher R^2 values (0.51 for FMOLS, 0.75 for DOLS). This situation reveals the capacity of the DOLS method to increase model fit by adding lagged variables. As a result, although both methods are effective in showing the long-term effects of corruption control and GDP growth on foreign direct investments in E7 and G7 countries, the DOLS method provides stronger results in terms of coefficient sizes, significance levels, and model fit strength.

Table 7. Panel FMOLS and DOLS Long-Term Forecast Results.

Dependent Variable: For		Coefficient	*t*-Statistic	*p*-Value	R^2		
					E7	G7	
Cor	E7	0.17	5.73	0.00 *	0.45	0.51	FMOLS
	G7	0.04	2.40	0.01*			
Gdp	E7	0.04	3.70	0.00 *			
	G7	0.19	5.90	0.00 *			
Fdi	E7	3.06	1.41	0.01 *			
	G7	3.63	0.68	0.49			

Table 7. *Cont.*

Dependent Variable: For		Coefficient	*t*-Statistic	*p*-Value	R^2		
					E7	G7	
Cor	E7	0.87	2.12	0.03 *	0.68	0.75	FDOLS
	G7	0.03	2.36	0.02 *			
Gdp	E7	0.14	2.16	0.03 *			
	G7	0.57	10.41	0.00 *			
Fdi	E7	1.37	4.21	0.00 *			
	G7	2.74	0.65	0.51			

Note: The * symbol indicates a statistically significant relationship at a 5% level.

5. Discussion

The findings of this study are in strong alignment with the existing literature examining the impact of corruption control on financial development and, in some respects, make significant contributions to the literature. Firstly, the negative relationship between corruption and financial development is a topic emphasized in many academic studies. For example, Mauro (1995) stated that corruption adversely affects economic growth and investments, while Demirgüç-Kunt and Maksimovic (1998) revealed that corruption reduces the efficiency of financial markets.

This study adds depth to the literature by separately examining the positive impact of corruption control on financial development for both developed (G7) and developing countries (E7). Specifically, the finding that the relationship between corruption control and financial development is more stable and positive in G7 countries aligns with North's (1990) theory of institutional economics. North argues that strong institutional structures enhance economic performance, and this study demonstrates that robust corruption control mechanisms contribute to the healthy functioning of financial markets.

The fact that corruption control affects financial development more markedly and strongly in E7 countries parallels studies highlighting the impact of institutional weaknesses on financial markets in developing nations. For instance, La Porta et al. (1998) stated that the protection of legal systems and property rights is critically important for the development of financial markets. In this context, our study shows that reforms aimed at corruption control in E7 countries can accelerate financial development, providing significant implications for policymakers.

The positive impact of foreign direct investments (FDI) from corruption control aligns with S.-J. Wei's (2000) finding that corruption hinders international capital flows. This study emphasizes that in countries where corruption control has increased, foreign investors' confidence rises and more investment is attracted, highlighting the contribution of foreign investments to the financial development of countries. Particularly in G7 countries, high levels of transparency and reliability explain foreign investors' interest in these markets.

The positive relationship between financial development and economic growth is supported by King and Levine's (1993) studies on financial intermediation and economic growth. They noted that the development of financial systems accelerates economic growth by promoting capital accumulation and technological innovations. Our study demonstrates that corruption control contributes to long-term economic growth by enhancing the efficiency of financial systems.

Focusing on the differences between developed and developing countries, this study complements the work of Acemoglu et al. (2001), who examined the impact of institutional differences on economic performance. While they argue that the quality of institutions determines the economic destiny of countries, this study reveals that corruption control is an important indicator representing institutional quality and demonstrates its impact on financial development.

In terms of policy recommendations and applications, our study aligns with Rodrik's (2000) arguments that good governance is indispensable for economic development. The finding that policies based on corruption control have positive effects on the financial sector and economic growth indicates that policymakers should prioritize combating corruption. Additionally, the emphasis that a one-size-fits-all solution is not applicable to all countries and that each country's unique conditions must be considered parallels Stiglitz's (2002) views on globalization and the need for policies to adapt to local conditions.

Jain et al. (2014), by investigating the influence of corruption on liquidity, investment flows, and the cost of capital, find that corruption raises foreign investors' costs and leads to a negative impact on investment decisions. This corresponds with our conclusion in this study: foreign investors are more confident when corruption control has increased in countries, and these countries consequently attract higher amounts of investment.

Erum and Hussain (2019), in their study of natural resource wealth, corruption, and economic growth, showed that abundance in natural resources may give rise to higher corruption and result in negative economic growth. Similarly, Chebab et al. (2022) investigated that corruption in natural resource-rich MENA countries hampers financial development. These studies indicated that corruption control is important for financial development and economic growth, specifically in resource-rich nations, and provide a view agreeable with the results presented in our study.

Sharma and Paramati (2020) support the idea that financial development can reduce corruption, and developing financial systems can thus be employed as an effective tool in combating corruption. This, in turn, might mean there could be a reverse relationship in our study, as corruption control and financial development may be seemingly interwoven in a complex dynamic. Our study also implicitly informs us that financial development can be used in combating corruption by increasing economic activities and providing market liquidity.

Considering BRICS economies, Alsagr and Hemmen (2021) investigated the effects of corruption on financial development. They obtained results that proved that corruption lessens the efficiency of the financial markets and slows down economic growth. These findings further confirm our study's conclusion that corruption control influences financial development more markedly and strongly in E7 countries. Moreover, these are also in tune with the finding that reforms related to corruption control in E7 countries can result in significant leaps in financial development.

Such findings were presented in the research of Ziernhold and Jung-Ivannikova regarding the impact of economic growth, corruption, and financial development in Ukraine. In 2021, they demonstrated how corruption suppresses economic growth and furthers impedes financial development. This supports our finding that corruption control has a positive effect on economic growth and contributes to the healthy functioning of financial systems.

Refakar (2021), examining the impact of corruption on U.S. foreign direct investment outflows, shows that countries with high levels of corruption attract less U.S. investment. This supports our study's finding that foreign investments are positively affected by corruption control and that this effect is stronger in G7 countries, where transparency is high.

Struthmann et al. (2022), examining the relationship between corruption control, financial development, and growth volatility, state that corruption control has a significant impact on the stability of economic growth. This finding is consistent with our study's conclusion that corruption control positively affects not only financial development but also economic growth. Notably, both studies emphasize that corruption control creates lasting effects on economic growth.

Trabelsi (2023) shows that the impact of corruption on economic growth is non-linear and that beyond a certain threshold, corruption seriously negatively affects growth. This supports our study's finding that corruption control contributes to the healthier functioning of financial systems and fosters long-term economic growth.

Ketners and Tsiatkovska (2024), analyzing the impact of anti-corruption strategies on social and economic development in Ukraine, show that effectively combating corruption accelerates economic development. This finding supports our study's emphasis in the policy recommendations and applications section that policies based on corruption control should be an integral part of economic growth strategies.

Karianga (2024), examining the impact of state fiscal corruption on development, states that corruption seriously hinders economic and social development. This finding is directly related to our study's finding that corruption control is a critical element for sustainable economic growth.

Limitations of This Study:

- Time Frame: The data used in the study covers the period from 2002 to 2021, and the effects of significant events, such as the pandemic, could not be fully controlled.
- Country Group Differences: While comparing G7 and E7 countries, major economic and institutional differences between countries are considered, however these differences need to be addressed more thoroughly in the analysis. Particularly in E7 countries, institutional weaknesses make it difficult to interpret the results universally.
- Complex Relationships: The relationship between corruption control and financial development is complex, and analyzing only the effects of these two variables may not fully reflect the outcomes. Other factors (e.g., political stability, institutional quality, economic shocks) may also affect this relationship; however, this study does not comprehensively evaluate the effects of these factors.
- General Methodological Limitations: The panel data analysis and cointegration tests used in the study are useful for detecting long-term relationships but may lead to the neglect of short-term effects. Additionally, these methods only allow testing specific hypotheses, and more advanced methodological approaches are required to observe possible causal relationships from a broader perspective.

Recommendations for Future Research:

- Expanded Country Group Analysis: Although this study focused on G7 and E7 countries, including more country groups would allow for a more comprehensive understanding of the relationship between corruption control and financial development in different economic structures and geographical regions. For example, comparing countries in Africa, Latin America, or Southeast Asia could enrich the overall findings.
- Inclusion of Political and Institutional Factors: The relationship between corruption control and financial development is complex and multifaceted. Therefore, future research could provide a more comprehensive perspective by including other variables such as political stability, institutional quality, and the rule of law in the analyses. An in-depth examination of how these factors mediate the relationship can be conducted.
- Separation of Short- and Long-Term Effects: The current study examined long-term relationships. However, short-term effects should also be considered. Future research can develop a more holistic approach by analyzing the effects of short-term policies and economic shocks on corruption control and financial development.

Relationship Between Corruption and Sustainable Development: Future research can examine more deeply the relationship between corruption control and sustainable development. By investigating the effects of corruption control on environmental sustain-

ability, energy efficiency, and social development, a broader development perspective can be developed.

6. Conclusions

It is anticipated that by the year 2050, the E7 countries will surpass the G7 countries economically. These forecasts are based on factors such as high growth rates, a young and evolving demographic structure, increased opportunities for global trade, and progress in reducing corruption within the E7 countries. The focus is on the ability of E7 countries to improve their investment climate and initiate structural changes for sustainable economic growth. For G7 countries, there is a need to invest more in innovation and technology, particularly with education at the forefront. The estimation results using the FMOLS and DOLS models indicate the following:

- Outward foreign direct investment (FDI) flows have a positive and significant effect on economic growth in both country groups; this effect is more pronounced in G7 countries.
- While FDI outflows have a significant and positive effect on financial development in E7 countries, no statistically significant effect was found in G7 countries.
- A statistically significant and negative effect was detected on anti-corruption efforts in both groups.

These findings suggest that the level and pace of development in each economy may lead to different outcomes. The stable economic environment and developed financial systems of G7 economies may explain why there is no significant effect on financial development.

Conversely, the financial markets of E7 countries are more focused on financial development and offer more favorable investment opportunities. The results reveal a close relationship between E7 and G7 countries in terms of economic growth and manipulation of corruption in exports. However, significant differences exist regarding financial progress: financial development affects exports in E7 countries, whereas it does not in G7 countries. Possible reasons for this situation are discussed below.

E7 Countries:

- Financial Development: With their rapidly growing economies, E7 countries regard financial development as the key to economic growth and attracting FDI. By developing their financial systems, they facilitate access to capital, promote financial innovations, and enhance investor confidence.
- Investment Environment and Risk Perception: They increase investment opportunities through new regulations and the expansion of financial inclusion. By utilizing various financial instruments and services, they transform savings into efficient investments.
- Investment Policies and Regulations: By offering investment-friendly policies and legal protections, they reduce corruption risks and gain the confidence of international investors. They align their regulations with international standards for integration into the global financial system.

G7 Countries:

- Mature Financial Systems: Possessing advanced and deep financial markets, the impact of financial development on FDI is limited. Investment decisions are more dependent on factors such as technological advancement, regulatory framework, and investor confidence.
- Secure Investment Environment: They offer a stable investment environment due to strict regulations, strong legal systems, and high investor confidence. Because of

the maturity of their financial markets, the effect of additional financial reforms on attracting FDI is low.

Conclusions and Recommendations:

- For E7 Countries: Financial development, global financial integration, and modernization of financial infrastructure should be prioritized. Enhancing financial literacy and ensuring regulatory stability will support long-term economic growth.
- For G7 Countries: They should maintain the efficiency of their existing financial systems and sustain their leadership roles in the global economy by focusing on innovation and global challenges.

Strategies to achieve the objectives of economic growth and attracting FDI for both country groups should be specific to the economic conditions of the countries. The country-specific adaptation of financial and regulatory policies is essential for sustainable economic development and investment attractiveness.

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Impact of Geopolitical Risks on Herding Behavior in Some MENA Stock Markets

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Abstract: In this study, we examine the herding behavior in MENA stock markets in response to global geopolitical risk by using daily data, ranging from 4 January 2011 to 31 December 2023, on stock-listed companies in some MENA countries (Egypt, Jordan, Lebanon, Morocco, Saudi Arabia, and Tunisia) and the daily geopolitical risk index. In our analysis, we consider that investors' behavior varies depending on the global economic and political period conditions. We use quantile regression analysis to investigate the effect of asymmetry on herding behavior among investors during bearish and bullish market conditions. The results show that herding behavior is evident in all stock markets, except for the Lebanon market, at a lower 5% quantile during down-market periods. A significant estimated coefficient of geopolitical risk was detected on the dispersion of stock returns, except for the stock markets of Morocco and Saudi Arabia. We found that a high level of geopolitical risk contributes to an increase in dispersion in the Lebanese stock market whereas it is associated with a high probability of increasing herding in the Jordanian and Tunisian stock markets. This paper contributes to the existing literature by explaining the impact of geopolitical risks on herding behavior in six MENA countries. This can be considered to be an empirical contribution as we propose to introduce the effect of geopolitical risks on the basis model of herding. Our findings can have significant implications for investors and policymakers in financial markets.

Keywords: geopolitical risk; herding behavior; quantile regression; MENA region; stock markets

1. Introduction

In recent years, researchers have been interested in providing answers to the inefficiency of equity markets via behavioral finance theory. Therefore, many authors have highlighted that the presence of biases, such as overconfidence, anchoring, mental accounting, emotional gaps, representativeness, herding, etc., can explain the anomalies detected in stock markets. These biases will be more important and more readily detected particularly during crises, downturns, and high-volatility periods where uncertainty becomes high and agents and deciders in the markets do not have the optimal solution, and therefore decisions can be mistaken. Uncertainty increases and becomes more intense and impacts investment to a greater extent chiefly during the problems related to growing tensions between states.

Many authors have been interested in the analysis of how irrational behavioral and finance biases affect the efficiency of stock markets in all countries around the world. Some of them give importance to the analysis of the effect of periods of high tensions and crises on herding behavior, i.e., during a crisis, investors abandon their decisions about

selling/buying stocks and decide to follow the crowd (Bouri et al., 2021; Chang et al., 2020). Geopolitical risks and uncertainties surrounding these turbulent periods and ambiguity about the world's political, economic, financial, and social circumstances have worried investors, especially smaller and younger investors, about the future of the stock market movements. However, in these turbulent situations, investors decide to follow others and the phenomenon of herding in the stock market can be detected. Despite the multitude of works interested in the analysis of herding behavior, only a few have been interested in the possible interconnection between uncertainty and herding behavior and introduced the impact of global economic, financial, and political changes into this bias. In this context, various measures associated with uncertainty and investor sentiment indexes are used to test for evidence of herding. Many studies link uncertainty with cryptocurrencies and geopolitical risks to the currency market (Huang, 2022; Ali, 2022) to analyze some properties of behavioral finance such as overconfidence, herding behavior, etc.

During periods of high uncertainty, investors often become more risk-averse and decide to follow others, which can provide them with psychological safety and reduce the perceived risk of making a wrong decision. In the same way, we think that geopolitical risks, which stand for the possibility of a political, economic, and social instability or conflict that may occur from interactions between nations and regions, can have significant effects on global economic activities, investments, and financial markets. Indeed, political instability in a country, or conflicts between countries such as the Russian–Ukrainian war or the American–Chinese trade war, increase uncertainty and volatility in the market. This can impact the emotions and reactions of investors and can therefore lead to irrational behavior. And thus, like uncertainty or oil price fluctuations, geopolitical risks can impact herding behavior. In this paper, we try to examine this property of herding in some MENA stock markets and its link with geopolitical risk concepts. We use the geopolitical risk index and separate it into periods of a high and low geopolitical risk index to study its impact on herding behavior in the MENA region. The main contribution of this study is embodied in the following aspects: this paper differs from previous research as, to our knowledge, it is the first to examine the relationship between stock market returns and geopolitical risks. We link the behavior of investors to states of geopolitical risk, and we divide the full sample into bearish and bullish stock market conditions. The decision to engage in this research is justified by a lack of studies that include the importance of uncertainty and geopolitical risks for herding behavior in MENA stock markets (let us quote, for example, the works of Mallek et al., 2022; Medhioub & Chaffai, 2022). We think that the results of this research can provide a helpful tool for investors and policymakers regarding the behavior of the market towards herding bias and its link to geopolitical risks in MENA countries.

For the analysis of herding behavior, previous studies suggested the robustness and reliability of quantile regressions as stock returns follow, in general, non-normal distributions and most studies have found evidence of herding at the extremely lower/upper tails of the return distribution. Therefore, quantile regression was largely used to examine herding at different quantiles of the distribution. Based on this method over the period 4 January 2011 to 31 December 2023, and by considering listed companies in six countries in the MENA region (Egypt, Jordan, Lebanon, Morocco, Saudi Arabia, and Tunisia), we conclude that the dispersion of geopolitical risk impacts the MENA returns with some differences in terms of herding behavior between the selected MENA countries in this analysis. Additionally, our results suggest evidence of asymmetry between downward and upward market conditions as well as between upper and lower quantiles.

The remainder of this paper is organized as follows. Section 2 briefly presents a literature review on herding behavior, taking into account the impact of external factors such as uncertainty, crisis, oil price fluctuations, etc. Section 3 is dedicated to presenting

the methodology and data description. Section 4 presents the empirical results. Finally, Section 5 discusses the results and concludes the paper.

2. A Literature Review on Herding Behavior and the Impact of External Factors

Several studies have shown that the abnormal behavior of investors, unpredictable and unexpected events, and instability negatively and significantly affect the level of efficiency in financial systems. In such cases, investors tend to make irrational decisions, and their actions in the market will be driven by their feelings, moods, and sentiment. Therefore, an alternative theory to the efficient market hypothesis named behavioral finance was developed. According to this theory, financial markets are not perfectly efficient, and behavioral biases such as overconfidence, anchoring, representativeness, and herding were captured. By applying various methods essentially based on historical information we can catch abnormal returns and the behavior of investors in the market. In fact, it has been proven in several studies (Brooks & Byrne, 2008, for example), that the behavior of investors can be influenced by events and information in the market, and that it can have a direct impact on stock price volatility. Therefore, behavioral finance theory can be considered a relevant theory in terms of explaining unexpected market changes.

Recent years, researchers have been interested in the analysis of herding behavior. The literature review devoted to this bias strongly indicates evidence of herding in many international markets (the US market, emerging stock markets, European stock markets, GCC markets, etc.). Additionally, most studies on herding behavior have insisted on the importance of asymmetric effects and have studied the existence of herding behavior during extreme market periods (Zhang et al., 2024; Bouri et al., 2021). According to Christie and Huang (1995), herding behavior leads to a decrease in the dispersion from the mean returns, and in case of extreme market movements investors try to follow the crowd and imitate the reaction of other investors. Chang et al. (2000) examined herding behavior for some developed/developing stock markets. They concluded that during extreme periods there is evidence of herding in the South Korean and Taiwanese stock markets whereas this bias is absent in the US and Hong Kong stock markets during the same period. Interested in the effects of herding behavior during crises, Lam and Qiao (2015) found evidence of significant herding behavior in the Hong Kong equity market during the Asian crisis (1997), the Russian crisis (1998), and the dot-com technology bubble (2003). Similarly, Prosad et al. (2012) found the same result in the case of the Indian equity market, where herding behavior was concluded during periods of excess volatility and stress periods. Chaffai and Medhioub (2018) highlighted evidence of herding behavior during up-market periods in the GCC stock market. By considering the importance of the oil sector in the GCC area, Medhioub and Chaffai (2021) included the effect of oil price fluctuations and dispersions on the GCC stock market. Based on a sectoral analysis, they found evidence of herding behavior during down- and up-market periods in the food and beverages sector, while this behavior is confirmed in the banking and services sectors during down-market periods only. Also, they highlighted that some sectors such as the insurance sector herd around oil returns during down-market periods and that oil return dispersions have a dominant influence on the food and beverages sector during both downward and upward market periods.

With the high spread of financial crises and their huge impact on economic, political, and social activities, herding behavior became an important topic in the financial literature and works have continued to explain the importance of herding behavior during market stress periods after the discovery of the COVID-19 virus. Authors were especially interested in the behavior of deciders, intermediaries, dealers, and investors toward bubbles and

crashes and how each one reacts to minimize damages and losses. In this context, because of the COVID-19 pandemic and the lockdown of activities, financial sectors were severely and negatively impacted. Investors do not exactly know what they do in trading transactions: do they follow the others in the markets, make their own decisions, or wait and not rush? Looking at the behavior of investors in the Indonesian stock exchange during the COVID-19 pandemic, Hirdinis (2021) concluded a significant herding effect on investment decisions. Investors try to copy from others in the market due to high market return volatilities which are essentially caused by the increase in uncertainty. Mishra and Mishra (2021) are interested in the study of herding behavior in banking and financial institutions listed in the Indian National Stock Exchange during the COVID-19 pandemic. Based on 54 financial companies and by using quantile regression analysis, they concluded that there was evidence of herding behavior under bull market conditions during the COVID-19 pandemic. In the same way, Dhall and Singh (2020) were interested in the study of herding in the Indian capital market during stress periods amid the pandemic. They concluded that herding is significantly present in the industry sector. Other novel works related herding behavior to the induced financial market uncertainty which became more severe during the COVID-19 pandemic. Most of the works insisted on a significant association between the increased uncertainty caused by the COVID-19 pandemic and the evidence of herding behavior during bull market periods. Bouri et al. (2021) highlighted that, because of the COVID-19 pandemic, there is evidence of herding in 49 global stock markets during this severe period. They distinguished a significant positive correlation between uncertainty and herding behavior, particularly in emerging stock markets as well as the European PIIGS (Portugal, Italy, Ireland, Greece, and Spain) stock markets. In another way, Lee et al. (2021) employed an online survey to highlight the effect of the public's risk perception, anxiety, and trust in social media on herding behavior during the COVID-19 pandemic. Their results showed that a state of anxiety is the most important factor affecting herding behavior.

Several studies show that herding behavior occurs during crises during which uncertainty is high (Chiang & Zheng, 2010; Economou et al., 2016). Cakan et al. (2019) examined the relationship between economic policy uncertainty and herding behavior in the South African housing market based on Markov switching and quantile regression analyses. They found plain evidence of herding behavior when uncertainty in the market is high. Huang (2022) finds that behavioral finance phenomena are crucial in explaining the increased volatility in cryptocurrencies. Along the same line, Lin and Li (2019) studied the influence of economic policy uncertainty on herding behavior in the US real estate market. They conclude that, during stressful market periods, uncertainty is high and tends to reduce the likelihood of herding in US REITs. Choi and Yoon (2020) show that when investor sentiment is high, investors in the market become more pessimistic about making decisions in the future and therefore decide to follow the crowd and exhibit herding behavior. When the sentiment is low, investors exhibit reverse herding behavior. Others have studied the effect of government policy responses on herding behavior. For example, Nouri-Goushki and Hojaji (2023) examined the impact of the government response stringency index on herding behavior in the Iranian stock market during the COVID-19 pandemic. They found that a low government response stringency index increased herding in the stock market.

Additionally, many studies have highlighted that fluctuations in oil prices and uncertainty can significantly impact herding behavior in financial markets (Indārs et al., 2019; Coskun et al., 2020; Medhioub & Chaffai, 2021; Koutmos, 2024). In fact, when oil prices fluctuate wildly or uncertainty is high, herding behavior increases, and investors tend to follow the actions of others in the market. Drops in oil prices can lead to an increase in uncertainty, which therefore can be a signal to investors to sell their stocks to avoid heavy losses, especially since they observe that other investors are selling their shares.

Additionally, during periods of high uncertainty, investors often become more risk-averse and decide to follow others, which can provide them psychological safety and reduce the perceived risk of making a wrong decision. In the same way, we think that geopolitical risks, which stand for the possibility of political, economic, and social instability or conflict that may occur from the interactions between nations and regions, can have significant effects on global economic activities, investments, and financial markets. Indeed, political instability in a country, or conflicts between countries such as the Russian–Ukrainian war or the American–Chinese trade war, increase uncertainty and volatility in the market. This can impact the emotions and the reactions of investors and can therefore lead to irrational behavior. And thus, like uncertainty or oil price fluctuations, geopolitical risks can impact herding behavior.

In the last decade, the MENA region has been known for many social, economic, and political problems, and since the Jasmin revolution in 2011, insecurity and instability have increased. Tunisia, Libya, Syria, Lebanon, and Egypt are the main countries largely affected during this period. Conflicts in the region have rehabilitated the relationships of the MENA countries because of the different political tensions and the increase in uncertainty. Also, social and economic problems, especially unemployment and inflation, aggravate the situation, and political decisions do not lead to the resolution of the difficult situations in the region. These problems have a significant effect on financial markets. It is highlighted that geopolitical risks are one of the most important factors affecting investment decisions and can influence investors, especially during periods of high political tension. Like economic policy uncertainty, we think that geopolitical risk can affect herding behavior. Investors place great importance to political events and take into consideration good/bad news when they invest in the market. Accordingly, examining the effect of geopolitical risks on herding behavior in the MENA stock market can be a topic of research and debate.

3. Method, Data, and Analysis

Most of the works analyzing herding behavior, except those based-on surveys, have used dispersion measures of returns as dependent variables and absolute and squared market returns as independent variables. Cross-sectional squared deviation of returns (CSSD) and cross-sectional absolute deviation of returns (CSAD) are considered the main measures of dispersion used in herding behavior modeling. Christie and Huang (1995) defined CSSD as follows:

$$CSSD_t = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(R_{i,t} - R_{m,t})^2} \quad (1)$$

where $R_{i,t}$ is the return of the stock price of company i at date t and Rmt is the stock market return at date t.

On the other hand, Chang et al. (2000) defined CSAD as follows:

$$CSAD_t = \frac{1}{N}\sum_{i=1}^{N}|R_{i,t} - R_{m,t}| \quad (2)$$

CSSD and CSAD are considered proxy variables to equity market herding that explain the rise and fall characterizing market returns during stress and boom periods from which herding can be tested. Non-linearity is the main characteristic of the irrational herding factor in the regression, which can be reflected by a significant negative relationship between dispersion and square returns. The basic equation used to analyze herding as developed by Chang et al. (2000) is expressed as follows:

$$CSAD_t = \beta_0 + \beta_1|R_{m,t}| + \beta_2 R_{m,t}^2 + \varepsilon_t \quad (3)$$

We confirm evidence of herding behavior when the estimated coefficient β_2 is negative and statistically significant.

After that, many works introduced other variables as explicative in the model, which can affect herding. In the case of GCC countries, for example, many papers are interested in analyzing herding behavior by including the influence of oil prices on herding. Ulussever and Demirer (2017), Medhioub and Chaffai (2021), Gabbori et al. (2021), and other researchers found that oil price fluctuations and uncertainty are crucial for the analysis of herding behavior. Recently, authors interested in the importance of economic policy uncertainty on herding behavior integrated the effect of economic policy uncertainty on herding behavior (Cakan et al., 2019; Bouri et al., 2021; for example). In this paper, we introduce the geopolitical risk index to study its effect on herding behavior in the MENA stock market. We considered therefore the following equation to model herding:

$$CSAD_t = \beta_0 + \beta_1|R_{m,t}| + \beta_2 R^2_{m,t} + \beta_3 GPR_t + \varepsilon_t \quad (4)$$

A significant positive coefficient β_3 indicates that geopolitical risk increases the dispersion of stock returns and therefore reduces herding in the MENA stock markets, whereas a significant negative coefficient β_3 reduces the stock market return dispersion and increases therefore herding behavior bias.

Because of asymmetries characterizing stock market returns and the sentiment of investors during different state cases, herding behavior can be analyzed differently among upward and downward market periods. According to many works, investors decide to follow the crowd during bullish periods due to the high confidence of investors in the increase in stock prices. Similarly, investors can follow others in the market during bearish periods due to the lack of investor confidence. To emphasize the significant impact of crises, crushes, bubbles, and turbulent phases on herding behavior we distinguish between upward and downward market periods. In this context, many authors such as Vidya et al. (2023), Hong et al. (2020), and Dhall and Singh (2020) considered the sign of market return (variable Rmt positive or negative) to investigate the asymmetry properties between bullish and bearish market conditions. While other authors, such as Jiang et al. (2022), Medhioub and Chafai (2018), and Balcilar et al. (2014), used regime switching models to consider the possibility of asymmetry between the different states of market conditions. In this paper, to take into account the possibility of the presence of asymmetric market conditions, we propose the following CSAD model:

$$\begin{aligned} CSAD_t &= \gamma_0 + \gamma_1 D_t * |R_{m,t}| + \gamma_2(1 - D_t) * |R_{m,t}| + \gamma_3 D_t * R^2_{m,t} + \gamma_4(1 - D_t) * R^2_{m,t} + \gamma_5 GPR_t + \varepsilon_t \\ D_t &= \begin{cases} 1 \; if \; R_{m,t} > 0 \\ 0 \; otherwise \end{cases} \end{aligned} \quad (5)$$

According to Equation (5), herding behavior is evident during bullish/bearish market conditions when γ_3/γ_4 is negative and statistically significant.

Previous works (such as Medhioub & Chafai, 2018, 2021; Ampofo et al., 2023) have highlighted the success of quantile regression models in analyzing herding behavior. These models are more robust to outliers and herding is more deduced and interpreted by considering upper and lower tails where dispersions are, in general, unstable. For that reason, we focus our analysis on extremely low and high returns for both bullish and bearish market conditions.

The primary objective of this research is to investigate the impact of geopolitical risks on herding behavior in five MENA stock markets. Additionally, we examine whether there is an asymmetry between downward and upward market conditions regarding herding behavior. To attain these objectives, the following hypotheses are tested:

H1. *There is evidence of a significant disparity in herding behavior between lower and upper quantiles within MENA stock markets.*

H2. *Herding behavior is more pronounced during downward than upward market conditions.*

H3. *High geopolitical risk levels significantly intensify herding behavior in MENA stock markets.*

4. Main Empirical Results

In this study, we use quantile regression models at lower 5% and upper 95% quantiles.

4.1. Data and Descriptive Statistics

For this analysis, data were collected from the international platform investing.com over the period 4 January 2011 to 31 December 2023, for the series of stock prices for the following countries: Egypt, Jordan, Lebanon, Morocco, Saudi Arabia, and Tunisia. To introduce the impact of geopolitical risk on herding behavior, we use the geopolitical risk index built by Caldara and Iacoviello (2022).

Table 1 presents the main descriptive statistics of stock market returns Rmt, and their respective CSAD dispersion variables.

Table 1. Descriptive statistics.

	Egypt		**Jordan**		**Lebanon**		**Morocco**		**Saudi Arabia**		**Tunisia**	
	CSAD	***Rmt***	***CSAD***	***Rmt***	***CSAD***	***Rmt***	***CSAD***	***Rmt***	***CSAD***	***Rmt***	***CSAD***	***Rmt***
Mean	0.0139	0.00051	0.0111	-4.95×10^{-5}	0.021	0.0039	0.0104	2.15×10^{-6}	0.0105	0.00024	0.00926	0.000193
Median	0.0126	0.00073	0.0106	-1.62×10^{-5}	0.0108	−0.00071	0.0097	9.06×10^{-5}	0.0094	0.00071	0.00877	0.000177
Std	0.00811	0.0143	0.00416	0.0048	0.134	0.136	0.00461	0.0069	0.0057	0.0107	0.000349	0.00496
Min	0.00217	−0.105	0.000	−0.0448	0.000	0.546	0.000	−0.0881	0.0000	−0.0832	0.000	−0.0409
Max	0.217	0.0758	0.0977	0.0275	0.646	−0.872	0.0578	0.0544	0.1703	0.0892	0.0343	0.0419
Skewness	8.827	−0.339	3.396	0.027	14.62	17.56	1.459	−0.998	8.336	−0.777	1.35	−0.825
Kurtosis	17.81	8.16	64.08	8.469	45.627	73.28	9.776	20.12	20.33	14.024	7.07	16.243
ADF	−17.5	−45.12	−12.56	−46.82	−22.69	−55.37	−15.86	−34.42	−34.44	−49.65	−13.87	−41.05
PP	−51.34	−45.23	−36.29	−47.15	−42.8	−51.43	−51.76	−48.97	−56.18	−50.44	−54.31	−41.67

Making use of Table 1, we can show some differences between stock markets. Standard deviations for CSAD variables and Rmt are more important for Lebanon compared to the other countries, and this can be explained by the large fluctuations and the difficult economic and financial situation in this country. On average, the CSAD variable is between 9.26×10^{-3} and 2.1×10^{-2}, while the average of the daily stock market return varies between -4.95×10^{-5} and 3.9×10^{-3}. All the series are stationary, and to show this, according to the ADF and Phillips–Perron (PP) tests, we accept the hypothesis of stationarity at a significance level of 1%. According to the skewness and kurtosis statistics, we can notice that the distributions of both the CSAD and Rmt variables are leptokurtic. Positive skew indicates that the tail on the right side of the distribution is longer than the left side and the bulk of the values lie to the left of the mean. The skewness statistics of the CSAD variables are greater than zero, indicating therefore the asymmetry of the CSAD distributions. Therefore, we can conclude that the property of normal distribution is violated in our analysis and the OLS regression method is not appropriate in our analysis. For this reason, we use the quantile regression method to analyze herding behavior in lower and upper tails only.

4.2. Empirical Results

As is proven in the previous section, the normality condition was rejected in all cases. For this reason, we will concentrate our interpretations in this section on the quantile regression results. The use of quantile regression allows us the possibility to consider the different possible curves of the independent variables against the lower and upper tails of the dependent variable.

For the explanation of the results, we will focus our attention on the sign and statistical significance of the estimated coefficients relative to the variables Rmt^2 and GPRt, respectively. Table 2 presents the results of Equation (4) for the six selected MENA countries. From the estimates of this table, we can notice that evidence of herding behavior is more evident at the lower quantile than the upper 95% quantile. Therefore, at the lower quantile, we accept the presence of herding in the Egyptian, Jordanian, Moroccan, Saudi, and Tunisian markets. In fact, for these markets, we obtain a negative and statistically significant estimated coefficient β_2. Even though herding behavior was concluded at the upper tail of the Moroccan stock market, the estimated coefficient β_2 is statistically negative and significant for Morocco only. β_2 for the Lebanon stock market is positive and statistically significant showing then an anti-herding behavior in this market. Due to the political, social, and economic problems in Lebanon in recent decades, investors' sentiment is low, and they do not have confidence in the information they receive.

At both the lower and upper tails, geopolitical risk increases the dispersion of stock returns for the Egyptian, Lebanese, and Saudi stock markets as the estimated coefficient β_3 is positive and statistically significant. Therefore, geopolitical risk movements reduce herding in these markets. When market returns are positive and high in the Jordanian and Tunisian stock markets, geopolitical risk movements increase herding as β_3 is negative and statistically significant. Thus, a higher geopolitical risk is related to an increase in the probability of economic crisis in the future, leading therefore to down-market conditions that increase herding in the Jordanian and Tunisian stock markets. In fact, due to the political, social, and economic instability experienced by these countries since the Arabian Jasmine revolution in 2011, investors have lost confidence in market indicators and performance, which therefore helps to increase the tendency to follow others in the market.

For a better understanding of the herding behavior in different moments of stock market fluctuations, and to distinguish between up-market and down-market periods, we propose a detailed analysis by decomposing the whole period into two sub-samples, the down- and up-market periods, to take into account the characteristics of asymmetries. This decomposition has largely been proven and discussed in the literature on herding bias.

Table 3 presents the results of the estimation of Equation (5) for the extreme lower and upper tails of the distribution by using quantile regression estimations.

Table 2. Full sample estimates of herding behavior in some MENA stock markets.

	Egypt		Jordan		Lebanon		Morocco		Saudi Arabia		Tunisia	
	τ = 5%	**τ = 95%**	**τ = 5%**	**τ = 95%**	**τ = 5%**	**τ = 95%**	**τ = 5%**	**τ = 95%**	**τ = 5%**	**τ = 95%**	**τ = 5%**	**τ = 95%**
Constant	0.0031 [a]	0.0155 [a]	0.0046 [a]	0.016 [a]	-6.12×10^{-5}	0.0045 [a]	0.0026 [a]	0.00124 [a]	0.0033 [a]	0.014 [a]	0.0032 [a]	0.013 [a]
|Rmt|	0.516 [a]	0.315 [a]	0.656 [a]	0.772 [a]	0.801 [a]	0.989 [a]	0.773 [a]	0.698 [a]	0.36 [a]	0.278 [c]	0.47 [a]	0.589 [a]
Rmt^2	−3.00 [a]	4.13 [b]	−3.9 [b]	−9.59	0.031 [a]	0.0015 [a]	−8.84 [b]	−3.02 [a]	−1.31 [a]	6.96	−0.029 [a]	−0.293
GPR	4.85×10^{-6} [b]	2.27×10^{-5} [a]	-5.58×10^{-6} [b]	-1.05×10^{-5} [a]	3.08×10^{-6} [a]	4.46×10^{-5} [a]	-9.5×10^{-7}	4.6×10^{-6} [b]	3.6×10^{-6}	1.3×10^{-6}	-6.8×10^{-6} [a]	-1.13×10^{-5} [a]
Pseudo R^2	0.272	0.258	0.15	0.191	0.797	0.904	0.229	0.286	0.194	0.251	0.163	0.204

For all tables, significance levels a, b, and c, respectively, represent 1%, 5%, and 10%.

Table 3. Bearish/bullish market period estimations.

	Egypt		Jordan		Lebanon		Morocco		Saudi Arabia		Tunisia	
	τ = 5%	**τ = 95%**	**τ = 5%**	**τ = 95%**	**τ = 5%**	**τ = 95%**	**τ = 5%**	**τ = 95%**	**τ = 5%**	**τ = 95%**	**τ = 5%**	**τ = 95%**
Constant	0.0033 [a]	0.016 [a]	0.0048 [a]	0.0157 [a]	-3.53×10^{-5}	0.0057 [a]	0.0026 [a]	0.00127 [a]	0.0035 [a]	0.011 [a]	0.003 [a]	0.0136 [a]
|Rmt Down|	0.486 [a]	0.27 [a]	0.634 [a]	0.72 [a]	0.791 [a]	0.877 [a]	0.722 [a]	0.647 [a]	0.355 [a]	0.429 [a]	0.506 [a]	0.555 [a]
|Rmt Up|	0.495 [a]	0.196 [b]	0.742 [a]	0.789 [a]	0.801 [a]	0.94 [a]	0.804 [a]	0.696 [b]	0.371 [a]	0.373 [a]	0.636 [a]	0.567 [b]
$Rmt\ Down^2$	−3.2 [a]	2.51 [a]	−4.82 [c]	−9.91 [a]	0.243 [a]	0.128 [a]	−7.38 [c]	−3.09 [a]	−0.981 [a]	0.586	−1.56 [b]	−5.71 [a]
$Rmt\ Up^2$	−1.32	9.51 [a]	−8.19 [a]	−10.4 [a]	0.031 [a]	0.009 [a]	−9.76 [a]	−2.672	−1.38 [a]	2.906 [b]	−4.01	18.06
GPR	4.4×10^{-6} [c]	4.28×10^{-5} [b]	-6.67×10^{-6} [a]	-1.16×10^{-5} [a]	3.02×10^{-6} [a]	3.93×10^{-5} [a]	1.36×10^{-7}	4.96×10^{-6}	2.55×10^{-6}	5.04×10^{-6}	-7.1×10^{-6} [a]	-1.35×10^{-5} [a]
Pseudo R^2	0.281	0.263	0.153	0.193	0.801	0.907	0.224	0.271	0.185	0.214	0.171	0.213

For all tables, significance levels a, b, and c, respectively, represent 1%, 5%, and 10%.

Looking at the results from Table 3, we can notice some discrepancies between countries. The results show that evidence of herding is detected more frequently in down-market periods than up-market periods in the Egyptian and Tunisian stock markets. Herding behavior is present during both down- and up-market conditions in the Moroccan and Saudi stock markets at the extreme lower 5% tail, and in the Jordanian stock market at both the lower 5% and the upper 95% tail. Lebanon represents a different market compared to the other markets in terms of herding for both lower and upper tails during down-/up-market conditions. On the other hand, the results indicate an anti-herding behavior followed by the investors of this country who understand the recent years of severe political, economic, financial, and social instability. The aggravated financial situation in this country has pushed the financial market into an uncertain period and an unpredictable future. Therefore, investors do not have confidence even in the other investors in the market and decide to not follow the crowd. Moreover, the high level of geopolitical risk contributes to the increase in the dispersion in the Lebanese stock market, which further reduces herding. The situation in the Egyptian stock market is almost like what is happening in Lebanon, except for the evidence of herding behavior observed during a bearish period at the low quantile level of 5%. Both countries have experienced problems of instability that have greatly affected their financial markets since 2011. In the same vein, Tunisia and Jordan are almost in the same situation as Lebanon and Egypt, but the herding behavior here is different from theirs. The results show evidence of herding behavior at both the upper and lower tails during bearish market conditions for the case of Jordan and Tunisia. Also, geopolitical risk is associated with a high probability of increased herding in the Jordanian and Tunisian stock markets, as geopolitical risk reduces the stock market return dispersion. Jordanian and Tunisian investors are too influenced by good and bad news in the world, affecting their behavior and encouraging them to follow the crowd.

On the other hand, geopolitical risk does not impact the Moroccan and the Saudi stock markets as the estimated coefficient γ_5 is not significant for both lower and upper tails. Geopolitical risks in these countries are not impactful on herding behavior. However, these countries were not affected by the 2011 Jasmine Revolution. For example, a country like Morocco took advantage of this revolution and succeeded in attracting investors from the countries affected during this period (Libya, for example). We conclude that there is evidence of herding behavior during both bearish and bullish market periods at a lower quantile of 5% for both countries. This result confirmed the fact that investors are sensitive to making decisions in the market during crisis periods and that this makes herding extremely easy to detect in most countries.

Overall, the general findings show that (i) there is an asymmetric herding reaction of investors during bearish and bullish market conditions. These findings are in line with those of Mobarek et al. (2014), Economou et al. (2016), Aharon (2021), and Ampofo et al. (2023). (ii) Investors tend to herd more in the down market than in the up market, implying that herding is more pronounced when market returns are negative. These results confirm the findings of Epstein and Schneider (2008), who find that investors take bad news more seriously than good news. Finally, (iii) there is a statistically significant impact of geopolitical risk during high-risk periods, especially for the countries most affected by the 2011 Jasmine Revolution.

5. Discussions and Conclusions

5.1. Discussions

In this paper, we examined how geopolitical risks can impact herding behavior in MENA stock markets. Compared to other previous studies, we can notice that our findings are in line with previous studies devoted to herding behavior analysis in different stock

markets regarding different time periods. First, our findings confirm the results found in previous works suggesting different results regarding herding behavior between lower and upper quantiles (Ullah & Elahi, 2015; Ansari, 2019; Choi & Yoon, 2020; Medhioub & Chaffai, 2021; Metawa et al., 2024). The hypothesis of a significant difference between lower and upper quantiles regarding herding behavior is confirmed.

Secondly, like uncertainty, economic policy uncertainty, or investor sentiment, geopolitical risks can intensify herding behavior in stock markets as investors base their decisions and actions on political events. Our findings confirm that herding behavior is more pronounced in countries suffering from political tensions and instability (Lebanon, for example). Therefore, we concluded that herding is more apparent with an increase in political instability. These results are in accordance with the research of Cakan et al. (2019) who highlighted a significant association between economic policy uncertainty and herding, where a higher EPU contributes to increased herding in global stock markets. Also, Coskun et al. (2020), Bouri et al. (2021), and Koutmos (2024) concluded that higher uncertainty is associated with increased herding, where uncertainty can create a volatile environment, making it difficult for investors to predict the impact of these factors on stocks. These findings confirm our hypothesis, suggesting the existence of a positive relationship between geopolitical risks and herding. In fact, following changes in legislation and laws, some ambiguity and inconsistency may occur, and market performance can be affected due to the high degree of risk and increase in uncertainty. Investors face difficulties in predicting the impact of these changes on their choices regarding selling and buying stocks in the market. For these reasons, among others sometimes, especially in extreme market conditions, they try to follow others in the market.

Finally, our empirical results confirm the hypothesis that states that there is significant evidence of asymmetry between downward and upward stock market conditions. These findings are in accordance with previous studies examining herding behavior. Indeed, this empirical study has confirmed, once again, that the property of asymmetry is one of the most impactful factors in examining herding behavior (see, for example, the studies of Chiang & Zheng, 2010; Galariotis et al., 2015; Islam, 2022; Jiang et al., 2022; Ahn et al., 2024). We concluded that there is evidence of stronger herding behavior during bearish, rather than bullish, market conditions. These findings provide a helpful tool for investors and policymakers on the behavior of the market towards the herding bias and its link to geopolitical risks in some MENA countries, especially after the Jasmin Revolution in 2011.

5.2. Conclusions

The objective of this research is to empirically examine herding behavior in six MENA stock markets (Egypt, Jordan, Lebanon, Morocco, Saudi Arabia, and Tunisia) under asymmetric market conditions and with the influence of geopolitical risks. Most of the studies suggested that herding behavior is one of the most important biases as investors try to follow the others in the market, especially during stressful periods such as financial crises, stock market crashes, the dot-com bubble, and the coronavirus stock market crash. These crashes have affected all sectors in all countries of the world. In another way, in the MENA region, bad/good news in the world and geopolitical strategy can play an important role in making decisions regarding MENA stock markets and investors can follow decisions made according to the available information, and they pay more attention to political news in the world. In addition, a second important factor affecting the investors' decisions is the economic and financial situation, where asymmetries and stress periods are impactful in terms of examining herding behavior. Furthermore, geopolitical risk can be significantly associated with the uncertainty factor in financial markets, which can therefore have a significant impact on the irrational herding behavior of investors. In this paper, we attempt to examine

the evidence of herding behavior in some MENA stock markets during the period 4 January 2011–31 December 2023, and to compare evidence for this bias in both bearish and bullish periods, and different states of geopolitical strategy risk. To the best of our knowledge, our work contributes to the existing empirical literature on the impact of geopolitical risk on herding behavior in MENA markets by using quantile regression analysis.

Our findings reveal a significant link between geopolitical risk and the dispersion of stock returns. Geopolitical risk reduces herding in the Egyptian and Lebanon markets while it increases herding in the Jordanian and Tunisian stock markets. These countries have experienced political, social, and economic difficulties and critical periods after the year 2011, which have affected the behavior of investors. Geopolitical risk has no effect on herding behavior in the case of the Moroccan and Saudi financial stock markets. The situation of these two countries is different from the other MENA countries considered in this study. The effect of geopolitical risks on herding behavior is more pronounced in countries highly impacted by the Arab Jasmin Revolution, to which investors in countries with high levels of uncertainty reacted differently to those with low levels of uncertainty.

The second important result are the differences existing between up/down periods, regarding which the evidence of herding behavior in MENA stock markets can be signaled more during periods of financial instability, high tensions, and high political risk. Based on quantile regressions for a better analysis of stock returns, characterized by non-normality, the results of extreme quantiles indicate there is evidence of herding behavior at the lower 5% quantile during bearish market conditions for all markets, except Lebanon, which has been experiencing very difficult times, especially in recent years. Herding behavior is also detected at the upper 95% tail during down periods in the Jordanian, Moroccan, and Tunisian stock markets. The results for these three markets are almost the same, the level of confidence of their investors is similar, and they share the same beliefs in extreme market fluctuations.

Despite this paper providing valuable insights into the domain of behavioral finance, it suffers from some limitations, which can improved upon in future research. One limitation is the generalization of the results and the implications for all sectors. Indeed, herding behavior can manifest differently in different periods and sectors and can also be affected by other factors such as volatility, volume trading, and social media. For example, during the 2008 financial crisis and the dot-com bubble, and because of significant market disruptions, evidence of herding behavior among investors was detected in the financial sector. Meanwhile, the oil price crash during the years 2014–2016 led to herding behavior among oil producers because of an overinvestment in energy production. Therefore, different political actions can have different impacts on different sectors from one period to another. Furthermore, the focus on the impact of geopolitical risks on herding behavior in the aggregated stock market can limit the pertinence of the results, and future research on herding behavior in sectoral analysis can be more important, and findings will certainly be more pertinent for policymakers and investors. In addition, in this paper, we have focused on analyzing the impact of geopolitical risks on herding behavior by neglecting the effects of other factors that can be important, such as volatility. However, we acknowledge that these variables can be significant and can represent valuable extensions for future research aiming to emphasize the impact of energy, geopolitical risk uncertainties, and other important factors such as inflation and exchange rates on herding bias in the financial markets.

A second important feature that can be a good field of future research is the association of cognitive bias anchoring with herding behavior and geopolitical risks. This bias, which occurs when investors base their decisions on their initial information (called the anchor), can significantly influence investor behavior during periods of geopolitical instability. Anchoring can intensify herding behavior as investors may anchor their decisions according

to initial reactions to geopolitical events, conflicts, cyberattacks, or terrorist threats, for example, leading therefore to a crowd movement in the market. Understanding these links between herding, anchoring, and geopolitical risks can provide deeper insights into the dynamics of stock markets and investor behavior during high-tension periods. Future research on the interconnectedness between these three concepts can be relevant and can help investors and policymakers to moderate risks and make optimal decisions.

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