Scientific Annals of Economics and Business

Alexandru Ioan Cuza University of Iasi

Volume 71 (LXXI), Issue 3, 2024

Editura Universității „Alexandru Ioan Cuza” din Iași
2024

Scientific Annals of Economics and Business (continues *Analele ştiinţifice ale Universităţii „Al.I. Cuza" din Iaşi. Ştiinţe economice / Scientific Annals of the Alexandru Ioan Cuza University of Iasi. Economic Sciences*)
Founded in 1954
ISSN–L 2501-1960; ISSN (Print) 2501-1960; ISSN (Online) 2501-3165
Publisher: Editura Universităţii „Alexandru Ioan Cuza" din Iaşi (http://www.editura.uaic.ro/)
Frequency: Four issues a year (March, June, September and December)

Indexed and Abstracted:
Clarivate Analytics Web of Science – Emerging Sources Citation Index, Scopus, EBSCO, EconLit (The American Economic Association's electronic bibliography), Directory of Open Access Journals (DOAJ), Research Papers in Economics (RePEc), ERIH PLUS, Central and Eastern European Online Library (CEEOL), Cabell's Directories, Scirus, IndexCopernicus, Online Catalogue of the ZBW - German National Library of Economics (ECONIS), Electronic Journals Library, The Knowledge Base Social Sciences in Eastern Europe, Scientific Commons, The ZDB, Intute: Social Science (SOSIG - Social Science Information Gateway), New Jour, GESIS SocioGuide, Genamics Journalseek, Catalogo Italiano dei Periodici (ACNP), Google Scholar, ResearchGate.

Journal metrics:
Clarivate Analytics - Journal Citation Reports 2023: Impact Factor: 0.9 (JIF quartile: Q3); 5 Year Impact Factor 0.8; JCI: 0.27; AIS: 0.105
Scopus: Quartile Q3; CiteScore 2023: 1.4; Scimago Journal Rank (SJR) 2023: 0.203; SNIP 2023: 0.542; CiteScore Tracker 2024: 1.6

Archiving:
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71 (3), 2024, 315-336
DOI: 10.47743/saeb-2024-0022

Cash Flow Dynamics: Amplifying Swing Models in a Volatile Economic Climate for Financial Resilience and Outcomes

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Abstract: In a volatile economic climate, understanding cash flow dynamics is crucial for companies to improve financial resilience and outcomes. This research focuses on amplifying swing models such as Cash Flow Management (CFM), Solutions (CFS), Dynamics (CFD), Boosters (CFB), Innovations (CFI), and Strategic (CFS) - on cash flow dynamics in a volatile economic climate. By examining the relationship between these models and determinant variables, the study aims to provide insights that can assist companies in achieving financial resilience and outcomes. The data were collected from finance and accounting representatives of 200 companies ((manufacturing (107), services (56), and trade (37)) in Kosovo in 2023 (quarters 1, 2, 3, and the first two months of quarter 4), while processing was done through exploratory factorial, reliability, and multiple regression analyses conducted using SPSS and AMOS software. The results of the study reveal a significant relationship between each cash flow model and the determinant variables. This highlights the importance of these models in comprehending cash flow dynamics within a volatile economic climate. Factors such as optimization strategy clarity, continuous monitoring, effective working capital management, accurate financial decision-making, and technological improvements contribute to positive cash flow. Additionally, precise management of fluctuations, financial advantage, cooperative departmental approaches, and effective communication also play a role in cash flow dynamics. By extending swings models, the study provides valuable insights that can assist firms in achieving financial resilience and overcoming the challenges of a volatile economic environment.

Keywords: cash flow dynamics; volatile economic climate; financial resilience; outcomes; amplifying swings models.

JEL classification: E3; F47; F65; G3.

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Article history: Received 7 June 2024 | Accepted 22 September 2024 | Published online 23 September 2024

To cite this article: Lulaj, E., Minguez-Vera, A. (2024). Cash Flow Dynamics: Amplifying Swing Models in a Volatile Economic Climate for Financial Resilience and Outcomes. *Scientific Annals of Economics and Business*, 71(3), 315-336. https://doi.org/10.47743/saeb-2024-0022.

1. INTRODUCTION

In today's dynamic global economy, businesses must adeptly navigate volatile economic climates to ensure their survival and success. Raza and Khan (2024) and Ren *et al.* (2023) underscore the critical importance of this adaptability. Moreover, according to Gregory (1976), while the existing literature on cash flow has provided valuable insights, the application of swing models in the context of a volatile economic climate remains relatively underexplored. Liu *et al.* (2023) emphasized that the current economic climate is characterized by unprecedented levels of uncertainty, volatility, and unforeseen challenges. Furthermore, in the realm of cash flow management, Magerakis *et al.* (2023) highlight its crucial role in financial resilience and outcomes for companies, while Ma *et al.* (2023) further explore this topic by examining the intricacies of cash flow dynamics, particularly through the amplification of swing models.

Naseer *et al.* (2023) emphasize that businesses must proactively develop robust strategies to not only survive but also thrive amid adversity. In this context, El Ghoul *et al.* (2023) highlight that cash flow becomes even more crucial, as it is the vital force of any organization. Moreover, Fawzi *et al.* (2015) emphasized that understanding, predicting, and strategically managing cash flow dynamics is essential to sustaining operations and achieving financial success. This research advances conventional cash flow models by integrating cutting-edge innovations such as Cash Flow Management (CFM) as investigated by Galka and Wappler (2023), Cash Flow Solutions (CFS) and Cash Flow Dynamics (CFD) as explored by Ghiami (2023), in addition to Cash Flow Boosters (CFB) as examined by Alves *et al.* (2022). Furthermore, it also incorporates Cash Flow Innovations (CFI) as researched by Zhang and Zhou (2022), and Cash Flow Strategic (CFS) as investigated by Chen *et al.* (2023).

Therefore, this study aims to illuminate the intricacies of financial resilience and outcomes for companies confronting the challenges of economic volatility. To achieve this, a comprehensive analysis of CFM, CFS, CFD, CFB, CFI, and CFS models will be conducted to derive meaningful conclusions regarding their effectiveness in volatile economic climates. Furthermore, this research endeavors to identify statistically significant relationships between each model and key determinant variables, thus providing a sophisticated understanding of cash flow dynamics.

The novelty of this article lies in its comprehensive evaluation of six models: Cash Flow Management (CFM), Solutions (CFS), Dynamics (CFD), Boosters (CFB), Innovations (CFI), and Strategic (CFS). Unlike previous literature, this study not only investigates the impact of these models on cash flow dynamics but also uncovers significant relationships between each model and determinant variables. The primary objective is to provide valuable insights to assist companies in achieving financial resilience amidst economic volatility. Additionally, the research fills a critical gap by highlighting the importance of accurately managing fluctuations, leveraging financial assets, adopting collaborative departmental approaches, and fostering effective communication to influence cash flow dynamics. By shedding light on these issues, this study contributes to a deeper understanding of cash flow management in volatile economic climates and provides practical guidance for companies seeking to navigate and thrive in such challenging environments.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

In today's dynamic and economically volatile environment, effective cash flow management has emerged as a pivotal factor for business survival and prosperity. The literature underscores the criticality of various cash flow models, notably Cash Flow Management (CFM), Cash Flow Solutions (CFS), Cash Flow Dynamics (CFD), Cash Flow Boosters (CFB), Cash Flow Innovations (CFI), and Cash Flow Strategic (CFS). These models have been widely acknowledged by scholars for their role in fostering financial resilience and achieving desired outcomes amidst economic volatility. Therefore, Righetto *et al.* (2016) emphasized that cash flow management is crucial for overcoming economic challenges. Moreover, Eskandari and Zamanian (2022) emphasized the importance of understanding, predicting, and strategically managing cash flow dynamics to achieve financial success. Furthermore, Lee *et al.* (2010) pointed out that the exploration of amplification of swing models within the framework of a volatile economic climate is an area that has received limited attention, indicating the need for new research to explore these models.

2.1 Cash Flow Management model

Concerning the Cash Flow Management (CFM) model and its pivotal factors such as the availability of cash flow information, effective management practices, accurate forecasting, the influence of sales volume, fostering departmental alignment with cash flow objectives, and comprehension of both short-term policies and long-term cash flow strategies. Drawing from these CFM model factors, Yi (2023) underscores that enhancing the level of information provision significantly mitigates cash flow sensitivity. Furthermore, Coulton *et al.* (2022) posit that bolstering the quality of financial reporting subsequent to cash flow forecasting directly impacts financial resilience and outcomes, especially within a volatile economic climate. According to Li *et al.* (2023), the significance of cash flow in sustaining a company's financial health and stability cannot be overstated. Stokes (2005) highlights the development of a dynamic model linking sales conditions and cash flow to enhance financial resilience. Furthermore, Arnold (2014) emphasizes that cash flow is influenced by firm-specific characteristics and industry conditions, which can amplify fluctuations in a volatile economic climate.

Drawing on the synthesized insights from the literature review, it is crucial to formulate the hypothesis for the Cash Flow Management (CFM) model, aiming to both validate and extend the findings of this study.

H1: Cash Flow Management model has a positive and statistically significant effect on Cash Flow in a volatile economic climate to achieve financial resilience and outcomes for businesses.

2.2 Cash Flow Solutions model

The Cash Flow Solutions (CFS) model encompasses several critical factors: a clear cash flow optimization strategy, ongoing cash flow monitoring to identify potential risks, effective working capital management, appropriate plans to address cash flow challenges, strategic financial decisions to optimize cash flow, and the integration of improved technology to enhance processes. Based on these factors, Leyman *et al.* (2019) emphasize the essential need

to enhance cash flow management strategies, particularly in the face of economic volatility, by employing amplifying swing models. So and Zhang (2022) highlight the importance of considering cultural heterogeneity in global operations for companies aiming to optimize cash flow. Barrett and Chaitanya (2023) argue that cash flow is crucial in determining the price of financial assets, thereby contributing to financial resilience and overall performance. Additionally, Maghsoudi *et al.* (2023) contend that digitizing cash flows can enhance speed, scalability, and financial transparency, especially for companies navigating a volatile economic climate.

Based on the synthesized insights derived from the literature review, it is essential to craft a hypothesis for the Cash Flow Solutions model, with the aim of validating and broadening the scope of the findings in this study.

H2: Cash Flow Solutions model has a positive and statistically significant effect on Cash Flow in a volatile economic climate to achieve financial resilience and outcomes for businesses.

2.3 Cash Flow Dynamics model

About Cash Flow Dynamics (CFD) model and its influencing factors: accurately managing cash flow fluctuations, recognizing positive cash flow contributions, rewarding contributing employees, promoting interdepartmental cooperation, implementing rigorous risk identification and mitigation processes, adopting cash flow management practices that enhance overall financial results, ensuring sufficient resources, and facilitating effective communication of goals and cash flow performance. According to Shehata (1976), the information generated from these factors is crucial for timely cash flow actions, helping to identify excess cash deficits and establish budgets based on various cash control policies. Yaari *et al.* (2016) recommend regularly reviewing cash flow to prevent distortions in CFD. Javadi *et al.* (2021) demonstrate that reducing cash flow retention can be mitigated by shareholders' ability in a volatile economic climate. Additionally, cash flow supports managerial decisions, as noted by Mioduchowska-Jaroszewicza (2022). Gupta and Krishnamurti (2023) suggest that firms fostering an employee-friendly environment with fair compensation, effective communication, and interdepartmental cooperation tend to achieve high cash flow, positively influencing financial resilience and outcomes.

Relying on the integrated insights synthesized from the literature review, it is crucial to formulate a hypothesis for the Cash Flow Dynamics model.

H3: Cash Flow Dynamics model has a positive and statistically significant effect on Cash Flow in a volatile economic climate to achieve financial resilience and outcomes for businesses.

2.4 Cash Flow Boosters model

In relation to the Cash Flow Boosters (CFB) model and its influencing factors, such as implementing measures to accelerate cash flow, ensuring effective communication about cash flow within the company, and providing adequate training to employees in cash flow management, Mullins (2020) suggests that companies aiming to improve their cash flow should address four key questions. These questions include understanding the sources and uses of cash, monitoring changes in profit margins, managing cash flow relationships with

customers and suppliers, and identifying strategies to improve financial resilience and positive outcomes. In contrast, Bloch (2017) highlights the need to reduce employee training budgets. Furthermore, Drissi *et al.* (2023) highlight that instability in the cash flow conversion cycle increases working capital requirements and limits self-financing capacity, particularly in a volatile economic climate.

Based on the integrated insights derived from the literature review, formulating a hypothesis for the Cash Flow Boosters model is essential.

H4: Cash Flow Boosters model has a positive and statistically significant effect on Cash Flow in a volatile economic climate to achieve financial resilience and outcomes for businesses.

2.5 Cash Flow Innovations model

The Cash Flow Innovations (CFI) model encompasses several critical factors: establishing clear procedures for managing accounts receivable, actively seeking opportunities to improve cash flow efficiency, optimizing invoicing and payment processes, and ensuring accurate cash flow reporting. Markus and Rideg (2021) assert a significant positive correlation between innovation efforts, as indicated by the CFI model, and competitiveness. This suggests that stronger cash flows correlate with improved competitive performance. Similarly, Francis *et al.* (2022) argue that the managerial approach to CFI influences firms' capability, capacity, and innovative efficiency, particularly in volatile economic conditions. Carter and Diro Ejara (2008) advise companies to maintain a focus on discounted cash flow and consider various internal and market factors that reflect their capabilities and capacity. Additionally, Adu-Ameyaw *et al.* (2022) emphasize that private firms tend to increase research and development spending relative to their cash flow, leverage, and industry information quality, highlighting the importance of financial resilience and outcomes over public counterparts.

Based on the integrated insights from the literature review, it is essential to formulate a hypothesis for the Cash Flow Innovations model.

H5: Cash Flow Innovations model has a positive and statistically significant effect on Cash Flow in a volatile economic climate to achieve financial resilience and outcomes for businesses.

2.6 Cash Flow Strategic model

In relation to the Cash Flow Strategic (CFS) model and its factors, Onjewu *et al.* (2023) underline the importance of negotiating favorable payment terms, addressing investment needs, and implementing cash flow strategies aligned with best practices. They assert that a substantial correlation exists between strategic planning and sales performance, attributing this to the direct impact of sales performance on cash flow. Moreover, they argue that this correlation is significantly enhanced by digitalization and e-commerce innovations, particularly in volatile economic conditions.

Formulating a hypothesis for the Cash Flow Innovations model is imperative, given the synthesized insights from the literature review.

H6: Cash Flow Strategic model has a positive and statistically significant effect on Cash Flow in a volatile economic climate to achieve financial resilience and outcomes for businesses.

Before presenting Figure no. 1, the text will include a brief introduction outlining the relationships between the hypotheses depicted in the figure. This introduction will provide context for the visual presentation of the constructed hypotheses and their interrelationships as elaborated in the literature review.

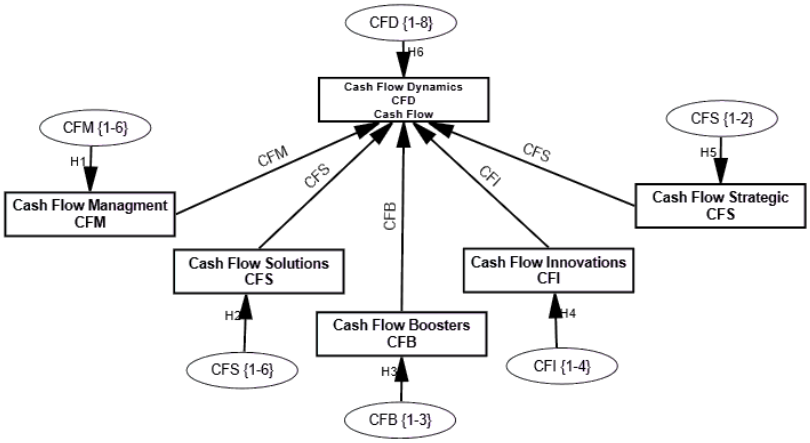

Figure no. 1 – Conceptual Model
Source: own elaboration (2023/24)

Figure no. 1 shows the conceptual model that highlights the relationships between the models such as: Cash Flow Management (CFM), Cash Flow Solutions (CFS), Cash Flow Dynamics (CFD), Cash Flow Boosters (CFB), Cash Flow Innovations (CFI), and Cash Flow Strategic (SFS) and their factors in the context of cash flow dynamics in a volatile economic climate to achieve financial resilience and outcomes for businesses. The effects of (CF←CFM, CF←CFS, CF←CFB, CF←CFD, CF←CFI, and CFD←CFS) are emphasized to verify the main hypotheses (H_1-H_6). Each factor follows a regression format, where $\hat{y}$ represents cash flow dynamics, α is the intercept term. Moreover, for the models include the corresponding factors with β coefficients indicating the strength and direction of their effects. A statistically significant relationship is indicated when these coefficients are significantly different from zero. Then, the error term μ accounts for unobservable factors that affect cash flow dynamics in a volatile economic climate to achieve financial resilience and outcomes for businesses. In general, this conceptual model aims to clarify the relationships between (CFM, CFS, CFD, CFB, CFI, and CFS) in the context of cash flow dynamics in a volatile economic climate to achieve financial resilience and outcomes for businesses.

3. METHODOLOGY

The research aims to explore the dynamics of cash flow in a volatile economic climate through amplifying swing models to assist companies in achieving financial resilience and

outcomes. Therefore, the research examines how the determinant variables effect each model to observe the dynamics of cash flow through amplifying swing models in a volatile economic climate. It also determines if there is a statistically significant relationship between each model and at least one factor (determinant variable). Overall, the research provides valuable insights and tools that businesses can utilize to improve their financial resilience, decision-making, risk management, and ultimately, achieve better financial outcomes.

3.1 Data collection

The data were collected from finance and accounting representatives of 200 companies in Kosovo in 2023 (quarters 1, 2, 3, and the first two months of quarter 4). These companies were categorized as manufacturing (107), services (56), and trade (37). The companies were selected to represent a diverse cross-section of the economy, including both listed companies and small and medium-sized enterprises (SMEs), in order to provide a comprehensive understanding of cash flow dynamics across different sectors. Data collection methods included an online questionnaire completed by 105 representatives and in-depth interviews conducted with 95 representatives. The online questionnaire was designed to collect quantitative data on various factors affecting cash flow using Likert scales (1=strongly disagree, 5=strongly agree). The in-depth interviews were designed to gather qualitative insights on the same topic, allowing participants to elaborate on their experiences and perspectives regarding cash flow dynamics. Their responses highlighted the significance of cash flow models and their factors (CFM1-6, CFS1-6, CFD1-8, CFB1-3, CFI1-4, and CFS1-3) in amplifying swing models in a volatile economic climate for financial resilience and outcomes. Table no. 1 provides a detailed summary of each variable, highlighting the importance of the six swing models in this research.

Table no. 1 – Definition and description of the study variables

Variable	Construct	Source
	Model 1: Cash Flow Management (CFM)	
CFM1	Current information about the company's cash flow is available	Lulaj and Iseni (2018)
CFM2	The company effectively manages and forecasts cash flow	Jermias *et al.* (2023)
CFM3	Cash flow forecasts are reliable and accurate	Jooste (2006)
CFM4	Sales volume affects the company's cash flow	Umit and Dagdemir (2023).
CFM5	Departments are encouraged to focus on cash flow goals	Andohol *et al.* (2024)
CFM6	Cash flow management policies, both short and long term, are known	
	Model 2: Cash Flow Solutions (CFS)	
CFS1	The company has a clear cash flow optimization strategy	Astami *et al.* (2017)
CFS2	Cash flow is constantly monitored to identify potential risks	Lulaj *et al.* (2023)
CFS3	The company manages working capital effectively	Steyn and Hamman (2003)
CFS4	The company has adequate contingency plans to address cash flow challenges.	Bejan *et al.* (2023)
CFS5	The company makes financial decisions with a focus on cash flow optimization.	
CFS6	The company uses technology to improve cash flow processes	
	Model 3: Cash Flow Dynamics (CFD)	
CFD1	The company has accurate management of cash flow	Rompotis (2024)
CFD2	fluctuations	Lulaj (2021), Lulaj

Variable	Construct	Source
CFD3	The company has priority for positive cash flow in financial decisions	(2023) Haskins *et al.* (1987) Yeboah (2023).
CFD4	The company recognizes and rewards employees who contribute to positive cash flow	
CFD5	The company has a collaborative approach to cash flow management across departments	
CFD6	The company has a rigorous process for identifying and addressing potential cash flow risks	
CFD7	The company has cash flow management practices that contribute positively to overall financial health	
CFD8	The company has provided sufficient resources for departments to align with cash flow goals	
	The company has effective communication of cash flow goals and performance	
	Model 4 ***Cash Flow Boosters (CFB)***	
CFB1	The company implements effective measures to accelerate the cash flow	Rusmin *et al.* (2014)
CFB2	The company has satisfactory cash flow communication within the organization	
CFB3	The company provides adequate cash flow management training to employees	
	Model 5 ***Cash Flow Innovations (CFI)***	
CFI1	The company has established clear procedures for managing accounts receivable	Lulaj *et al.* (2024a) Mohammadi *et al.* (2018) Rejón López *et al.* (2023)
CFI2	The company actively seeks opportunities to improve cash flow efficiency	
CFI3	The company's billing and payment processes contribute positively to cash flow	
CFI4	The company has accurate cash flow reporting	
	Model 6 ***Cash Flow Strategic (CFS)***	
CFS1	The company actively pursues opportunities to negotiate favorable payment terms	Lulaj *et al.* (2024b) Cheatham and Cheatham (1993),
CFS2	The company effectively balances investment needs with cash flow considerations	
CFS3	The company's cash flow strategies are consistent with industry best practices	

Source: prepared by the authors (2023/24)

Table no. 1 shows the factors for the six swing models of this research: Cash Flow Management (CFM), Solutions (CFS), Dynamics (CFD), Boosters (CFB), Innovations (CFI), and Strategy (CFS). The CFM model includes six factors (CFM1-6), CFS model includes six factors (CFS1-6), CFD model includes eight factors (CFD1-8), CFB model includes three factors (CFB1-3), CFI model includes three factors (CFI1-3), and CFS model includes three factors (CFS1-3).

3.2 Data analysis

The study thoroughly analyzed the data to assess how each model (1-6) effects cash flow dynamics. Advanced techniques such as exploratory factorial analysis (EFA), reliability analysis (Cronbach's alpha), multiple regression analysis (PCA), and regression weights were used. Specialized software, such as SPSS (64) and AMOS (23.0), facilitated the analysis. Furthermore, Spearman (1927) emphasized that key tests were conducted to evaluate the significance of the models and factors, as well as to validate the proposed hypotheses.

The multiple regression equation for the effects of the factors in their models:

$$\hat{y}\imath = \alpha_0 + \beta_1(xi) + \beta_2(x2) + \beta_3(x3) + \beta_4(x4) + \beta_5(x5) + \beta_6(x6) + \mu \neq 0$$

where, for $i = n$, observations,
$\hat{y}\imath$ = dependent variable (CFM,CFS,CFD,CFB,CFI,and CFS,
xi = explanatory (independent)variables
$\beta 0$ = y-intercept (constant term)
βp = slope coefficients for each explanatory variable
ϵ = the model's error term (also known as the residuals)for each model of this stud

Thus, to discern the impact of each factor within its model, the equations for each model and factor are elaborated below.

$$\text{H1: } \widehat{CFM} = \alpha_0 + \beta_1(CFM1) + \beta_2(CFM2) + \beta_3(CFM3) + \beta_4(CFM4) + \beta_5(CFM5) + \beta_6(CFM6) + \mu \neq 0$$

$$\text{H2: } \widehat{CFS} = \alpha_0 + \beta_1(CFS1) + \beta_2(CFS2) + \beta_3(CFS3) + \beta_4(CFS4) + \beta_5(CFS5) + \beta_6(CFS6) + \mu \neq 0$$

$$\text{H3: } \widehat{CFD} = \alpha_0 + \beta_1(CFD1) + \beta_2(CFD2) + \beta_3(CFD3) + \beta_4(CFD4) + \beta_5(CFD5) + \beta_6(CFD6) + +\beta_7(CFD7) + \beta_8(CFD8) + \mu \neq 0$$

$$\text{H4: } \widehat{CFB} = \alpha_0 + \beta_1(CFB1) + \beta_2(CFB2) + \beta_3(CFB3) + \mu \neq 0$$

$$\text{H5: } \widehat{CFI} = \alpha_0 + \beta_1(CFI1) + \beta_2(CFI2) + \beta_3(CFI3) + \beta_4(CFI4) + \mu \neq 0$$

$$\text{H6: } \widehat{CFS} = \alpha_0 + \beta_1(CFS1) + \beta_2(CFS2) + \beta_3(CFS3) + \mu \neq 0$$

Figure no. 2 presents the econometric framework for the swing models (CFM, CFS, CFD, CFB, CFI, and CFS) and their effect on each factor in the context of cash flow dynamics in a volatile economic climate to achieve financial resilience and outcomes for businesses. The research comprised four steps: in the first step (H1), exploratory factorial analysis (EFA) and its tests were used to analyze the data. In the second step (H2), reliability analysis and its tests were conducted. In the third step (H3), multiple regression analysis and its tests were employed to see the effect of each factor in each model, and in the fourth step (H4), regression weights and its tests were utilized to verify the hypotheses (H1-H6). These steps were undertaken to delve into cash flow dynamics.

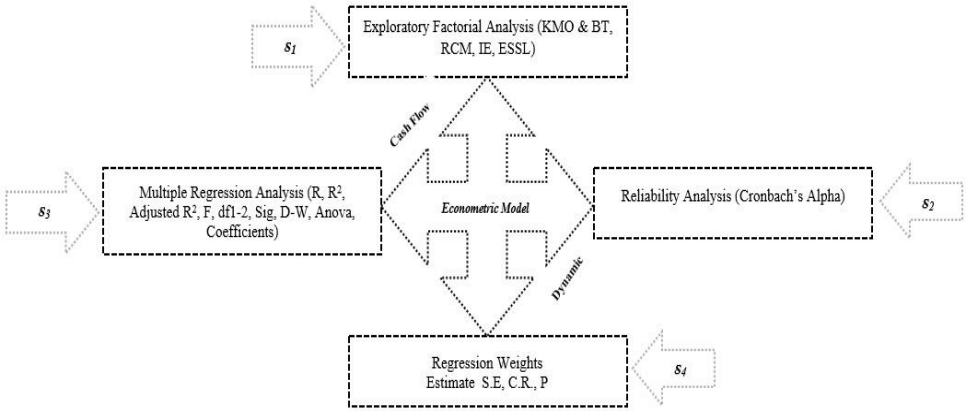

Figure no. 2 – Econometric Framework
Source: own elaboration (2023/24)

4. RESULTS

As described in the literature review and methodology outlined in the results section, the data were analyzed using tailored analyses for each cash flow dynamics model (CFM, CFS, CFD, CFB, CFI, and CFS).

Table no. 2 – Exploratory factorial analysis (EFA) reliability analysis (Cronbach's Alpha)

Item	Construct	Factor Loading λ	KMO and Bartlett's Test	Variance Explained (VE) Cronbach's Alpha	Interpretation
Model 1 Cash Flow Management (CFM)					
CFM1	Current information about the company's cash flow is available	0.824			
CFM2	The company effectively manages and forecasts cash flow	0.743	KMO=0.850 χ^2= 398.426 df=15 Sig.=0.000	54.2% α=0.829	(Kaiser, 1970) (Cronbach, 1951) Valid results
CFM3	Cash flow forecasts are reliable and accurate	0.643			
CFM4	Sales volume affects the company's cash flow	0.777			
CFM5	Departments are encouraged to focus on cash flow goals	0.671			
CFM6	Cash flow management policies, both short and long term, are known	0.744			
Model 2 Cash Flow Solutions (CFS)					
CFS1	The company has a clear cash flow optimization strategy	0.819			
CFS2	Cash flow is constantly monitored to identify potential risks	0.767	KMO=0.883 χ^2= 446.729 df=15 Sig.=0.000	58.2% α =0.856	Valid results
CFS3	The company manages working capital effectively	0.765			
CFS4	The company has adequate contingency plans to address cash flow challenges.	0.738			
CFS5	The company makes financial decisions with a focus on cash flow optimization.	0.760			

CFS6	The company uses technology to improve cash flow processes	0.725			
	Model 3 Cash Flow Dynamics (CFD)				
CFD1	The company has accurate management of cash flow fluctuations	0.608			
CFD2	The company has priority for positive cash flow in financial decisions	0.710			
CFD3	The company recognizes and rewards employees who contribute to positive cash flow	0.638	KMO=0.903		
CFD4	The company has a collaborative approach to cash flow management across departments	0.761	χ^2= 541.677 df=28	50.4% α = 0.858	Valid results
CFD5	The company has a rigorous process for identifying and addressing potential cash flow risks	0.751	Sig.=0.000		
CFD6	The company has cash flow management practices that contribute positively to overall financial health	0.699			
CFD7	The company has provided sufficient resources for departments to align with cash flow goals	0.700			
CFD8	The company has effective communication of cash flow goals and performance	0.793			
	Model 4 Cash Flow Boosters (CFB)				
CFB1	The company implements effective measures to accelerate the cash flow	0.763			
CFB2	The company has satisfactory cash flow communication within the organization	0.806	KMO=0.662 χ^2= 93.729 df=3	61.1% α = 0.681	Valid results
CFB3	The company provides adequate cash flow management training to employees	0.775	Sig.=0.000		
	Model 5 Cash Flow Innovations (CFI)				
CFI1	The company has established clear procedures for managing accounts receivable	0.780			
CFI2	The company actively seeks opportunities to improve cash flow efficiency	0.805	KMO=0.780 χ^2= 221.197 df=6	61.4% α = 0.790	Valid results
CFI3	The company's billing and payment processes contribute positively to cash flow	0.745	Sig.=0.000		
CFI4	The company has accurate cash flow reporting	0.803			
	Model 6 Cash Flow Strategic (CFS)				
CFS1	The company actively pursues opportunities to negotiate favorable payment terms	0.823			
CFS2	The company effectively balances investment needs with cash flow considerations	0.857	KMO=0.702 χ^2= 171.521 df=3	70.1% α =0.787	Valid results
CFS3	The company's cash flow strategies are consistent with industry best practices	0.832	Sig.=0.000		

Note: KMO=Kaiser-Meyer-Olkin, χ^2=Chi-Square, df =degrees of freedom, ***p<.001, α=Cronbach's Alpha.
Source: table prepared by the authors (2023/24).

Table no. 2 presents the Component Matrix-PCA by (EFA), which highlights the importance of the models such as Cash Flow Management (CFM), Cash Flow Solutions (CFS), Cash Flow Dynamics (CFD), Cash Flow Boosters (CFB), Cash Flow Innovations (CFI), and Cash Flow Strategic (CFS) models in the context of cash flow dynamics in a volatile economic climate to achieve financial resilience and outcomes for businesses. All factors in each model have values greater than 0.50, indicating their importance. The KMO test (Kaiser and Rice, 1974) confirms the reliable fit of the data to the models (CFM,

KMO=0.850; CFS, KMO=0.883; CFD, KMO=0.903; CFB, KMO=0.662; CFI, KMO=0.780; CFS, KMO=0.702), and Bartlett's Sphericity test shows the significant and meaningful correlation between the factors (Sig.=0.000). Also, the reliability analysis (Cronbach's Alpha) shows a high degree of reliability in the data of all models (CFM, CFS, CFD, CFB, CFI and CFS, $0.80 \leq \alpha \leq 0.83$, 0.86, 0.86, 0.68, 0.79, 0.79), while the Eigenvalues (VE) emphasize the importance of the variance, which has a value above 50% in each model (1-6).

Table no. 3 – Model Summary

Model Summary[b]											
Model	R	R^2	Adjusted R^2	S.E	Change Statistics-ANOVA					Durbin - Watson	Interpretation Model 1-6
					R^2 Change	F Change	df1	df 2	Sig. F Change		
CFM	0.988[a]	0.977	0.976	0.09690	0.977	1350.407	6	193	0.000	2.021	
CFS	0.967[a]	0.936	0.934	0.15696	0.936	468.251	6	193	0.000	1.924	Statistically
CFD	0.980[a]	0.960	0.958	0.12273	0.960	571.542	8	191	0.000	1.843	significant for all
CFB	0.938[a]	0.879	0.877	0.20913	0.879	475.999	3	196	0.000	1.763	models
CFI	0.942[a]	0.888	0.885	0.19652	0.888	385.065	4	195	0.000	1.910	($p < 0.05$)
CFS	0.935[a]	0.874	0.872	0.23309	0.874	453.792	3	196	0.000	1.585	F (Sig.=0.000)

Note: [b]Dependent variables: CFM, CFS, CFD, CFB, CFI, and CFS, S.E.- Std. Error of the Estimate, [a] Predictors: (Constant): (CFM1-6, CFS1-6, CFD1-8, CFB1-3, CFI1-4, and CFS1-3), *p<0.005.

Source: table prepared by the authors (2023/24)

Table no. 3 presents the model summary for all models (CFM, CFS, CFD, CFB, CFI, and CFS) and their factors (CFF1-6, CFS1-6, CFD1-8, CFB1-3, CFI1-4, and CFS1) -3) at the 0.05 level of significance in the context of cash flow dynamics in a volatile economic climate to achieve financial resilience and outcomes for businesses. According to R, for all models it is emphasized that there are positive and significant relationships between the models and their factors (predictors): CFM with (CFM1-6) of 99%, CFS with (CFS1-6) of 97%, CFD with (CFD1-8) of 98%, CFB with (CFB1-3) of 94%, CFI (1-4) of 94%, and CFS (1-3) of 94%. According to the R^2 for model 1 (.977), it is emphasized that 98% of the predictors influence CFM, while 2% is explained by variables outside the model. For model 2 (0.936) it is emphasized that 94% of the predictors influence CFS, while 6% is explained by variables outside the model. For model 3 (0.960), it is emphasized that 96% of the predictors influence CFD, while 4% is explained by variables outside the model. For models 4 and 5 (0.879, 0.888), 88% and 89% of the predictors influence CFB and CFI, while 12% and 11% are explained by variables outside the model. For model 6 (0.874) it is emphasized that 87% of the predictors influence CFS, while 13% are explained by variables outside the model, also the results of ANOVA (R2 change, S.E., F-test value and Sig.) confirm the appropriateness of the models and the statistical significance of the results. According to the Durbin-Watson test for all models 1-6 (2.021, 1.924, 1.843, 1.763, 1.910 and 1.585), there is no autocorrelation between the variables.

Table no. 4 – Coefficients

Coefficients[a]									
Model 1		U.C		S.C	t	Sig.	95.0% C.I for B		Interpretation
		B	S.E.	Beta			LB	UB	Model 1-6
CFM	(Constant)	0.159	0.046		3.427	0.001***	0.068	0.251	CFM 1-6 variables are statistically significant at 0.001 level (p<0.001)
	CFM1	0.147	0.010	0.234	14.504	0.000***	0.127	0.167	
	CFM2	0.169	0.011	0.209	14.933	0.000***	0.147	0.191	
	CFM3	0.160	0.009	0.230	17.836	0.000***	0.143	0.178	
	CFM4	0.171	0.011	0.238	16.033	0.000***	0.150	0.192	
	CFM5	0.168	0.010	0.214	16.194	0.000***	0.148	0.189	
	CFM6	0.146	0.010	0.218	14.957	0.000***	0.127	0.165	
Model 2									
CFS	(Constant)	0.183	0.074		2.470	0.014*	0.037	0.329	CFS1-6 variables are statistically significant at 0.05 and 0.001 levels (p<0.05, p<0.001)
	CFS1	0.157	0.020	0.206	7.851	0.000***	0.118	0.197	
	CFS2	0.151	0.017	0.213	8.864	0.000***	0.118	0.185	
	CFS3	0.113	0.018	0.150	6.270	0.000***	0.078	0.149	
	CFS4	0.155	0.017	0.218	9.178	0.000***	0.122	0.189	
	CFS5	0.192	0.019	0.248	10.368	0.000***	0.156	0.229	
	CFS6	0.181	0.018	0.234	10.009	0.000***	0.145	0.217	
Model 3									
CFD	(Constant)	0.281	0.060		4.696	0.000***	0.163	0.399	CFD1-8 variables are statistically significant at 0.001 level (p<0.001)
	CFD1	0.164	0.013	0.209	12.446	0.000***	0.138	0.191	
	CFD2	0.141	0.012	0.216	11.773	0.000***	0.117	0.164	
	CFD3	0.072	0.012	0.106	5.985	0.000***	0.048	0.096	
	CFD4	0.137	0.012	0.217	11.102	0.000***	0.113	0.162	
	CFD5	0.093	0.013	0.138	7.199	0.000***	0.067	0.118	
	CFD6	0.110	0.012	0.166	8.831	0.000***	0.085	0.134	
	CFD7	0.085	0.013	0.121	6.649	0.000***	0.060	0.111	
	CFD8	0.127	0.013	0.198	9.651	0.000***	0.101	0.153	
Model 4									
CFB	(Constant)	0.779	0.087		8.918	0.000***	0.607	0.951	CFB1-3 variables are statistically significant at 0.001 level (p<0.001)
	CFB1	0.345	0.021	0.457	16.219	0.000***	0.303	0.387	
	CFB2	0.264	0.020	0.385	13.204	0.000***	0.224	0.303	
	CFB3	0.218	0.017	0.356	12.523	0.000***	0.184	0.252	
Model 5									
CFI	(Constant)	0.406	0.095		4.262	0.000***	0.218	0.594	CFI1-4 variables are statistically significant at 0.001 level (p<0.001)
	CFI1	0.254	0.022	0.343	11.352	0.000***	0.210	0.299	
	CFI2	0.220	0.025	0.272	8.800	0.000***	0.171	0.269	
	CFI3	0.227	0.021	0.316	10.880	0.000***	0.186	0.269	
	CFI4	0.199	0.023	0.273	8.862	0.000***	0.155	0.244	
Model 6									
CFS	(Constant)	0.504	0.094		5.352	0.000***	0.319	0.690	CFS1-3 variables are statistically significant at 0.001 level (p<0.001)
	CFS1	0.248	0.025	0.319	10.014	0.000***	0.199	0.296	
	CFS2	0.351	0.027	0.436	12.952	0.000***	0.297	0.404	
	CFS3	0.273	0.025	0.358	11.058	0.000***	0.224	0.321	

Note: [b]Dependent variables: CFM, CFS, CFD, CFB, CFI, and CFS; S.C-Standardized Coefficients, U.C-Unstandardized Coefficients, S.E- Std. Error, LB-Lower Bound, UB-Upper Bound, C.I-Confidence Interval for B, *p<.005, Predictors: (Constant): (CFM1-6, CFS1-6, CFD1-8, CFB1-3, CFI1-4, and CFS1-3), *** p<.001, *p<.05

Source: table prepared by the authors (2023/24)

Table no. 4 presents the results of the model coefficients (CFM, CFS, CFD, CFB, CFI, and CFS) and their factors (CFF1-6, CFS1-6, CFD1-8, CFB1-3, CFI1-4, and CFS1) -3) at a significance level of 0.05 and 0.001 in the context of cash flow dynamics in a volatile economic climate to achieve financial resilience and outcomes for businesses. Findings of the model for cash flow management (CFM): regarding model 1 (CFM), it is emphasized that the constant is (0.159), emphasizing that if the independent variables (CFM1-6) are zero, then the companies will have cash flow management of 16%. All independent variables of the CFM model have an important and significant impact on the model, therefore an increase in the availability of current cash flow information (CFM1) will increase by 15% (CFM), an increase in effective cash management (CFM2) will increase by 17% (CFM), an increase in accurate and reliable cash forecasting (CFM3) will increase by 16% (CFM), an increase in sales volume (CFM4) will increase by 17% (CFM), an increase in encouraging departments to focus on cash flow targets (CFM5) will increase by 17% (CFM), an increase in the management of long-term and short-term monetary policies (CFM6) will increase by 15% (CFM). According to the standardized beta coefficient, all variables have a significant impact on the model, with the most important variables being CFM4 (24%) and CFM1 (23%), which highlight the impact of sales volume and currently available cash flow information on cash flow management.

$$\widehat{CFM} = \alpha_0 + \beta_1(CFM1) + \beta_2(CFM2) + \beta_3(CFM3) + \beta_4(CFM4) + \beta_5(CFM5) + \beta_6(CFM6) = 0.159 + 0.147x_1 + 0.169x_2 + 0.160x_3 + 0.171x_4 + 0.168x_5 + 0.146x_6 + 0.02\mu$$

According to the 95% confidence interval (Sig.2-tailed), it is noted that the *p-value* for variables CFM1-6 is smaller (p<0.001). Therefore, all factors effect the FCM model.

Findings of the model for cash flow solutions (CFS): regarding model 2 (CFM), it is emphasized that the constant is (0.183), emphasizing that if the independent variables (CFS1-6) are zero, then companies will have forward flow solutions of 18%. Further, all the independent variables of the CFS model have an important and significant impact on the model, therefore an increase in the clarity of the cash flow optimization strategy (CFS1) will increase by 16% (CFS), an increase in the monitoring of continuous cash flow to monitor potential risks (CFS2) will increase by 15% (CFS), an increase in the effective management of working capital (CFS3) will increase by 13% (CFS), an increase in appropriate plans the company's ability to address challenges (CFS3) will increase by 16% (CFS), an increase in the accuracy of financial decisions (CFS4) will increase by 19% (CFS), an increase in technology improvement (CFS6) will to increase by 18% (CFS). According to the standardized Beta coefficient, it is emphasized that all variables have a significant impact on the model, but the most important variables are (CFS5=25%, CFS6=23%) or the accuracy in financial decision-making and the improvement of technology will increase the choices of the flow of money.

$$\widehat{CFS} = \alpha_0 + \beta_1(CFS1) + \beta_2(CFS2) + \beta_3(CFS3) + \beta_4(CFS4) + \beta_5(CFS5) + \beta_6(CFS6) = 0.183 + 0.157x_1 + 0.151x_2 + 0.113x_3 + 0.155x_4 + 0.192x_5 + 0.181x_6 + 0.06\mu$$

According to the 95% confidence interval (Sig.2-tailed), it is noted that the *p-value* for variables CFS1-6 is smaller (p<0.001). Therefore, all factors effect the CFS model.

Findings of the model for cash flow dynamics (CFD): regarding model 3 (CFD), it is emphasized that the constant is (0.281), which emphasizes that if the independent variables (CFD1-8) are zero, then the companies will have cash flow dynamics of 28%. Furthermore, all the independent variables of the CFD model have an important and significant influence on the model. Therefore an increase in the accurate management of cash flow fluctuations (CFD1) will increase by 16% (CFD), an increase in the positive advantage of the company in financial flows (CFD2) will increase by 14% (CFD), an increase in the remuneration of employees who contribute to the positive cash flow (CFD3) will increase by 7% (CFD), an increase in the cooperation of departments for cash flow management (CFD4) will increase by 14% (CFD), an increase in identifying and addressing potential cash flow risks (CFD5) will increase by 9% (CFD), an increase in effective management practices that contribute positively to overall financial health (CFD6) will increase by 11% (CFD), an increase in ensuring sufficient resources for departments (CFD7) will increase by 9% (CFD), an increase in effective communication of goals and performance (CFD8) will increase by 13% (CFD). According to the standardized Beta coefficient, it is emphasized that all variables have a significant impact on the model, but the most important variables are (CFD2=22%, CFD4=22%) or the positive advantages of the company in financial decisions, as well as the cooperative approach of the departments for management cash flow.

$$\begin{aligned}\widehat{CFD} &= \alpha_0 + \beta_1(CFD1) + \beta_2(CFD2) + \beta_3(CFD3) + \beta_4(CFD4) + \beta_5(CFD5) + \beta_6(CFD6) \\ &\quad + \beta_7(CFD7) + \beta_8(CFD8) \\ &= 0.281 + 0.164x_1 + 0.141x_2 + 0.072x_3 + 0.137x_4 + 0.093x_5 + 0.110x_6 \\ &\quad + 0.085x_7 + 0.127x_8 + 0.04\mu\end{aligned}$$

According to the 95% confidence interval (Sig.2-tailed), it is noted that the *p-value* for variables CFD1-8 is smaller ($p<0.001$). Therefore, all factors effect the CFD model.

Findings of the model for cash flow boosters (CFB): regarding model 4 (CFB), it is emphasized that the constant is (0.779), which emphasizes that if the independent variables (CFB1-3) are zero, then companies will have cash flow boosters of 78%. Further, all the independent variables of the CFB model have an important and significant impact on the model, therefore, an increase in the implementation of effective measures to accelerate cash flow (CFB1) will increase by 35% (CFB), an increase in satisfactory cash flow communication within the organization (CFB2) will increase by 26% (CFB), an increase in the provision of adequate training for employees for cash flow management (CFB3) will increase by 22% (CFB). According to the standardized Beta coefficient, it is emphasized that all variables have a significant impact on the model, but the most important variable is (CFB1=46%) or the implementation of effective measures to accelerate cash flow.

$$\begin{aligned}\widehat{CFB} &= \alpha_0 + \beta_1(CFB1) + \beta_2(CFB2) + \beta_3(CFB3) \\ &= 0.779 + 0.345x_1 + 0.264x_2 + 0.218x_3 + 0.12\mu\end{aligned}$$

According to the 95% confidence interval (Sig.2-tailed), it is noted that the *p-value* for variables CFB1-3 is smaller ($p<0.001$). Therefore, all factors effect the CFB model.

Findings of the model for cash flow innovations (CFI): regarding model 5 (CFI), it is emphasized that the constant is (0.406), which emphasizes that if the independent variables (CFI1-4) are zero, then companies will have cash flow innovation of 41%. In addition, all

the independent variables of the CFI model have an important and significant impact on the model, therefore, an increase in the establishment of clear procedures for the management of accounts receivable (CFI1) will increase by 25% (CFI), an increase in opportunities to improve cash flow efficiency (CFI2) will increase by 22%, an increase in the company's invoicing and payment processes (CFI3) will increase by 23%, an increase in accurate cash flow reporting (CFI4) will increase by 20% (CFI). According to the standardized Beta coefficient, it is emphasized that all variables have a significant impact on the model, but the most important variable is (CFI1=34%) or the establishment of clear procedures for the managing of accounts receivable.

$$\widehat{CFI} = \alpha_0 + \beta_1(CFI1) + \beta_2(CFI2) + \beta_3(CFI3) + \beta_4(CFI4)$$
$$= 0.406 + 0.254x_1 + 0.220x_2 + 0.227x_3 + 0.199x_4 + 0.11\mu$$

According to the 95% confidence interval (Sig.2-tailed), it is noted that the *p-value* for variables CFI1-4 is smaller (p<0.001). Therefore, all factors effect the CFI model.

Findings of the model for strategic cash flow (CFS): regarding model 6 (CFS), it is emphasized that the constant is (0.504), which emphasizes that if the independent variables (CFS1-3) are zero, then companies will have a cash flow strategy of 50%. Furthermore, all the independent variables of the CFS model have an important and significant impact on the model, therefore an increase in the possibility of negotiating favorable payment terms (CFS1) will increase by 25% (CFS), an increase in the effective balancing of investment needs with cash flow considerations (CFS2) will increase by 35% (CFS), an increase in effective company strategies in line with industry best practices (CFS3) will increase by 27% (CFS). According to the standardized Beta coefficient, it is emphasized that all variables have a significant impact on the model, but the most important variable is (CFS2=44%) or the effective balancing of investment needs with cash-flow considerations.

$$\widehat{CFS} = \alpha_0 + \beta_1(CFS1) + \beta_2(CFS2) + \beta_3(CFS3)$$
$$= 0.504 + 0.248x_1 + 0.351x_2 + 0.273x_3 + 0.13\mu$$

According to the 95% confidence interval (Sig.2-tailed), it is noted that the *p-value* for variables CFS1-3 is smaller (p<0.001). Therefore, all factors effect the CFS model.

Table no. 5 – Regression Weights and Standardized Regression Weights of the models (Verification of cash flow models)

Regression Weights							**Standardized Regression Weights**
Model	**Paths**	**Estimate**	**S.E.**	**C.R.**	**P**	**Interpretation**	**Estimate**
1	CF <--- CFM	0.680	0.071	9.643	***	Accepted	0.678
2	CF <--- CFS	0.639	0.084	7.628	***	Accepted	0.549
3	CF <--- CFD	0.713	0.081	7.601	***	Accepted	0.543
4	CF <--- CFB	0.817	0.079	10.372	***	Accepted	0.723
5	CF <--- CFI	0.648	0.073	8.874	***	Accepted	0.630
6	CF <--- CFS	0.821	0.085	9.621	***	Accepted	0.677

Source: Table prepared by the authors (2023/24). Note: *p<.005. Hypotheses (1-5)

Table no. 5 presents the regression weights and standardized regression weights of the models (CFM, CFS, CFB, CFI, and CFS) in CFD and their factors (CFM1-6, CFS1-6, CFB1-3, CFI1-4, and CFS1-3) at the significance level of 0.05 in the context of cash flow dynamics in a volatile economic climate to achieve financial resilience and outcomes for businesses. According to Model 1 (CF←CFM), it is emphasized that cash flow management (CFM) has a significant and positive effect on cash flow (CF), meaning that an increase in cash flow management will be accompanied by a sustainable increase in the cash flow, therefore, (H_1) is accepted. According to Model 2 (CF←CFS), it is emphasized that cash flow solutions (CFS) have a significant and positive effect on cash flow (CF), meaning that an increase in cash flow solutions will be accompanied by a sustainable increase in the cash flow, therefore, (H_2) is accepted. According to Model 3 (CF←CFB), it is emphasized that cash flow boosters (CFB) have a significant and positive effect on cash flow (CF), meaning that an increase in cash flow boosters will be accompanied by a sustainable increase in the cash flow, therefore, (H_3) is accepted. According to Model 4 (CF←CFI), it is emphasized that cash flow innovations (CFI) have a significant and positive effect on cash flow (CF), meaning that an increase in cash flow innovations will be accompanied by a sustainable increase in the cash flow, therefore, (H_4) is accepted. According to Model 5 (CF←CFS), it is emphasized that cash flow strategic (CFS) has a significant and positive effect on cash flow (CF), meaning that an increase in cash flow strategies will be accompanied by a sustainable increase in the cash flow dynamics, therefore, (H_5) is accepted. Therefore, it is emphasized that all hypotheses for all the models are confirmed, concluding their significance and significant effect in a volatile economic climate to achieve financial resilience and outcomes for businesses.

5. DISCUSSION

In today's financial environment, effective cash flow management is paramount for navigating volatile economic conditions. Notably, various models such as Cash Flow Management (CFM), Cash Flow Solutions (CFS), Cash Flow Dynamics (CFD), Cash Flow Boosters (CFB), Cash Flow Innovations (CFI), and Strategic Cash Flow (CFS) have emerged as indispensable tools for strengthening financial resilience and shaping outcomes. Scholars have highlighted the intricate interplay of cash flow dynamics as pivotal for strategic decision-making, particularly in volatile economic climates. This discussion synthesizes insights from previous research by Keefe and Nguyen (2023), and Zhu *et al.* (2023) to elucidate existing paradigms in cash flow management.

In terms of the swing models and their factors, prior studies by Larkin (2013), Nallareddy *et al.* (2020), and Lin *et al.* (2022) highlight the significance of factors such as positive customer evaluation, consistent cash flows exceeding profits, and the impact of dual-class structures on net operating cash flow. Furthermore, this discussion delves into the unique contributions of the present research, elucidating how the amplified swings within the cash flow dynamics foster financial resilience and favorable outcomes amidst economic volatility.

The data analysis techniques employed, including exploratory factorial analysis, reliability analysis, and multiple regression analysis, support the reliability and validity of the relationships between the models and their factors. Statistical tests such as the Kaiser-Meyer-Olkin (KMO) and Bartlett's Sphericity confirm the data's goodness of fit, while

reliability analysis underscores data consistency across all models. Specifically, findings from the CFM model underscore the significance of effective cash flow management practices, while the CFS model emphasizes the identification and implementation of tailored cash flow solutions. Similarly, insights from the CFD model underscore the importance of managing cash flow fluctuations and fostering interdepartmental cooperation.

Moreover, the findings from the CFB and CFI models reinforce the importance of accelerating cash flow and implementing innovative strategies. Finally, the CFS model highlights the significance of negotiating favorable terms and aligning investments with cash flow considerations. Overall, the validation of hypotheses across all models and their factors confirms the positive effects of these factors and models in improving financial resilience and driving favorable outcomes in volatile economic climates. By leveraging the insights from these models, businesses can improve their cash flow management practices and foster financial growth.

6. CONCLUSIONS AND FUTURE STUDIES

The research, centered on amplifying swings models to understand cash flow dynamics in a volatile economic climate, provides crucial insights. Using advanced techniques such as exploratory factorial analysis, reliability analysis, and multiple regression analysis, the study scrutinized six models (CFM, CFS, CFD, CFB, CFI, and CFS). The findings confirm the pivotal role of these models in comprehending cash flow dynamics. Statistical tests, including the KMO test and Bartlett's Sphericity test, affirm the models' reliable fit, while Cronbach's Alpha underscores high data reliability. Eigenvalues emphasize the significance of variance in each model. The results hold practical implications for businesses aiming to navigate economic volatility. The CFM model underscores the importance of effective cash flow management practices, while the CFS model focuses on forward flow solutions, highlighting the role of factors like technology improvement. The CFD model emphasizes the significance of positive advantages in financial decisions and cooperative departmental approaches. Similarly, the CFB and CFI models shed light on the importance of specific measures and innovations in achieving cash flow boosters. The study relies on data collected exclusively from companies in Kosovo in 2023, potentially limiting the generalizability of the findings to broader contexts. Additionally, the online questionnaire may introduce response bias, impacting the robustness of the results. Future research can explore additional factors and variables that influence cash flow dynamics and validate the findings across different industries and regions. Overall, the findings confirm the significance of effective cash flow models in navigating a volatile economic climate and achieving financial resilience and outcomes for businesses. By implementing insights from these models, companies can bolster their cash flow practices, navigate economic uncertainties, and foster overall financial health.

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Scientific Annals of Economics and Business
71 (3), 2024, 337-351
DOI: 10.47743/saeb-2024-0020

The Antecedents of Utilitarian and Hedonic Motivations for Online Shopping Satisfaction

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Abstract: Empirical studies indicate that utilitarian and hedonic shopping motivations have a profound effect on customer satisfaction in a physical brick-and-mortar shopping environment. Studies have also started to surface which underscore the importance of these motivations in the realm of e-commerce. The study, therefore, seeks to determine the antecedents of utilitarian and hedonic motivations for online shopping satisfaction. A quantitative research method with a descriptive research design was implemented in this study. The data was collected through a survey method from a sample of 215 online shoppers in an emerging economy, South Africa. The study utilised previously validated scales. Multivariate regression analysis was performed to determine the factors that influence utilitarian and hedonic motivations for online shopping satisfaction. The results reveal that information availability, cost saving, wider selection, convenience, and efficiency are the antecedents of utilitarian dimensions that determine online shopping satisfaction, while status, adventure, social shopping, idea shopping, and gratification are considered the antecedents of hedonic motivations of online shopping that influence satisfaction. The results of the study offer insight into why consumers engage in online shopping by determining the factors that influence utilitarian and hedonic motivations. Accordingly, the study offers practical recommendations to e-retailers on how to best serve their customers by focusing on the individual building blocks of utilitarian and hedonic shopping motivations.

Keywords: utilitarian motivation; hedonic motivation; satisfaction; online shopping.

JEL classification: M30; M31.

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Article history: Received 6 May 2024 | Accepted 14 July 2024 | Published online 24 September 2024

To cite this article: Redda, E. H. (2024). The Antecedents of Utilitarian and Hedonic Motivations for Online Shopping Satisfaction. *Scientific Annals of Economics and Business*, 71(3), 337-351. https://doi.org/10.47743/saeb-2024-0020.

1. INTRODUCTION

Online shopping, the buying of goods and services via the internet of things (IoT), has become part of our daily lives in many respects. While billions of people must still gain access to the internet and be able to engage in activities such as online shopping, quite a large number of people, including those in developing economies, have already gained access to the Internet. For example, by the end of 2021, people with access to the Internet worldwide were approximately 4.9 billion, representing around two-thirds of the world's population (Statista, 2022b), presenting a great e-commerce opportunity. Worldwide, online shopping revenue was estimated at 5.2 trillion USD in 2021, and this is projected to reach 8.1 trillion USD in 2026 (Statista, 2022a). There is no doubt that Covid-19 has had a positive impact on accelerating the adoption of online shopping and boasting e-commerce globally. This is probably the only and main positive impact of Covid-19. In South Africa, online consumer spending increased by 68 percent during the first year of the Covid-19 outbreak (Newsroom, 2020), and has been showing steady growth since then, and more so after the outbreak of Covid-19. The focus of this paper, however, goes beyond the Covid-19 phenomenon – it seeks to investigate the antecedents of utilitarian and hedonic motivations for online shopping satisfaction so that marketers, e-retailers, and other business decision-makers have a deeper understanding of why consumers engage in online shopping and what contributes to their satisfaction. Ascertaining the critical factors determining utilitarian and hedonic motivations that influence online shopping satisfaction will be the main contribution of the study. In the ensuing section, a review of the literature on the topic will be presented to provide context to the current study.

Various empirical studies have been conducted on the subject in other parts of the world. For example, factors such as "security, information availability, shipping, quality, pricing and time" have been found as determinants of online shopping satisfaction among Serbian customers (Vasi *et al.*, 2019). However, the study did not look at utilitarian and hedonic motivations specifically. The study of Kertasunjaya *et al.* (2020) confirms that both hedonic and utilitarian motivations have a significant and positive influence on customer satisfaction among patrons who frequent restaurants in the Indonesian market. In the same market, Indonesia, Evelina *et al.* (2020) found that hedonic and utilitarian values are the drivers of satisfaction of customers in the e-commerce industry.

A study by Anand *et al.* (2019) attempted to determine the impact of hedonic and utilitarian shopping motivation on customer satisfaction in the Malaysian economy based on the technology acceptance model and the theory of planned behaviour. The study found that attitude, perception, and hedonic motivation were antecedents of online shopping satisfaction. The utilitarian motivation was not found as a determinant of online shopping satisfaction. In another emerging economy, India, Jaiswal and Singh (2020) found that customisation, economic value, post-purchase experience, and customer services are the primary criteria by which customers assess their whole online experience and satisfaction.

Davis *et al.* (2013) confirm that there is a direct impact of hedonic consumption on customer purchase and usage, and an indirect causal effect of utilitarian consumption on customer purchase and usage of games. There was no specific focus on distinguishing between hedonic and utilitarian motivations or determinants. Anitha and Krishnan (2021) study indicates that positive attitudes and perceived usefulness do influence utilitarian and hedonistic shopping motivations, which, in turn, influence online satisfaction. Yen *et al.*

(2014) investigated the contingent effect of both utilitarian and hedonic motivation on repurchase intention and the study found that a consumer's hedonic orientation has a slightly higher influence on shopping satisfaction than utilitarian orientation. Kumar and Sadarangani (2018) conducted a study on the impact of hedonic and utilitarian motivations on the purchase intention of foreign brand clothing in India, and both were found to have a significant influence. Anand *et al.* (2019) posit that a deeper understanding of key antecedents that enhance consumer satisfaction is essential for online marketers to be successful. In South Africa, Redda (2020) study found that both utilitarian and hedonic values are determinants of customer attitude towards online shopping, and customer attitude, and in turn, are determinants of customer intentions within the e-commerce context. However, the study did not determine the impact of these motivations on online shopping customer satisfaction, which the current study is aiming to close the research gap. The current study, will, thus fill the research gap by determining the antecedents of utilitarian and hedonic motivations for online shopping satisfaction.

2. LITERATURE REVIEW: MOTIVATIONS FOR SHOPPING

Marketing literature attests that numerous theories have been documented that explicate the behaviour of consumers and the process they take when conducting decisions. Some of the prominent theories include the *diffusion of innovations* by Rogers (1995), *the theory of reasoned action* by Hale *et al.* (2002), the *theory of planned behaviour* by Ajzen (1991), the *decomposed version of the theory of planned behaviour* by Taylor and Todd (1995), the *technology acceptance model* by Bagozzi *et al.* (1992) and the *extended version of technology acceptance model* by Venkatesh and Davis (2000). The focus of this paper is not to apply or interrogate such theories or models. This paper focuses on what motivates consumers to engage in online shopping and how satisfaction is achieved or derived from online shopping experience.

Consumer psychology is an important factor when it comes to consumption-related decisions. There could be various motivations as to why certain consumers engage in a certain manner when it comes to the consumption of goods and services. The material world does give consumers satisfaction and consumers are frequently observed purchasing things to improve their emotions, communicate their uniqueness to people around them, or just amuse themselves, meet a certain need, or solve a specific problem. A consumer may engage in the consumption of goods and services either for psychological needs or functional needs. Empirical literature indicates that utilitarian and hedonic shopping motivations have a profound effect on customer satisfaction in physical brick-and-mortar shopping environments such as shopping malls, boutiques and restaurants (Kertasunjaya *et al.*, 2020).

As indicated earlier, the focus of this study is on utilitarian and hedonic motivations of customer satisfaction in the case of online shopping. The literature below will focus on these two typologies of consumer motivations as documented in the literature (Anand *et al.*, 2019; Vasi *et al.*, 2019; Evelina *et al.*, 2020; Jaiswal and Singh, 2020; Anitha and Krishnan, 2021). The factors or elements discussed under each typology are presented in Table no. 1. The differences and similarities between these two typologies of consumer motivations can be explained as follows: while utilitarian motivation refers to the "utility or functional value of an object", hedonic motivation refers to the "emotional or sensory experiences of the shopping experience itself". More descriptions are presented in the ensuing sections.

Table no. 1 – Typologies of consumer motivations

Utilitarian motivations	Hedonic motivations
1. Wider/diversified selection	1. Adventure/explore
2. Information availability	2. Gratification shopping
3. Efficiency	3. Social
4. Achievement	4. Idea
5. Convenience	5. Authority and status
6. Better deals/cost saving	

Source: researcher`s construction

In the following section, studies that specifically relate to utilitarian and hedonic motivations will be provided.

2.1 Utilitarian motivations

The term utilitarian motivation refers to the "gratification derived from something that enables the consumer to solve problems or accomplish tasks" (Babin and Harris, 2016; Özen and Kodaz, 2016). Utilitarian motivations are related to efficiency and logical decision-making processes; they pertain to an object's usefulness or functional value, worth or qualities (Batra and Ahtola, 1991). In other words, they are goals-oriented traits that relate to efficiency and logical decision-making; they pertain to an object's utility or functional value (Davis *et al.*, 2013; Basaran and Buyukyilmaz, 2015; Yoh *et al.*, 2016; Redda, 2020).

The selection of utilitarian consumption motivations investigated in this study is based on the literature record, which showed wider use among marketing research scholars, and these include wider/diversified selection (Alba *et al.*, 1997; Arnold and Reynolds, 2003; Kim, 2006); information availability (Wolfinbarger and Gilly, 2001); efficiency (Babin *et al.*, 1994; Kim, 2006); achievement (Babin *et al.*, 1994; Kim, 2006); convenience (Burke, 1997); and cost saving/better deals (To *et al.*, 2007). These factors have been found as crucial dimensions that explain consumers` utilitarian motivation for purchasing decisions. Within the context of this study, the following operational definitions and descriptions are provided for these factors:

- *Wider/diversified selection* refers to the quantity, quality, and variation or diversity of products available to consumers. E-retailers do provide a wide range of products online as they are in a better position to do so than brick-and-mortar malls. Consumers are afforded a wider selection of products, which is key for online shoppers.
- *Information availability* refers to the amount of information made available to the consumer when they engage in online shopping, such as product specifications, prices and promotions. This information is critical in encouraging consumers to purchase things through online platforms.
- *Efficiency* refers to how quickly consumers are able to conduct shopping on online platforms. Consumers who rely on online shopping can save time and resources, and this is one of the main motivations for online shopping.
- *Achievement* refers to a goal-oriented shopping method in which locating specific items that were planned for at the start of the journey is considered a crucial component by the customer.

- *Convenience* refers to the ease with which customers can conduct their online shopping. Online shopping is not bound by time, space, or weather, and consumers can conduct their shopping 24/7 from the comfort of their place of choice.
- *Cost saving/better deals* refer to how consumers can obtain products at lower prices and better deals through search and negotiations because the information is at their fingertips; they can easily compare prices and ask for a better deal from e-retailers.

2.2 Hedonic motivations

Hedonic attributes include sensory experiences such as emotion, satisfaction and fantasy (Arnold and Reynolds, 2003; To *et al.*, 2007). As a result, emotional or sensory shopping experiences are the driving factors of hedonic consumption incentives (To *et al.*, 2007; Davis *et al.*, 2013; Haq *et al.*, 2014; Arul Rajan, 2020; Redda, 2020). In hedonic shopping, consumers place an emphasis on the shopping process (To *et al.*, 2007).

The selection of hedonic consumption motivations investigated in this study are based on the literature record, which showed wider use among marketing research scholars and these include adventure/explore (Kim, 2006; Arnold and Reynolds, 2012); gratification shopping (To *et al.*, 2007); social shopping (Kim, 2006; Arnold and Reynolds, 2012; Chiu *et al.*, 2014); idea shopping (Arnold and Reynolds, 2003, 2012); as well as authority and status (To *et al.*, 2007). These dimensions have been identified as crucial in explaining consumers' hedonic motivation for purchasing decisions. The following operational definitions and descriptions are provided for these factors:

- *Adventure/explore shopping* is a "type of shopping consumer engages for stimulation, adventure, and the feeling of being in another world; the shopping trip is made for the sheer excitement and adventure".
- In a traditional setting, social shopping refers to the enjoyment of shopping with family and friends and socialising while shopping, and interacting with others; in a digital setting, it refers to shopping experiences with individuals who share similar interests via online platforms such as social media.
- *Idea shopping* refers to the need to keep up with trends, fashion, and innovation in today's fast-paced digital environment. Consumers are eager to learn about new items and market breakthroughs and innovations.
- *Gratification buying* is defined as purchasing done to relieve stress, improve one's mood, or treat oneself.
- *Authority and status* refer to the control and prestige consumers enjoy when they do online shopping. Consumers have full control over their shopping activity in terms of what to see, order, and when to receive the delivery because they control their online platform.

2.3 Online shopping satisfaction

The concept of "satisfaction" may refer to the pleasure one feels after receiving goods or services that make them happy or feel good (Buttle, 1996). Delight may result from satisfaction with services that pleasantly surprise the customer (Gupta and Bansal, 2012). From a disconfirmation point of view, satisfaction is viewed as a comparison between customer expectations and experience of the actual delivery of a product or a service

(Bloemer and de Ruyter, 1998; Ekiz and Bavik, 2008). Anand *et al.* (2019) documented several studies that indicate the positive impact of utilitarian and hedonic motivation on online shopping satisfaction. This study seeks to determine the influence of utilitarian dimensions such as wider/diversified selection (Alba *et al.*, 1997; Arnold and Reynolds, 2003; Kim, 2006); information availability (Wolfinbarger and Gilly, 2001); efficiency (Babin *et al.*, 1994; Kim, 2006); achievement (Babin *et al.*, 1994; Kim, 2006); convenience (Burke, 1997); and cost saving/better deals (To *et al.*, 2007) on online shopping satisfaction. Similarly, it also aims to determine the influence of hedonic variables, namely adventure/explore (Kim, 2006; Arnold and Reynolds, 2012); gratification shopping (To *et al.*, 2007); social shopping (Kim, 2006; Arnold and Reynolds, 2012; Chiu *et al.*, 2014); idea shopping (Arnold and Reynolds, 2003, 2012); as well as authority and status (Parsons, 2002; To *et al.*, 2007) on online shopping satisfaction.

2.4 Empirical studies on utilitarian and hedonic motivations

Empirical studies conducted in various parts of the world have confirmed that utilitarian and hedonic motivations do have an influence on customer satisfaction. For instance, the study by (Kertasunjaya *et al.*, 2020) confirms that both hedonic and utilitarian motivations have a significant and positive influence on customer satisfaction among patrons who frequent restaurants in the Indonesian market. Within the e-commerce context, Evelina *et al.* (2020) found that hedonic and utilitarian values as the drivers of satisfaction of customers. These studies, which were conducted within different contexts, attest to the efficacy of the utilitarian and hedonic constructs in explaining customer satisfaction levels.

Anand *et al.* (2019) used the technology acceptance model and the theory of planned behaviour to investigate the impact of hedonic and utilitarian shopping motives on consumer satisfaction in the Malaysian economy. According to the study, attitude, perception and hedonic motivation were all predictors of online purchasing satisfaction. The utilitarian motive was not discovered to be a predictor of online buying satisfaction. Jaiswal and Singh (2020) discovered that customisation, economic value, post-purchase experience, and customer services are the major characteristics by which customers evaluate their overall online experience and satisfaction in the Indian economy.

Davis *et al.* (2013) confirm that hedonic consumption has a direct impact on game purchase and usage, and utilitarian consumption has an indirect causal effect on game purchase and usage. According to Anitha and Krishnan (2021) research, positive attitudes and perceived utility promote utilitarian and hedonistic purchase motivations, which influence online satisfaction. Yen *et al.* (2014) investigated the contingent effect of utilitarian and hedonic motivation on repurchase intention and discovered that hedonic orientation influences shopping satisfaction somewhat more than utilitarian orientation does. Kumar and Yadav (2021) conducted a study on the impact of utilitarian and hedonic motivation for sustainable consumption. Their findings indicated that information availability and customized offerings have a significant impact on utilitarian motivation, as well as adventure, authority, and status have a significant impact on hedonic motivation for sustainable consumption.

2.5 Research questions and objectives

As elucidated in the literature review above, both utilitarian and hedonic motivations are multidimensional constructs, and therefore the following two key research questions are formulated to guide the study:

- Which utilitarian attributes have an influence online shopping satisfaction? and
- Which hedonic attributes have an influence online shopping satisfaction?

Understanding the dimensions/attributes that make up utilitarian and hedonic consumption values is crucial in our effort to understand and explain consumer behaviour and decision-making which have serious implications on the practice of marketing. As elucidated earlier, there is(are) well-documented evidence/studies that underscore the importance of utilitarian and hedonic shopping motivations on customer satisfaction in traditional and physical forms of retailing. The objective of this study is to determine the antecedents of utilitarian and hedonic motivations for online shopping satisfaction. In other words, the study aims to determine such motivations' impact on customer satisfaction for shopping conducted via the world wide web. This aspect underscores the study's significance and its tangible contribution. Marketing practitioners will gain practical insight into which factors to focus on so that they can influence the utilitarian and hedonic dimensions that contribute to online shopping customer satisfaction.

3. RESEARCH DESIGN AND METHOD

To attain its goals, this study used a descriptive research design and a quantitative research approach. Non-probability sampling strategies such as convenience and snowball sampling were used in the study. To obtain data from a varied set of internet buyers in Gauteng, South Africa's economic hub, a structured self-administered questionnaire was issued using Survey Monkey. 215 valid replies were received and analysed using this data-gathering approach.

The study utilised previously validated scales (Arnold and Reynolds, 2003; Kim, 2006; To *et al.*, 2007). For utilitarian motivations: wider/diversified selection (3 questions relating to quantity, quality, and variation or diversity of products), information availability (3 questions relating to availability and quality of information), efficiency (3 questions relating to how quickly one completes an online transaction), achievement (3 questions relating to whether a consumer can achieve and complete purchase requirements on the e-store), convenience (4 questions relating to the ease with which customers can conduct their online shopping) and cost saving/better deals (3 questions relating to obtaining better deal on the e-store) were asked. For hedonic motivations: adventure/explore (3 questions relating to stimulation, excitement, adventure), gratification (3 questions relating to stress relief, improving one's mood, and obtaining pleasure), social shopping (3 questions that deal with the enjoyment of shopping with family and friends and socialising while shopping, and interacting with others; in a digital setting), idea (3 questions relating to trends, fashion, and innovation in today's fast-paced digital environment) and authority and status (3 questions relating to control and prestige consumers enjoy when they do online shopping) were compiled. Satisfaction was measured using 4 questions relating to how satisfied consumers are with their online shopping experience. The scales used in this study have been proven to be reliable and valid in previous studies. To collect responses, a six-point Likert scale (anchored from 1 (strongly disagree) to 6

(strongly agree) was used. Before collecting data for the main study, a pilot study (with a sample size of 50) was conducted to determine the internal consistency reliability of the scale as an additional measure. No items were removed during the pilot testing stage because all of the constructs had a Cronbach alpha greater than 0.70.

The study conforms to ethical standards and ethics clearance was obtained (ECONIT-2017-088) to conduct the study. Participation in the study was voluntary and consent was obtained from the participants to partake in the study and anonymity was ensured. This sample size is sufficient to conduct the type of statistical analysis used in this study (Malhotra and Indrayan, 2010). The variables and measuring items for the utilitarian, hedonic, and satisfaction components employed in this study were derived from previously validated instruments. Appropriate statistical analyses such as descriptive statistics, correlation analysis, reliability, and validity analyses were conducted as standard statistical procedures. To address the main research objective of the study, multivariate regression analyses were performed.

The multivariate regression analysis that determined the utilitarian motivations of online shopping satisfaction was specified as follows:

$$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 + \beta 6X6 + \varepsilon$$

where Y represents the dependent variable (online shopping satisfaction0.

$\beta 0$ is the intercept (constant) term.

$\beta 1$ to $\beta 6$ are the coefficients of the respective independent variables ($X1$ to $X6$) which are utilitarian dimensions, representing their influence on the dependent variable.

$X1$ to $X6$ are the independent variables.

ε represents the error term, accounting for the variability in the dependent variable that cannot be explained by the independent variables.

Similarly, another multivariate regression analysis was performed to determine the hedonic motivations of online shopping satisfaction and was represented as follows:

$$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 + \varepsilon$$

where Y represents the dependent variable (online shopping satisfaction0.

$\beta 0$ is the intercept (constant) term.

$\beta 1$ to $\beta 5$ are the coefficients of the respective independent variables ($X1$ to $X5$) which are hedonic dimensions, representing their influence on the dependent variable.

$X1$ to $X5$ are the independent variables.

ε represents the error term, accounting for the variability in the dependent variable that cannot be explained by the independent variables.

4. ANALYSES AND DISCUSSION OF RESULTS

4.1 Descriptive analysis

The sample of 215 was gender balanced, with 55.35 percent (n=119) females and 44.65 percent (n=96) males. The demographic data revealed that the majority of respondents (25%) were between the ages of 35 and 44, followed by the age cohorts 18 to 24 (33%), and 25 to 34 (25%). (13 percent). Only 11% were over the age of 45. The vast majority (over

80%) of respondents said they shop online for fashion, branded goods, and imported goods (products not available in local markets). A significant proportion of respondents (65%) said they shop online for local and athletic products.

4.2 Correlation analysis

Table no. 2 reports the correlation between utilitarian motivations and online shopping satisfaction. The results indicate that there is a positive association between most of the pairs of the constructs of the study at either 0.01 or 0.05 significance levels with the exception of the correlation between convenience and cost saving, convenience and achievement, and convenience and information availability. However, it should be noted that each of the utilitarian dimensions or attributes is positively correlated with the satisfaction construct, which then paves the way for further analysis using multivariate regression analysis. Therefore, cost saving, achievement, wider selection, information availability, convenience, and efficiency are positively associated with online shopping satisfaction. The signs of the correlation were as expected and logically pointed toward the nomological validity of the measurement theory. None of the coefficients were above 0.9, so there were no multicollinearity issues. Acceptable Cronbach's alpha > 0.7 (Hair *et al.*, 2010); > 0.6 (Malhotra and Indrayan, 2010), suggesting internal-consistency reliability of scales.

Table no. 2 – Correlation between utilitarian motivations and online shopping satisfaction

Research constructs		1	2	3	4	5	6	7
Cost saving	(1)	1						
Achievement	(2)	.401**	1					
Wider selection	(3)	.336**	.358**	1				
Information availability	(4)	.567**	.359**	.340**	1			
Convenience	(5)	0.080	0.125	0.031	.144*	1		
Efficiency	(6)	.389**	.346**	.304**	.370**	.260**	1	
Satisfaction	(7)	.518**	.390**	.468**	.486**	.234**	.466**	1

Note: **Correlation significant at the 0.01 level (2-tailed); *Correlation significant at the 0.05 level (2-tailed)

Table no. 3 illustrates the correlation between hedonic motivations and online shopping satisfaction. The results indicate that there is a positive association between most of the pairs of the constructs of the study at either the 0.01 or 0.05 significance levels. The correlation between social shopping and adventure was not significant. However, all of the hedonic dimensions or attributes are positively correlated with the satisfaction construct, which then paves the way for further analysis using multivariate regression analysis. The figures of the correlation were as anticipated and rationally indicated nomological validity of the measurement theory. None of the coefficients were above 0.9, so there were no multicollinearity issues. Acceptable Cronbach's alpha > 0.7 (Hair *et al.*, 2010); > 0.6 (Malhotra and Indrayan, 2010), suggesting internal-consistency reliability of scales.

Table no. 3 – Correlation between hedonic motivations and online shopping satisfaction

Research constructs		1	2	3	4	5	6
Authority/status	(1)	1					
Adventure	(2)	.343**	1				
Social shopping	(3)	.143*	0.099	1			
Idea shopping	(4)	.390**	.291**	.338**	1		
Gratification	(5)	.565**	.316**	.161*	.384**	1	
Satisfaction	(6)	.517**	.477**	.310**	.466**	.561**	1

Note: **Correlation significant at the 0.01 level (2-tailed); *Correlation significant at the 0.05 level (2-tailed)

4.3 Multivariate regression analysis

Following correlation analysis, multivariate regression analysis was conducted to determine the causal effect of antecedents of utilitarian and hedonic motivations on customer satisfaction in the case of online shopping. Firstly, the influence of utilitarian dimensions on online shopping satisfaction is presented.

The influence of utilitarian dimensions on online shopping satisfaction

Table no. 4 reports the results of multivariate regression: utilitarian dimensions and online shopping satisfaction. The six utilitarian dimensions, independent variables (IVs), were regressed with online customer satisfaction, dependent variable (DV). Each of the variables examined in the model generated tolerance values over the 0.10 threshold level, and the variance inflation factor (VIF) was less than 10, indicating that the variables were not multicollinear, substantiating the findings of the correlation analysis (see Table no. 4). The regression model produced a significant F-ratio (F = 29.281; $p \leq 0.00$), suggesting the appropriateness of the model in explaining online customer satisfaction. The model containing the six antecedents, namely cost saving, wider selection, information availability, convenience and efficiency, explained 46 per cent of the variance in customer satisfaction of online shopping, evidenced by the adjusted R^2 value of 0.458. The achievement construct was not found to have a statistically significant influence on online shopping satisfaction. However, a conclusion can safely be made that indeed utilitarian dimensions or attributes of online shopping do have a significant influence on online customer satisfaction. This finding does corroborate previously conducted empirical studies (Davis *et al.*, 2013; Evelina *et al.*, 2020; Kertasunjaya *et al.*, 2020; Anitha and Krishnan, 2021).

Table no. 4 – Results of multivariate regression: Utilitarian dimensions and online shopping satisfaction

Model	R	R-square	Adjusted R-square	Std. error of the estimate
1	.677a	0.458	0.442	0.777171

	B	Std. Error	Beta	T-statistics	P-values	Tolerance	VIF
(Constant)	0.025	0.502		0.05	0.960		
Cost saving	0.21	0.058	0.236	3.591	0.000	0.604	1.655
Achievement	0.089	0.074	0.071	1.204	0.230	0.746	1.34

Model	R	R-square	Adjusted R-square	Std. error of the estimate
1	.677a	0.458	0.442	0.777171

	B	Std. Error	Beta	T-statistics	P-values	Tolerance	VIF
Wider selection	0.293	0.067	0.251	4.364	0.000	0.79	1.265
Information availability	0.136	0.057	0.155	2.406	0.017	0.625	1.6
Convenience	0.11	0.046	0.128	2.411	0.017	0.921	1.086
Efficiency	0.175	0.057	0.183	3.061	0.002	0.731	1.368

The influence of hedonic dimensions on online shopping satisfaction

The six utilitarian dimensions, independent variables (IVs), were regressed with online customer satisfaction, dependent variable (DV). Each of the variables examined in the model generated tolerance values over the 0.10 threshold level, and the variance inflation factor (VIF) was less than 10, indicating that the variables were not multicollinear, substantiating the findings of the correlation analysis (see Table no. 5). The regression model produced a significant F-ratio (F = 42.292; $p \leq 0.00$), suggesting the appropriateness of the model in explaining online customer satisfaction. The model containing the five antecedents, namely authority/status, adventure, social shopping, idea shopping and gratification, explained 49 per cent of the variance in customer satisfaction with online shopping, evidenced by the adjusted R^2 value of 0.491. Therefore, the study concludes that indeed hedonic dimensions or attributes of online shopping do have a significant influence on online customer satisfaction. The result of this study does produce similar results to previously conducted empirical studies around the world (Davis *et al.*, 2013; Evelina *et al.*, 2020; Kertasunjaya *et al.*, 2020; Anitha and Krishnan, 2021).

Table no. 5 – Results of multivariate regression: Utilitarian dimensions and online shopping satisfaction

Model	R	R Square	Adjusted Square R	Std. Error of the Estimate
1	.709[a]	0.503	0.491	0.742407

	B	Std. Error	Beta	T-statistics	P-values	Tolerance	VIF
(Constant)	-0.017	0.444		-0.037	0.970		
Authority/status	0.161	0.055	0.180	2.924	0.004	0.626	1.596
Adventure	0.317	0.064	0.263	4.938	0.000	0.840	1.190
Social	0.141	0.046	0.159	3.074	0.002	0.884	1.131
Idea	0.147	0.055	0.154	2.674	0.008	0.721	1.388
Gratification	0.258	0.054	0.291	4.775	0.000	0.639	1.565

As indicated above, this study confirms the findings of previous studies such as the study of Kertasunjaya *et al.* (2020), which found both hedonic and utilitarian motivations as determinants of customer satisfaction among patrons who dine at restaurants. More specifically, the finding of this study also corroborates the findings of the study conducted by Evelina *et al.* (2020), which was conducted within an e-commerce context. Evelina *et al.*

(2020) found that hedonic and utilitarian values are the drivers of online customer satisfaction.

Anand *et al.* (2019) study posits that attitude, perception and hedonic motivation were all predictors of online purchasing satisfaction. The utilitarian motive was not found to be a predictor of online buying satisfaction, which contradicts the current study. Furthermore, this study is also in agreement with the findings of several other studies (Jaiswal and Singh, 2020; Anitha and Krishnan, 2021). Jaiswal and Singh (2020) study indicated that customisation, economic value, post-purchase experience, and customer services are the major characteristics by which customers evaluate their overall online experience and satisfaction, and Anitha and Krishnan (2021) suggested that positive attitudes and perceived utility promote utilitarian and hedonistic purchase motivations, which influence online satisfaction.

5. CONCLUSION

The goal for any marketing professional, whether online or offline, is to close a transaction. The study's findings provide insight into why consumers shop online by identifying the factors that influence utilitarian and hedonic motivations. As a result, the study provides e-retailers with practical recommendations on how to best serve their customers by focusing on the individual building blocks of utilitarian and hedonic shopping motivations. The main findings suggest that information availability, cost saving, wider selection, convenience, and efficiency are the antecedents of utilitarian dimensions that determine online shopping satisfaction, while status, adventure, social shopping, idea shopping, and gratification are considered the antecedents of hedonic motivations of online shopping that influence satisfaction. These findings do have managerial implications to marketing practitioners.

Marketers of e-retailers are advised to try to appeal to online shoppers by focusing on the dimensions of utilitarian and hedonic motivation dimensions to achieve customer satisfaction in the case of online shopping. For example, e-retailers should provide a wide range of products online as they are because when consumers are afforded a wider selection of products, they are likely to find what they need or want and will be satisfied. Another area for e-retailers is providing sufficient and crucial information to the customer, as such information is critical in encouraging consumers to purchase things through online platforms. Consumers who rely upon online shopping can save time and resources, and this is one of the main motivations for online shopping, and therefore e-retailers should ensure the efficiency of their processes. Convenience is one of the main reasons cited by online shoppers for buying online. Online shopping is not bound by time, space, or weather, and consumers can conduct their shopping 24/7 from the comfort of their place of choice, which is a big bonus to e-retailers. E-retailers should also note that cost-saving/better deals are one of the motivating factors for online shopping. Consumers are able to obtain products at lower prices and better deals through search and negotiations because the information is at their fingertips; they can easily compare prices and ask for a better deal from e-retailers. These are the utilitarian aspects or dimensions that e-retailers should take into account when they design their marketing strategy for their online platforms.

In terms of hedonic aspects or dimensions, e-retailers should, for example, allow their customers the option of adventure and the ability to explore their entire offering with ease as

some shopping trips are made for sheer excitement and adventure. In a digital setting, online shoppers share similar interests via online platforms such as social media and in this way influence each other's decisions; noting this, e-retailers should maintain an excellent social media presence. Such information is sought as idea shopping cues by online shoppers to satisfy their need of keeping up with trends and fashion in today's fast-paced digital environment. Consumers often aim for gratification from buying online in the hope of relieving stress, improving their mood, and treating themselves. Online shopping does provide control and prestige to consumers when they engage in online buying. In a nutshell, e-retailers should work on the building blocks of what constitutes utilitarian and hedonic motivations to achieve customer satisfaction in the case of online shopping.

The study adopted a non-probability sampling strategy such as convenience and snowball sampling, and the sample size was 215 in a certain geographical location, Gauteng Province, South Africa. While the study applied an acceptable sampling technique and sample size, more participants can be included in future studies to test whether the findings of this study will hold. Although Gauteng is the economic hub of South Africa and with a diverse population, this limitation can be overcome by carrying out a similar study across the nine provinces of the country to improve the generalisability of findings. Future studies may also include additional dependent variables such as loyalty and trust and mediating or moderating variables such as gender and income to observe their effect.

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Scientific Annals of Economics and Business
71 (3), 2024, 353-380
DOI: 10.47743/saeb-2024-0021

Assessment of Cryptocurrencies Integration into the Financial Market by Applying a Dynamic Equicorrelation Model

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Abstract: This work aims to contribute to a deeper understanding of cryptocurrencies, which have emerged as a unique form within the financial market. While there are numerous cryptocurrencies available, most individuals are only familiar with Bitcoin. This knowledge gap and the lack of literature on the subject motivated the present study to shed light on the key characteristics of cryptocurrencies, along with their advantages and disadvantages. Additionally, we seek to investigate the integration of cryptocurrencies within the financial market by applying a dynamic equicorrelation model. The analysis covers ten cryptocurrencies from June 2nd, 2016 to May 25th, 2021. Through the implementation of the dynamic equicorrelation model, we have reached the conclusion that the degree of integration among cryptocurrencies primarily depends on factors such as trading volume, global stock index performance, energy price fluctuations, gold price movements, financial stress index levels, and the index of US implied volatility.

Keywords: cryptocurrencies; bitcoin; Blockchain; finance; decentralization; Dynamic Equicorrelation Model.

JEL classification: G11; E44; O33.

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Article history: Received 4 June 2024 | Accepted 22 September 2024 | Published online 25 September 2024

To cite this article: Gomes, G., Queirós, M., Ramos, P. (2024). Assessment of Cryptocurrencies Integration into the Financial Market by Applying a Dynamic Equicorrelation Model. *Scientific Annals of Economics and Business*, 71 (3), 353-380. https://doi.org/10.47743/saeb-2024-0021.

1. INTRODUCTION

In the last decade, due to significant technological advancements, new and more sophisticated forms of payment and investment have emerged (Wątorek *et al.*, 2023). Supply, demand, macroeconomic conditions, speculation, and even rumors have been significant factors influencing investor behavior (Rudkin *et al.*, 2023). These factors can drive cryptocurrency prices, making it challenging for investors to take precise positions in trading or investment (Boiko *et al.*, 2021). Cryptocurrency is a virtual currency that utilizes advanced encryption techniques to regulate its monetary units. Cryptography has been applied to enhance payment security and verify transactions. This encryption has also instilled confidence among its users. Cryptocurrency can be transacted without interference from a central entity such as a bank (Poongodi *et al.*, 2020). It has potential impacts, including its susceptibility to money laundering. While governments cannot control these virtual currencies, they can regulate and tax them. As new technologies advance and cryptocurrency adoption increases, more and more businesses are compelled to accept this payment method (Andriole, 2020). Bitcoin (BTC) was the first cryptocurrency created and currently accounts for approximately 50% of the total market capitalization and trading volume. Cryptocurrency exchanges operate 24/7 (Borri and Shakhnov, 2020). Ethereum (ETH) is a decentralized platform that executes smart contracts. It utilizes its own currency, Ether, which has also garnered significant attention and holds the second position[1] among over 4,000 cryptocurrencies in terms of market capitalization (Mensi *et al.*, 2019). Ripple (XRP) is the only cryptocurrency that does not use Blockchain[2]. XRP was developed and launched in 2012 by a company with the same name, aiming to create a simplified, decentralized payment system using blockchain-inspired technology to facilitate secure, instant, and cost-effective global financial transactions. This cryptocurrency has been adopted by many banks and consistently ranks among the top five cryptocurrencies by market capitalization (Leising and Robinson, 2018). Despite the existence of thousands of cryptocurrencies on the market, either as substitutes or replicas of BTC, Litecoin (LTC) was the first BTC substitute by presenting a modified version of BTC's core concepts, including the mining algorithm[3] (Tu and Xue, 2019). The first BTC replica was Bitcoin Cash (BCH), which entered a new blockchain ledger on August 1st, 2017. However, BCH shared the same ledger and user base as BTC prior to that date. This replica avoided the high costs associated with attracting new users and, therefore, gained recognition more easily (Tu and Xue, 2019).

This research aims to extend the existing body of literature by providing novel insights into the cryptocurrency market. Instead of focusing solely on established features, the study seeks to identify and highlight the unique factors that position cryptocurrencies as potential alternatives to traditional currencies. The subsequent sections will delve into a detailed analysis of the profitability, volatility, and market integration of the top ten cryptocurrencies, offering a nuanced perspective on their performance.

The main contributions of this study can be summarized as follows:

1. Clarifying the characteristics of cryptocurrencies and their advantages and disadvantages.
2. Identifying novel reasons supporting the potential of cryptocurrencies as alternatives to traditional currencies.
3. Analyzing the profitability and volatility of the top ten cryptocurrencies.

4. Assessing the integration of cryptocurrencies into the financial market using a dynamic equicorrelation model.
5. Investigating the determinants influencing equicorrelation among cryptocurrencies.

These contributions align with the aim of this study to provide a more nuanced and insightful understanding of the cryptocurrency market.

For the study ten top cryptocurrencies were selected and analyzed. We considered the integration of these cryptocurrencies in the market from June 2nd, 2016, to May 25th, 2021. A Dynamic EquiCorrelation (DECO) Model was used to analyze these cryptocurrencies and infer market integration. We also applied this model to calculate the correlation among the cryptocurrencies. This full study consists of two components. The first component involves estimating the dynamic equicorrelation among the cryptocurrencies, which is dynamic because it varies over time. The second component aims to identify the determinants of this equicorrelation.

The paper is divided into five sections. The first section serves as an introduction to the research topic, outlining the objectives, research methodology, and the overall structure of the document. The second section of the paper is dedicated to a literature review, focusing on four specific top cryptocurrencies available in the market: Bitcoin, Ethereum, Ripple, and Litecoin. In the third section, the adopted methodology for the empirical study is discussed, providing an explanation of the DECO model and its estimation process. Moving on to the fourth section, the empirical analysis is presented, which includes details about the data sample, procedure, and results. The analysis primarily revolves around the application of the DECO model to calculate the correlation among the cryptocurrencies. Finally, in the fifth and final section, the paper concludes with the main findings, limitations of the current work, and suggestions for future research.

2. CRYPTOCURRENCIES

Cryptocurrency is a term that is not widely known in general, but it has gradually been capturing the attention of people and potential investors. However, it is a topic that has significant global emphasis. In recent years, there has been a prominent growth in new technologies, which in turn require a restructuring of the economy (Ma *et al.*, 2020). Cryptocurrencies are extremely attractive to investors due to various factors, including their transparency, trading speed, high liquidity, and ease of use (Zhang and Gregoriou, 2020). In 2012, the European Central Bank (ECB) defined virtual currency as a type of unregulated digital money that is electronically generated, issued and controlled by its developers, and used and accepted within a specific virtual community (Paulino and Mendonça, 2019). Cryptocurrencies were designed to become an alternative to the gaps created by financial institutions (Nakamato, 2009). Currently, there are more than 13,000 cryptocurrencies contributing to a total market capitalization of over $574 billion. Ether (ETH), Tether (USDT), Ripple (XRP), Chainlink (LINK), BCH, Litecoin (LTC), and Bitcoin (BTC) are some of the over 4,000 cryptocurrencies existing worldwide. It is worth noting that BTC stands out as having the largest market capitalization and the highest unit value. We can consider cryptocurrencies as a medium of exchange, meaning it is a mechanism that can be used to pay someone or settle a debt or financial obligation.

2.1 Bitcoin

There have been several attempts to create a centralized system to facilitate the exchange of virtual currency. Bitcoin emerged as a decentralized solution, as its creator, who identified themselves by the pseudonym Satoshi Nakamoto, believed that success could only be achieved through the decentralization of digital money (McKay and Peters, 2018). BTC is a peer-to-peer payment system created in 2009 by Nakamoto. It is the first open-source digital currency, operating on a software algorithm that utilizes the global internet network to record and verify transactions (Hanif *et al.*, 2023). As a cryptocurrency, it operates on the principles of cryptography to control the creation and exchange of BTC. Accessing the network requires downloading software and joining the BTC network, enabling participants to perform operations, update transactions, and verify them (Ciaian *et al.*, 2016). On October 9th, 2009, during the early transactions, the exchange rate between BTC and the U.S. dollar was established based on the cost of electricity required to generate 1 BTC. It was estimated that 1 USD would be equivalent to 1309.03 BTC. On January 12, 2009, the first virtual BTC transaction took place between Satoshi Nakamoto, the programmer, and Hal Finney, a cryptographic activist (Paulino and Mendonça, 2019). While Bitcoin is a virtual currency, it resembles traditional money in certain aspects. However, it possesses unique characteristics. Unlike traditional currencies controlled by monetary authorities, BTC challenges this notion. This cryptocurrency is not controlled by any authority; the money belongs 100% to the individual who possesses it, with no possibility of being moved by third parties. To prevent counterfeiting or duplication, an advanced cryptographic system is employed, given that it operates as a decentralized currency (Amoza *et al.*, 2014). There are some differences between the traditional banking payment system and the cryptocurrency payment system, but there are also some similarities. In the banking payment system, one needs to possess an account number with a specific banking institution. The entity provides a bank card and a PIN code to facilitate transactions. The PIN code is essential for using the card, serving as a security measure and a way to prove ownership of the bank account. Additionally, the bank keeps a record of transactions made by its customers. Finally, a person can use an electronic communication system to identify themselves as the account holder and request the transfer of funds associated with their account number to another person's account in a different bank (Silva *et al.*, 2020). On the other hand, in the cryptocurrency payment system, instead of having an account number as in the traditional banking system, a person wishing to make a payment using cryptocurrency has a public address. They control this public address using a private key, similar to a PIN number. To make payments using cryptocurrency, the use of an electronic communication system, specifically the internet, is essential to identify the network and request digital tokens associated with their public address to be transferred to another person's public address. This process is facilitated by changes made in the blockchain ledger by a group of participants known as miners, who use their computational power to validate transactions. In summary, both parties controlling the public addresses can see these changes, providing proof that tokens have been transferred from one address to another (Silva *et al.*, 2020). Despite the various benefits that BTC presents, there are some disadvantages to consider. One of these is its considerable price volatility throughout its existence (Brito and Castillo, 2013; Charfeddine *et al.*, 2022). Public key cryptography requires that each user receives two keys: a private key, which is confidential, and a public key known to all users (Brito and

Castillo, 2013). The owner transfers a certain amount of BTC to a specific person by digitally signing a hash of the previous transaction and the public key of the next owner. A recipient can validate the signatures to verify the chain of ownership (Nakamato, 2009). In conclusion, Bitcoin, as the pioneering cryptocurrency, boasts a decentralized and transparent ledger system based on blockchain technology. Its decentralized nature, achieved through a proof-of-work consensus mechanism, enhances security and mitigates the risk of centralized control. Bitcoin's fixed supply and deflationary nature contribute to its appeal as a store of value. However, concerns arise regarding its scalability and environmental impact due to energy-intensive mining processes (Karaömer, 2022).

2.2 Ether

Blockchain is one of the largest public platforms that supports smart contracts. ETH, known as Ether, was introduced to facilitate the implementation of smart contracts as this cryptocurrency introduces the concept of an account, which is formally an address. ETH is used to compensate the mining nodes of participants (Hasan *et al.*, 2022). Currently, the interactive relationship between users and smart contracts is still unknown, as current research on this cryptocurrency is centralized around security and performance issues of blockchain technology (Lin *et al.*, 2020). After the implementation of smart contracts on the blockchain, and also due to the immutability of the code, security becomes a particularly serious concern. Therefore, the presence of a bug or vulnerability in the code can be very critical, as it cannot be corrected and may result in financial losses for the owner of the buggy contract (Staderini *et al.*, 2020). In 1997, Szabo introduced the concept of smart contracts. These smart contracts, due to their ability to automatically execute computerized transactions according to external and internal conditions, were considered the major innovation presented in the second generation of blockchain technology (Staderini *et al.*, 2020). Smart contracts differ from traditional contracts because they are computable, meaning they are programs used to verify and enforce the terms of a particular agreement, which improves their security and reduces costs (Bistarelli *et al.*, 2020). Through a complete Turing language, ETH smart contracts can be programmed, including a powerful set of tools for their development. In the Ethereum platform, an immutable version of a compiled smart contract can be deployed and executed using the ETH virtual machine (Correas *et al.*, 2021). The unit of measurement used for the execution of smart contracts is gas units. Miners receive a certain amount of ether that comes from applying a gas price to the total amount of gas required to complete a transaction (Correas *et al.*, 2021). In conclusion, Ether operates on the Ethereum blockchain and distinguishes itself by facilitating smart contracts. This feature enables the creation of decentralized applications (DApps) and decentralized autonomous organizations (DAOs). While Ethereum's programmability enhances its utility, challenges include scalability issues and the transition to a proof-of-stake consensus, aiming to address environmental concerns associated with proof-of-work.

2.3 Ripple

Just like BTC, XRP is a peer-to-peer network, but it operates on a mutual credit system. Ripple is not only the name of the cryptocurrency, but also the name of the company that acquired the Ryan Fugger's Ripple project. Fugger transferred the rights of the name Ripple to

the start-up OpenCoin in 2012, but in 2013 the name was changed again to Ripple Labs, and finally in 2015 to Ripple (Rella, 2020). In 2013, the founders of the Ripple developed the Ripple Ledger, which combined with Fugger's credit network, resulted in a distributed currency exchange on a ledger inspired by blockchain technology. In 2015, Ripple shifted its focus to cross-border interbank payment services for financial institutions (Rella, 2020). According to "Global: Another Cryptocurrency Causes Ripples"[4], XRP is a cryptocurrency not tied to the dollar, allowing the XRP platform to seek the shortest path through numerous clients buying and selling their distinct currencies[5] to complete the transaction. XRP and its potential successors will drive the adoption of blockchain technology with the goal of processing international payments. In 2017, according to Leising and Robinson (2018), there was a surprising increase in the value of the XRP cryptocurrency between late September and early January 2018. Ripple began exploring business ideas around XRP at a time when there was little guidance on digital tokens[6] (Jeff, 2020). XRP offers faster transaction processing for transfers between two countries and aims to reduce or even eliminate fees for cross-border transfers (Adams, 2021). One advantage of XRP over BTC is that XRP can typically complete transfers in three to five seconds, while BTC can take up to forty minutes to process a transfer (Kauflin, 2014). Nowadays, international payments are generally made using the SWIFT network[7], which is the international mechanism through which most banks communicate to conduct transactions. However, banks show little interest in using XRP due to the low likelihood of their customers trusting cryptocurrency payments (Leising and Robinson, 2018). In conclusion, Ripple stands out with its focus on facilitating fast and cost-effective cross-border transactions. The Ripple network employs a consensus algorithm, providing quick settlement times. However, centralization concerns arise due to a more controlled validation process involving trusted nodes. The XRP cryptocurrency is designed to minimize volatility in value during transactions, emphasizing stability but raising questions about decentralization.

2.4 Litecoin

Currently, in the cryptocurrency market, there are several replicas of BTC. However, LTC was created with the intention of replacing BTC by implementing an alternative platform to attract its own users (Tu and Xue, 2019). LTC is based on an open-source protocol and is also not governed by any central authority. This cryptocurrency was introduced on October 7th, 2011, and is currently one of the largest cryptocurrencies, with a total market capitalization of over 15 billion U.S. dollars[8]. However, LTC has some gaps in terms of privacy protection (Zhang *et al.*, 2020). LTC is a peer-to-peer cryptographic currency inspired by BTC. Both do not require the assistance of financial organizations, making them similar. LTC is electronically transferred with significantly reduced transaction fees (Padmavathi and Suresh, 2019). However, according to (Zhang *et al.*, 2020), it has three distinct differences from BTC:

- It provides faster transaction confirmation times than BTC since the block time interval is 2.5 minutes.
- LTC issues four times more coins than BTC.
- LTC uses the encryption algorithm proposed by Percival, making it more accessible to common computer miners.

The creation of LTC involves the mining process, which consists of solving mathematical problems using computers, and the successful computer receives the LTC

(Padmavathi and Suresh, 2019). Just like BTC, LTC transactions are also recorded on the blockchain. LTC uses the scrypt algorithm, as the initial purpose of using this algorithm was to allow miners to mine both cryptocurrencies simultaneously. This algorithm utilizes a sequential memory-hard function, meaning it contains more memory than a memory-less algorithm. Although the scrypt algorithm offers dual resistance to attacks within the same time frame, it has the drawback of increasing orphaned blocks and the size of the blockchain (Padmavathi and Suresh, 2019). In conclusion, often considered the silver to Bitcoin's gold, Litecoin shares similarities with Bitcoin but offers faster transaction confirmation times. Its adoption of the Scrypt algorithm aims to make mining more accessible. While Litecoin provides a faster and more scalable alternative, questions persist about its ability to differentiate significantly from Bitcoin and secure a distinct market niche.

A critical examination of leading cryptocurrencies reveals common challenges (Kumar *et al.*, 2022). Scalability concerns, energy consumption in proof-of-work systems, and centralization risks underscore the need for continuous innovation. Additionally, the speculative nature of cryptocurrency markets and price volatility present challenges for their mainstream adoption. Regulatory uncertainties and potential governance issues further contribute to the complex landscape. Ultimately, while leading cryptocurrencies offer unique features, their limitations and challenges warrant a critical perspective. Ongoing efforts to address scalability, environmental impact, and governance issues are crucial for the sustained evolution and broader acceptance of cryptocurrencies in the financial landscape. A balanced approach that acknowledges both strengths and weaknesses is essential for informed discussions on the role of cryptocurrencies in the future of finance (Łęt *et al.*, 2023).

2.5 Blockchain

There are two types of blockchains: public and private. In the public blockchain anyone can participate, unlike in the private blockchain. This decentralized system has a ledger that records all transactions, which can be referred to as nodes or parties (Lucas and Paez, 2019). Originated from the cryptocurrency BTC, Blockchain[9] aims to provide anonymous exchange of digital money through its decentralized system (Prybila *et al.*, 2020). Validating transactions in this decentralized system posed a challenge since there is no centralized entity or authority. As mentioned, blockchain is a public ledger that stores all transactions since the creation of BTC. A payment transfer can be made by deducting the balance in the ledger of the person making the payment while increasing the balance in the ledger of the recipient (Prybila *et al.*, 2020). Blockchain is a new type of infrastructure that integrates technologies, including data storage, forming a chain of blocks, each containing a set of transactions that provide transaction confirmations to users and verify ownership rights of BTC. Once a block is added to the blockchain, it is extremely difficult to alter or remove. As new transactions are processed, the blockchain is extended (Zaghloul *et al.*, 2020). The main characteristics of a blockchain network are consensus, provenance, and immutability. Consensus is necessary for a transaction to be valid, requiring agreement among all participants. Provenance ensures that all participants know the history of the asset. Lastly, immutability means that a transaction cannot be altered once recorded in the ledger. In the case of an incorrect transaction, the only way to reverse it is by creating a new transaction, and both transactions will be visible (Case *et al.*, 2020). This cryptographic technology is used to ensure the security of data transmission and access. Smart contracts,

composed of automated script codes, are used to program the data. Due to the integration of various technologies, the cluster jointly maintains the security and operation of the blockchain network and builds trust with machines (Li and He, 2020). To carry out a double-spending attack, an attacker would need to control more than 51% of the computational power of the internal network. Otherwise, executing a double-spending attack becomes infeasible. A miner is a computer connected to the internet that verifies the transactions that have been conducted. Miners assess the legitimacy of each transaction as part of the mining process by timestamping each transaction and determining if there has been any double-spending (Ferreira *et al.*, 2017). Virtual currencies need to achieve price stability in the market if they are intended to be used as a means of payment and not just for investment purposes. Due to their significant price volatility, which tends to rise in the long term and fluctuate widely in the short term, they are not considered the most suitable method of payment. Because of this volatility, people are incentivized to hold these currencies with the intention of gaining profits in the future. If used as a means of payment, there is a risk of losing money due to their instability (Saito and Iwamura, 2018).

3. METHODOLOGY

In the early 1980s, the first volatility models were developed. In fact, volatility has always attracted significant attention in finance (Aboura and Chevallier, 2014). The search for reliable correlation estimates between financial variables has been a motivation for the development of academic papers, professional conferences, among others (Engle, 2002). Currently, in terms of risk management, it is highly significant to have the ability to estimate high-dimensional asset matrices. However, several numerical problems arise for classical multivariate Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models (Aboura and Chevallier, 2014). The Dynamic Conditional Correlation (DCC) model aims to be implemented in large-scale systems. This model has only been successfully applied in studies containing up to 100 assets, as the estimation becomes increasingly challenging with the increase in the system's size (Engle and Kelly, 2012). The DCC first estimates univariate GARCH models to calculate conditional variances and standardized residuals. In the second stage, it estimates the conditional correlation. Thus, this model is estimated in two steps (Aboura and Chevallier, 2014). The Dynamic EquiCorrelation (DECO) model was chosen for the present study. Unlike the DCC model, the DECO model can support a large set of variables without encountering estimation issues due to numerical problems (Bouri *et al.*, 2021). GARCH models are ubiquitous for estimating the conditional volatility of time series data. This model is particularly important because it continues to generate extensions of existing models. These extensions allow researchers to choose the model that best fits their needs (Yelamanchili, 2021). DECO model is a competitor of DCC model as it possesses features that the DCC lacks. The correlations in the DECO model are based on broader information, while the DCC model falls short in that regard as it relies on a more limited set of information (Engle and Kelly, 2012). The DECO model assumes that the mean of the conditional correlation can vary over time and is equal to the average of all correlation pairs. By applying this model, a correlation between cryptocurrencies is obtained, which can vary over time. This model first adjusts the individual volatility of cryptocurrencies and then estimates the correlations (Engle and Kelly, 2012).

3.1 Dynamic Equicorrelation Model

Let R_t be an n × 1 vector of cryptocurrency returns, i.e. $R_t = [R_{1t,}R_{2t}, \dots, R_{nt}]'$, assumed to have a normal distribution.

$$R_t|I_{t-1} \sim N(0, H_t) \tag{1}$$

According to Engle (2002), the conditional covariance matrix H_t can be decomposed as follows:

$$H_t = D_t R_t D_t \tag{2}$$

$$\varepsilon_t = H^{1/2} z_t \tag{3}$$

$$R_t = \left[diag(Q_t)^{-1/2}\right] Q_t \left[diag(Q_t)^{-1/2}\right] \tag{4}$$

where D_t is a diagonal matrix containing the conditional standard deviations from the univariate GARCH models, R_t corresponds to the time-varying conditional correlation matrix, ε_t is an n × 1 vector of conditional residuals based on information up to time *t-1*, z_t denotes an n × 1 vector of standardized residuals, and Q_t is the conditional correlation matrix of the standardized residuals.

In the first stage, it is necessary to estimate the matrix $D_t = diag\sqrt{\{H_t\}}$, a diagonal matrix with the conditional variances of each of the returns along the main diagonal. The elements of the matrix H_t are calculated using the following univariate GARCH (1,1) model:

$$h_{i,t} = \omega_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i h_{i,t-1} \tag{5}$$

where $h_{i,t}$ corresponds to the conditional variance of each return series, ω_i is a constant term, α_i controls the ARCH effect, and β_i measures the persistence of the volatility process. To ensure that the conditional variances are positive and stable, the following conditions must be satisfied: $\alpha_i > 0$ and $\alpha_i + \beta_i < 1$. After estimating the univariate GARCH process, the standardized residuals z_t are used to estimate the parameters of the conditional correlation.

The dynamics of Q in the DCC process is given by:

$$Q_t = (1 - \theta_1 - \theta_2)\bar{Q} = \theta_1 z_{t-1} z'_{t-1} = \theta_2 Q_{t-1} \tag{6}$$

where θ_1, θ_2 and φ are parameters, $n_t = I(z_t < 0) \circ z_t$ is a functional indicator that takes the value 1 if the argument is true and 0 otherwise, and "○" denotes the Hadamard product.

$\bar{Q}_j = E[z_t z'_t]$ and $\bar{N}_j = E[n_t n'_t]$ are the unconditional correlation matrices of z_t and n_t, respectively.

The time-varying conditional correlation matrix R_t is given by:

$$R_t = Q_t^{*-1} Q_t Q_t^{*-1} \tag{7}$$

where Q_t^* is a diagonal matrix with the square root of the i-th diagonal of Q_t in the i-th position of its diagonal, and can be written in the following form:

$$R_t = \begin{pmatrix} 1 & \bar{\rho_t} & \cdots & \bar{\rho_t} \\ \bar{\rho_t} & 1 & \cdots & \bar{\rho_t} \\ \vdots & \vdots & \ddots & \vdots \\ \bar{\rho_t} & \bar{\rho_t} & \bar{\rho_t} & 1 \end{pmatrix}$$

or alternatively, in the following equivalent form,

$$R_t = (1 - \bar{\rho_t}) I_n + \bar{\rho_t} J_n \tag{8}$$

where I_n is the identity matrix of order n, J_n denotes the n-by- n matrix of ones, and $\bar{\rho_t}$ represents the equicorrelation given by:

$$\bar{\rho_t} = \frac{2}{n(n-1)} \sum_{i \neq j} \rho_{ij,t} = \frac{2}{n(n-1)} \sum_{i \neq j} \frac{q_{ij,t}}{\sqrt{q_{ii,t} q_{jj,t}}}. \tag{9}$$

The scalar DECO model is defined as follows:

$$Q_t = (1 - \alpha - \beta)\bar{Q} + \alpha e_{t-1} e'_{t-1} + \beta Q_{t-1} \tag{10}$$

By modeling the equicorrelation of returns in this way, we obtain a time series that can be used to determine the main factors that affect this equicorrelation. This analysis can be carried out using a multiple linear regression model, where these factors are included as explanatory variables:

$$Equicorrelation_t = b_0 + \sum_{i=1}^{n} b_i X_{i,t} + e_t \tag{11}$$

3.2 Data Description

The empirical study focused on the analysis of ten cryptocurrencies, namely Bitcoin, Dash, Dogecoin, Ether, Litecoin, Monero, Nem, Ripple, Stellar and Waves. The first and most well-known cryptocurrency, Bitcoin (BTC) operates on a decentralized network using blockchain technology. It serves as a peer-to-peer digital currency without the need for intermediaries. Dash (DASH), short for "digital cash," focuses on fast and private transactions. It offers features like PrivateSend and InstantSend, aiming to make cryptocurrency transactions both secure and quick. Originally started as a meme, Dogecoin (DOGE) has become a popular cryptocurrency. It features a Shiba Inu dog from the "Doge" meme and is often used for tipping and charitable donations. The native cryptocurrency of the Ethereum platform, Ether (ETH) is not just a digital currency but also fuels smart contracts and decentralized applications (DApps) within the Ethereum ecosystem. Created as the "silver to Bitcoin's gold," Litecoin (LTC) is a peer-to-peer cryptocurrency that offers faster transaction confirmation times. It shares many similarities with Bitcoin but with some technical differences. Monero (XMR) focuses on privacy and anonymity. It employs advanced cryptographic techniques to ensure private, untraceable transactions, making it a preferred choice for users seeking enhanced privacy. NEM (New Economy Movement) (XEM) is a blockchain platform that aims to provide customizable blockchain solutions. It offers features like the harvesting of coins and a unique consensus algorithm. Ripple (XRP) is both a cryptocurrency and a technology designed for seamless, fast, and cost-effective cross-border payments. It aims to facilitate international transactions between financial institutions. Stellar (XLM) is a decentralized platform designed to facilitate fast, low-cost cross-border payments and transactions. It aims to connect people, banks, and payment systems to make money more fluid. Waves (WAVES) is a blockchain platform that enables the creation and transfer of custom blockchain tokens. It emphasizes user-friendly token creation and decentralized exchange capabilities.

4. EMPIRICAL STUDY

4.1 Data Analysis

The empirical study focused on the analysis of ten cryptocurrencies, namely Bitcoin, Ether, Dash, Ripple, Stellar, Waves, Monero, Dogecoin, Litecoin, and Nem, as presented in Table no. 1. The daily prices of these cryptocurrencies were extracted from the website https://coinmarketcap.com/. These cryptocurrencies were chosen from the more than 13,000[10] virtual currencies existing in the cryptocurrency market, conditioned by the start of Ether's price history. The sample period spans from June 2nd, 2016, to May 25th, 2021, considering a relevant period of ups and downs in the cryptocurrency market. The empirical analysis was conducted using logarithmic returns multiplied by 100, resulting in a total of 1819 observations.

The plots in Figure no. 1 show the evolution of the price of the ten cryptocurrencies under study and the evolution of their returns. In March 2020, due to the COVID-19 pandemic, there was a noticeable decline in the returns of all cryptocurrencies. However, the market has shown the ability to recover quickly (Demiralay and Golitsis, 2021).

Table no. 1 – Cryptocurrencies used in the empirical study

Name	*Acronym*	*Cost (USD)*[11]	*Market capitalization (USD)*
Bitcoin	BTC	61,820.0	1.15T[12]
Dash[13]	DASH	198.41	2.03B
Dogecoin	DOGE	0.30	38.31B
Ether	ETH	2,431.70	281.36B[14]
Litecoin	LTC	318.37	21.21B
Monero[5]	XMR	271.74	4.89B
Nem[5]	XEM	0.2054	1.87B
Ripple	XRP	1.65	74.34B
Stellar	XLM	0.3744	47.87B
Waves[5]	WAVES	26.18	9.04B

Table no. 2 presents the statistical summary of daily returns of the ten cryptocurrencies in the considered period.

The ADF test was conducted with a constant and a lag length determined according to the autocorrelation plot, which is found in Appendix A. In this test, the null hypothesis assumes that the series is non-stationary. In this case, if the test statistic value is less than -2.86 (value for a sample size larger than 500), the null hypothesis is rejected. Looking at Table 2, we can see that the ADF test statistic value is always less than -2.86, thus rejecting the null hypothesis and concluding that the series is stationary.

The Jarque-Bera test is a statistical test that checks whether the sample data has symmetry and kurtosis similar to a normal distribution (null hypothesis: the data follows a normal distribution). The Jarque-Bera test statistics indicates that all return series are not normally distributed.

Table no. 2 – Statistical summary of daily returns and stationarity test.

	Mean	**Min.**	**Max.**	**SD**	**Asymmetry**[15]	**Kurtosis**[16]	**Jarque Bera**	**ADF Statistic**	**ARCH-LM p-value**
Bitcoin	0.235	-46.47	22.51	4.13	-0.80	11.88	10.915***	-44.0***	0.0000
Dash	0.175	-46.55	45.13	6.24	0.50	9.75	7,299.1***	-29.7***	0.0000
Dogecoin	0.402	-51.49	151.62	8.09	4.54	76.66	452,423***	-41.2***	0.0000
Ether	0.291	-55.07	29.01	5.73	-0.54	8.85	6,043.2***	-23.5***	0.0000
Litecoin	0.201	-44.90	51.03	5.96	0.37	11.20	9,563.1***	-43.5***	0.0000
Monero	0.307	-53.42	58.46	6.43	0.40	12.13	11,224***	-30.5***	0.0000
Nem	0.251	-42.27	99.54	7.66	1.80	22.11	38,090***	-32.6***	0.0000
Ripple	0.282	-61.64	102.75	7.44	2.09	32.39	80,962***	-43.8***	0.0000
Stellar	0.311	-41.00	72.32	7.83	1.88	16.33	21,317***	-29.0***	0.0000
Waves	0.143	-73.44	45.03	7.56	-0.70	11.51	10,220***	-42.0***	0.0000

Note: "***" indicates the rejection of the null hypothesis at the 0.1% level for both the Jarque-Bera normality test and the Augmented Dickey-Fuller unit root test.

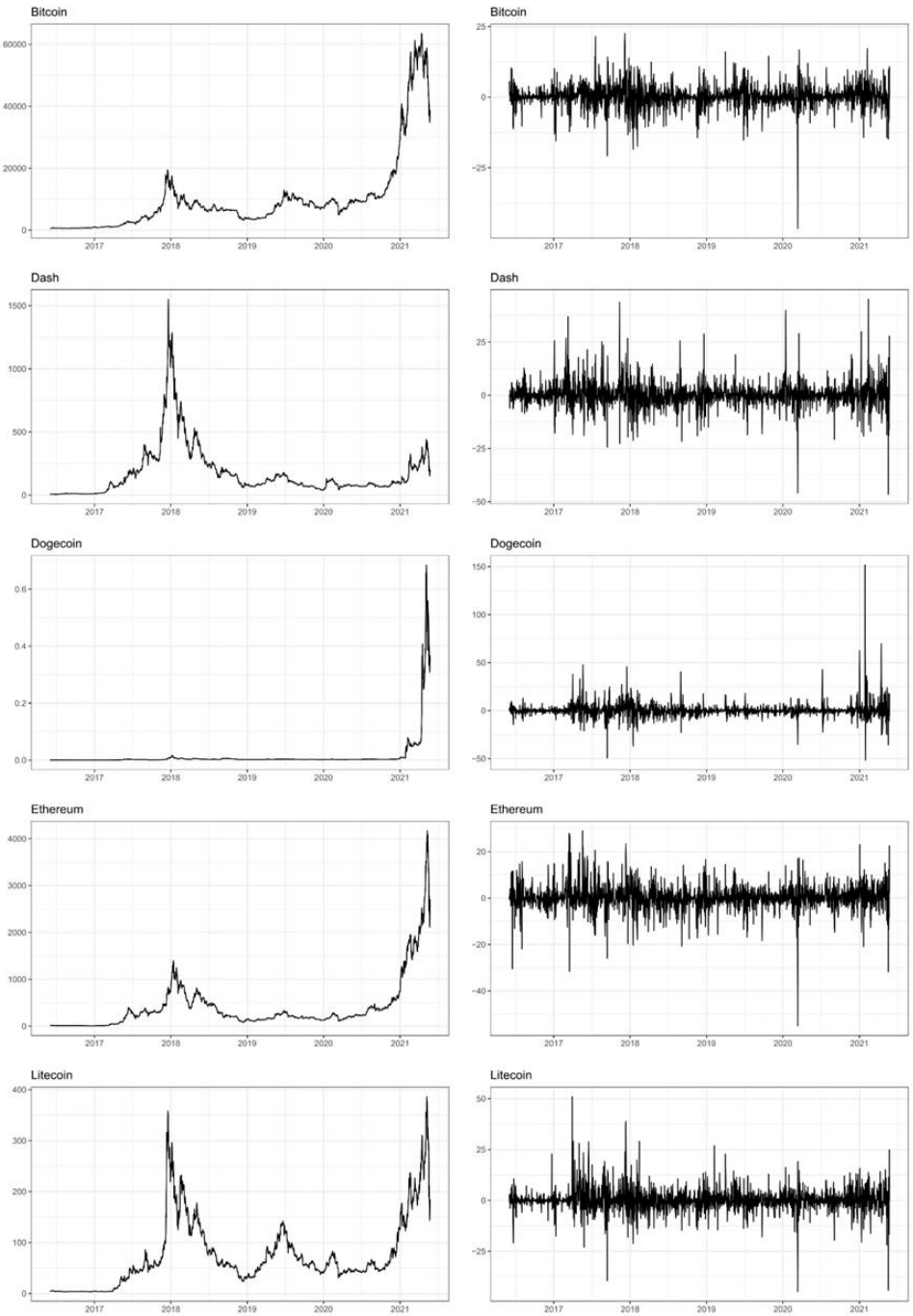

Figure no. 1 – Cryptocurrencies' price (on the left) and return (on the right)

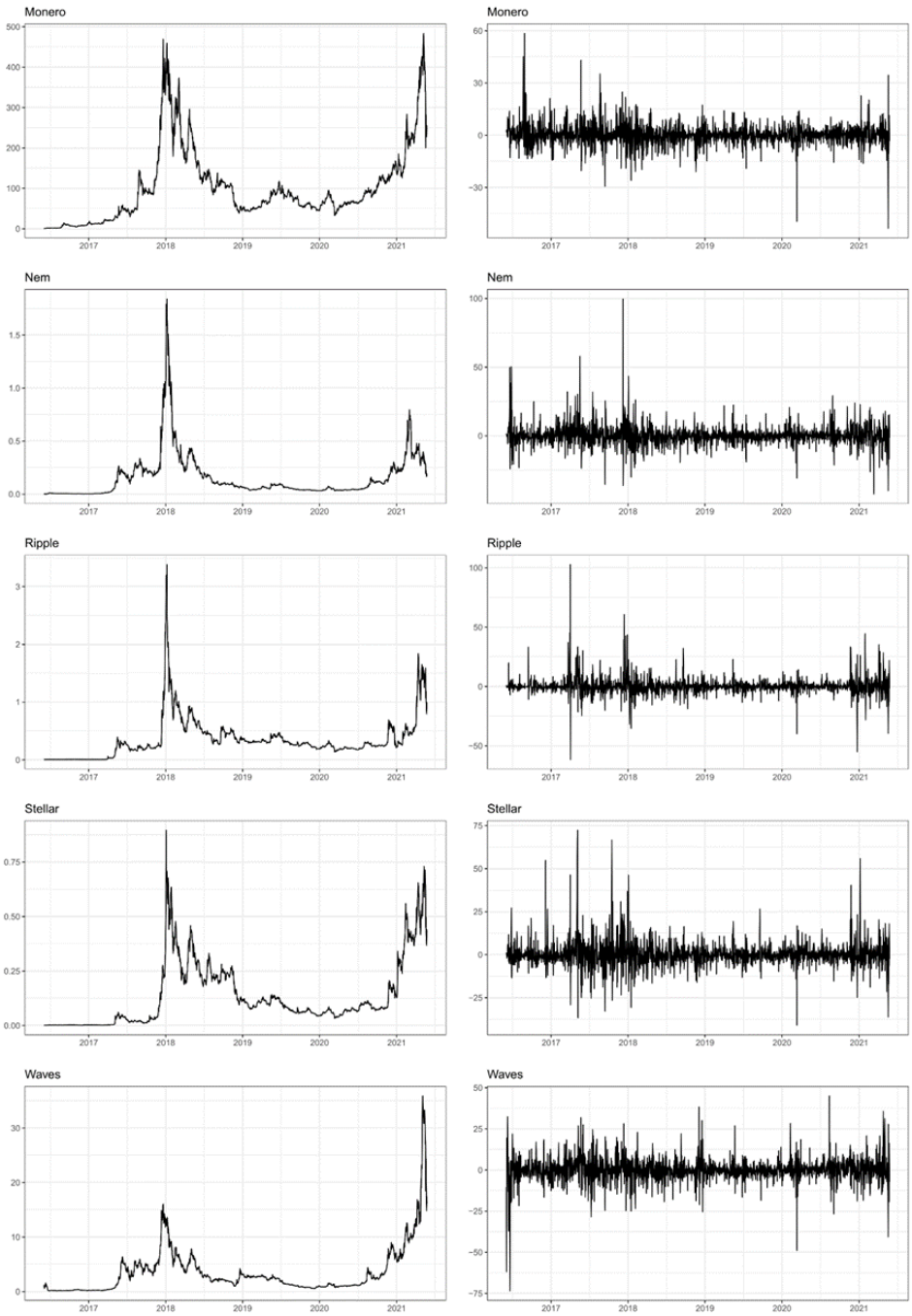

Figure 1 – Cryptocurrencies' price (on the left) and return (on the right) (*continued*)

The ARCH-LM test was used to test for the presence of heteroscedasticity. When the null hypothesis is rejected, which is the case here, it means there are no ARCH effects, indicating that heteroscedasticity was accounted for by the GARCH model.

We can observe that Dogecoin (DOGE) and Stellar (XLM) provide higher average returns compared to other cryptocurrencies. BTC is the least volatile, unlike DOGE, which is the most volatile. Analyzing the risk-adjusted return, we can see that DOGE and Stellar are more attractive, while Dash and Waves are less attractive. It is notable that the skewness values are mostly positive, indicating that nearly all cryptocurrencies exhibit positive skewness, except for BTC, Ether (ETH), and Waves. Lastly, it is worth mentioning that all return series have high kurtosis, especially DOGE.

Table no. 3 presents the Pearson correlation matrix of the returns for the ten cryptocurrencies studied, during the sampling period. We can observe a generally high linear association among the different cryptocurrencies. The correlations are positive and range from 0.3066 (Waves/Dogecoin) to 0.6776 (Litecoin/Bitcoin).

Table no. 3 – Correlation matrix of daily returns

	Bitcoin	**Dash**	**Dogecoin**	**Ether**	**Litecoin**	**Monero**	**Nem**	**Ripple**	**Stellar**	**Waves**
Bitcoin	1.0000									
Dash	0.5727	1.0000								
Dogecoin	0.4461	0.3645	1.0000							
Ether	0.6440	0.5931	0.4021	1.0000						
Litecoin	0.6776	0.5841	0.4541	0.6332	1.0000					
Monero	0.5984	0.6168	0.3631	0.5699	0.5646	1.0000				
Nem	0.4683	0.4490	0.3422	0.4819	0.4734	0.4326	1.0000			
Ripple	0.4039	0.3823	0.3558	0.4361	0.4691	0.3945	0.3960	1.0000		
Stellar	0.4550	0.4247	0.4153	0.4760	0.4832	0.4703	0.4784	0.6137	1.0000	
Waves	0.5032	0.4408	0.3066	0.4962	0.4830	0.4513	0.3584	0.3180	0.3805	1.0000

4.2 DECO Model Results

Table no. 4 presents the DECO model estimates for the returns of the ten cryptocurrencies. In the first step, the GARCH (1,1) model specified in Equation (5) was estimated for each return, while in the second step, the equicorrelation value was estimated using Equation (11).

Table no. 4 – DECO model estimates for cryptocurrency returns

Step II: DECO	α	β	
Returns	0.0223***	0.9717***	
Step I: GARCH(1,1)	ω	α	β
Bitcoin	0.7982**	0.1570***	0.8187***
Dash	2.0521***	0.2564***	0.7425***
Dogecoin	0.3936	0.0854***	0.9135***
Ether	2.7617***	0.1711***	0.7604***
Litecoin	1.5786	0.0738***	0.8855***
Monero	1.6844***	0.1523***	0.8276***
Nem	4.6333	0,3456	0.6533***
Ripple	4.4816**	0.4078***	0.5911***
Stellar	3.3766*	0.2312***	0.7492***
Waves	2.7221*	0.2717***	0.7241***
Log-likelihood	-51386.82		

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

The sum of the parameters α (0.0223) and β (0.9717) close to 1 suggests a high persistence of conditional covariance, which indicates a strong correlation between the cryptocurrencies and implies integrated equicorrelation. Additionally, both α and β parameters are statistically significant. Since this study focuses on equicorrelation, we will not delve into the coefficients of the GARCH model. However, it can be generally mentioned that they are positive and statistically significant.

Figure no. 2 displays the estimation results of the DECO model, representing the estimated correlation of returns over time. We can immediately conclude that the estimated equicorrelations are highly volatile and exhibit an increasing trend over time. Note that the term "equi" indicates that the correlation at each moment is equal to the average of all pairs of correlations. By averaging all pairs of correlations, the model assumes that the average correlation represents the global correlation. Between mid-2016 and late 2017, there is a decrease in cryptocurrency returns, which may have been influenced by the Bitfinex hack that occurred in August 2016 (Demiralay and Golitsis, 2021). However, in 2017, there is an upward trend until mid-2018. According to Demiralay and Golitsis (2021), the Coincheck hack occurred in January 2018, leading to an increase in correlation until mid-2018. Subsequently, there is another downward trend that extends until the beginning of 2020. In early 2020, there is a sharp increase, which could possibly be associated with speculative market movements, potentially related to the onset of the COVID-19 pandemic that disrupted the market. However, the market quickly realizes that it is an artificial surge and begins to correct. As a result, there is a sharp decline until the end of 2020. From 2021 onwards, a consistent recovery is observed until May 2021. Overall, there is a high correlation ranging between 0.2 and 0.8.

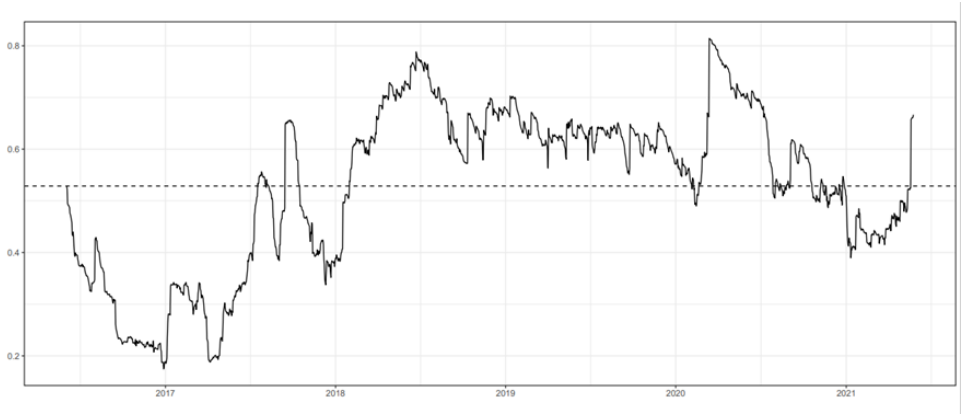

Figure no. 2 – Equicorrelation of returns

4.3 Determinants of the Equicorrelation

To investigate the main determinants/drivers of equicorrelation, a multiple linear regression model was estimated, incorporating several explanatory variables, namely: trading volume, global stock index, energy price, gold price, economic policy uncertainty,

financial stress, and US implied volatility index. These variables were motivated by similar previous studies (Balcilar *et al.*, 2017).

$$Equicorrelation_t = b_0 + \sum_{i=1}^{10} b_i \ln(TV_{i,t}) + b_{11}GEI_t + b_{12}EN_t + b_{13}GLD_t + b_{14}EPU_t + b_{15}FSI_t + b_{16}VIX_t + e_t \quad (12)$$

where,

- TV (Trading Volume) represents the trading volume of each of the ten cryptocurrencies (i.e., the amount of assets traded daily).
- GEI (Global Equity Index) denotes the global stock index[17] (evaluated through theoretical portfolios of stocks). It is based on the performance of these stocks, which represent a significant portion of the stocks traded on a particular exchange, allowing the overall performance of the stock market to be measured. In summary, the global equity index serves as a basis for investors to analyze the performance of their business portfolio.
- EN (Energy Price) denotes the price of energy.
- GLD (Gold Price) denotes the price of gold.
- EPU (Economic Policy Uncertainty) denotes the uncertainty of economic policy.
- FSI (Financial Stress Index) denotes the implied volatility index of the United States.
- VIX (US Implied Volatility Index) corresponds to the financial stress index.

This data was extracted from the Thomson Reuters program. Unlike the trading volume of each of the ten cryptocurrencies, which is available daily, seven days a week, the global stock index, gold price, energy price, US implied volatility index, and financial stress index are only available for five days a week. To estimate the value of these variables on weekends, a simple linear interpolation method was used.

Table no. 5 presents the results of the least squares estimation of the equicorrelation's regression: considering all explanatory variables (Model 1); considering only the trading volume of each of the ten cryptocurrencies (Model 2); considering only global financial system indicators (Model 3).

As observed in Table no. 5, Model 1, which considers all explanatory variables, shows the highest Adjusted R-squared value. In this model, all cryptocurrencies are statistically significant at least at the 1% level, except for BTC, which is not statistically significant. The variables GEI, EN, GLD, EPU, FSI, and VIX are also statistically significant at least at the 5% level, which reinforces the findings of Bouri et al. (2021) that state the degree of integration among cryptocurrencies mainly depending on TV, EPU, and VIX. In contrast to Bouri *et al.* (2021), our study includes three additional statistically significant variables related to the financial market, namely GEI, EN, GLD, and FSI.

Trading volume is positively related to return equicorrelation for five out of the ten cryptocurrencies. The exceptions are DOGE, LTC, XMR, XEM, and XRP, where the relationship is negative. Thus, our study concludes that the degree of integration among cryptocurrencies primarily depends on trading volume, global stock index, energy price, gold price, financial stress index, and US implied volatility index. This result highlights a

weakened association between the integration of the cryptocurrency market and the financial market. Stakeholders are being influenced by the volume traded between cryptocurrencies rather than economic factors such as EN and GLD.

Table no. 5 – Determinants of the returns' equicorrelation

	Model 1	Model 2	Model 3
ln(Bitcoin)	0.00735	0.05464***	
ln(Dash)	0.02310***	0.02350***	
ln(Dogecoin)	-0.01322***	-0.03640***	
ln(Ether)	0.05692***	0.04297***	
ln(Litecoin)	-0.01577***	-0.01808***	
ln(Monero)	-0.01471***	-0.05268***	
ln(Nem)	-0.01055***	-0.01693***	
ln(Ripple)	-0.01106**	-0.00192	
ln(Stellar)	0.01223***	0.01490***	
ln(Waves)	0.01936***	0.02067***	
GEI	-0.00201***		0.00050*
EN	0.02124***		0.03856***
GLD	0.00018***		0.00025***
EPU	0.00006*		0.00037***
FSI	0.03075***		0.01454***
VIX	-0.00270***		0.00662***
Constant	-0.61200***	-0.420539***	-0.70820***
Ajusted R^2	0.7518	0.6188	0.4597
F Statistic	344.9 (0,00000)	296.0 (0,00000)	258.7 (0,00000)

Note: Statistical significance level codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

The prices among cryptocurrencies are considerably correlated, but this correlation is not justified by economic factors. Instead, it is primarily driven by the trading volume of these cryptocurrencies, indicating a certain level of market maturity. It was surprising to find that the largest cryptocurrency, BTC, did not contribute to this conclusion. However, these results are explained by all other cryptocurrencies, namely DASH, DOGE, ETH, LTC, XMR, XEM, XRP, XLM, and WAVES.

4.4 Discussion

These findings align with and extend prior literature on the factors influencing the degree of integration among cryptocurrencies. Consistent with the work of Bouri *et al.* (2021), our study underscores the significance of certain key variables in understanding cryptocurrency market integration. Specifically, the inclusion of trading volume, global stock index, energy prices, gold prices, financial stress index, and US implied volatility index as statistically significant factors supports and expands upon the observations made by Bouri *et al.* (2021). In comparison to Bouri *et al.* (2021), our study introduces three additional variables – GEI, EN, and GLD – that exhibit statistical significance, contributing to a more comprehensive understanding of the factors influencing cryptocurrency integration. The positive relationship between trading volume and return equicorrelation for the majority of cryptocurrencies is consistent with the notion that heightened trading activity plays a pivotal role in fostering integration. This finding resonates with prior literature

emphasizing the influence of trading volume on market dynamics and inter-asset correlations. Surprisingly, the negative relationship observed in certain cryptocurrencies (DOGE, LTC, XMR, XEM, and XRP) suggests nuanced variations in integration dynamics. This highlights the importance of considering individual cryptocurrency characteristics and behaviors within the broader market context. The conclusion that the correlation among cryptocurrency prices is primarily driven by trading volume rather than economic factors, such as EN and GLD, aligns with existing research emphasizing the distinctive nature of cryptocurrency markets. The unexpected non-significance of BTC in contributing to this conclusion adds an intriguing dimension to the discussion. While BTC is traditionally considered a market leader, its limited influence in this context may indicate that other cryptocurrencies, each with unique attributes, collectively play a more prominent role in determining market correlations. This nuanced insight challenges conventional assumptions and underscores the need for a nuanced understanding of the diverse factors at play in the cryptocurrency landscape. In summary, our results not only confirm but also extend the existing literature on cryptocurrency market integration. The inclusion of additional significant variables and the nuanced relationship between trading volume and correlations contribute to a more comprehensive understanding of the complex dynamics within the cryptocurrency market.

The implications of our findings hold significant relevance for both investors and policymakers in the cryptocurrency space, offering insights that can guide strategic decisions and regulatory considerations. The observed positive relationship between trading volume and return equicorrelation suggests that investors may benefit from diversifying their portfolios based on trading activity. A nuanced understanding of how various cryptocurrencies respond to trading volume can inform investment strategies, allowing investors to optimize risk and return profiles. The finding that price correlations among cryptocurrencies are primarily driven by trading volume rather than economic factors implies a certain level of market maturity. Investors can use this insight to gauge the maturity and stability of the cryptocurrency market, potentially influencing their confidence in allocating assets to this evolving space. The nuanced variations in the relationship between trading volume and correlations for specific cryptocurrencies (DOGE, LTC, XMR, XEM, and XRP) highlight the importance of considering individual cryptocurrency behaviors. Investors may benefit from a tailored approach, taking into account the unique characteristics of each cryptocurrency when constructing their portfolios. Understanding that trading volume plays a central role in driving correlations among cryptocurrencies emphasizes the need for regulators to monitor and potentially regulate trading activities. Policymakers could explore measures to ensure fair and transparent trading practices, mitigating potential risks associated with excessive trading volumes. The observed correlation dynamics provide insights into the factors influencing market stability. Policymakers can use this information to design interventions or measures that enhance market stability, potentially minimizing the impact of extreme price movements and ensuring a more resilient cryptocurrency market. Policymakers could also initiate educational programs to inform investors about the nuanced relationship between trading volume and correlations. This could contribute to a more informed investor base, fostering responsible investment practices and reducing the likelihood of market disruptions driven by uninformed trading behavior.

5. CONCLUSIONS

The present study aimed to assess the integration of cryptocurrencies in the financial market using a dynamic equicorrelation model. The DECO model was applied to ten cryptocurrencies that have significant market value, namely: BTC, ETH, Dash, XRP, XLM, Waves, XMR, DOGE, LTC, and XEM. Among these, DOGE and XLM exhibited higher average returns. BTC was found to be the least volatile, while DOGE was the most volatile.

Through the analysis of daily return statistical summaries and stationarity tests, several conclusions were drawn: (1) the ADF test rejected the null hypothesis, indicating that the return series are stationary; (2) the Jarque Bera test indicated that the returns do not follow a normal distribution; (3) the ARCH-LM test confirmed the presence of heteroscedasticity in the daily returns.

Regarding the results of the DECO model for cryptocurrency returns, it was observed that there is a high persistence of conditional covariance, indicating a strong correlation among them and suggesting integrated equicorrelation. The empirical analysis of return equicorrelation revealed a positive correlation ranging between 0.2 and 0.8, which varies over time and is generally considerably high. The estimated equicorrelations exhibited some oscillations caused by hacking attacks, such as the Bitfinex hack in August 2016, the Coincheck hack in January 2018, and the bans imposed by the Chinese and Indian governments on cryptocurrency operations. All these factors had an impact on the cryptocurrency market.

Determining the factors influencing return's equicorrelation, various potential drivers were studied, and the results were consistent with those of a study conducted by Bouri *et al.* (2021). It was concluded that the degree of integration between cryptocurrencies primarily depends on trading volume, global stock indices, energy prices, gold prices, financial stress index, and the implied volatility index of the United States. It was found that the cryptocurrency market is not strongly linked to the behavior of the overall financial market but is primarily influenced by transaction volume among cryptocurrencies. It was also observed that prices among cryptocurrencies are highly correlated, which is not explained by economic factors but rather by the volume of transactions, indicating a certain level of maturity in the cryptocurrency market.

It is worth mentioning that cryptocurrencies and blockchain technology have attracted more interest from industry and investment sectors than from academia. Consequently, blockchain technology is one of the few areas of research and investigation led by industry professionals and investors, with few academic works on the subject (Rehman *et al.*, 2020).

For future research, it would be important to understand the driving factor behind the nearly 50% devaluation of the BTC cryptocurrency between April and May 2021. Speculation suggests that this decline in value occurred after Tesla's CEO, Elon Musk, expressed doubts about this asset. Musk had announced that he would suspend the decision, previously announced in March, to accept BTC as a means of payment for Tesla electric cars due to environmental concerns. The reason behind this decision was Musk's realization that BTC consumes a significant amount of energy, much of which comes from fossil fuels. Following this news, there was an immediate impact on the BTC price, leading to a substantial devaluation in a short period of time. However, there is no scientific research that confirms this claim, so it is important to investigate the reasons behind this abrupt decline in BTC. It would also be interesting to investigate the significant price increase in

the Dash cryptocurrency between late 2017 and early 2018. There are rumors that the main reason for this price appreciation during that period was the launch of Dash Text[18] in Venezuela, but there is no scientific evidence to support this claim.

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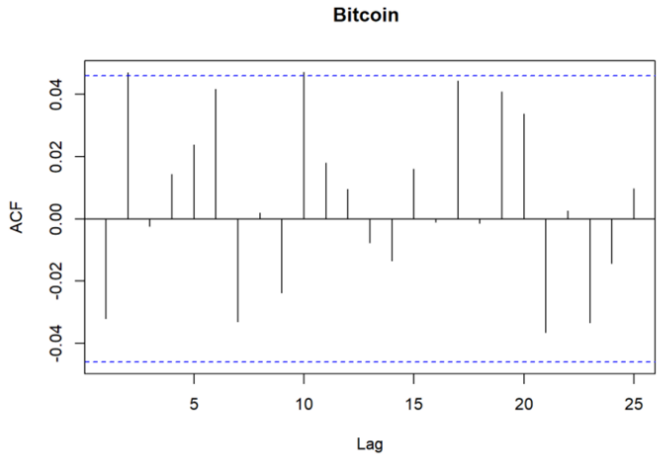
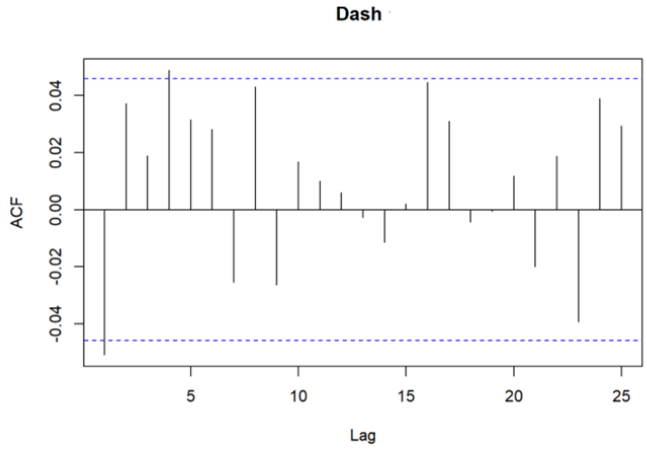
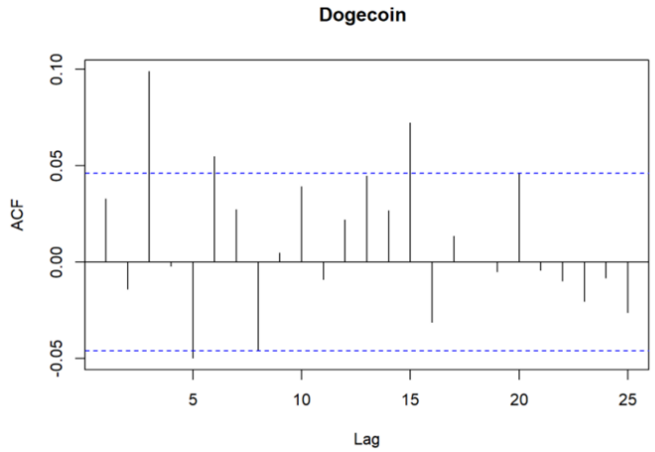
ANNEX

Autocorrelation function of cryptocurrencies return






Dogecoin
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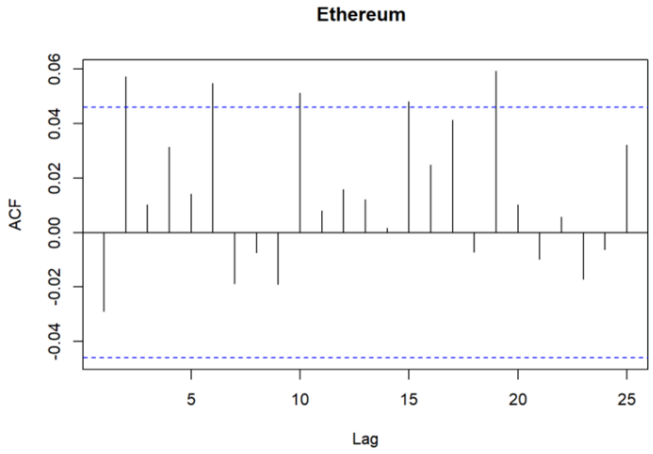
Ethereum
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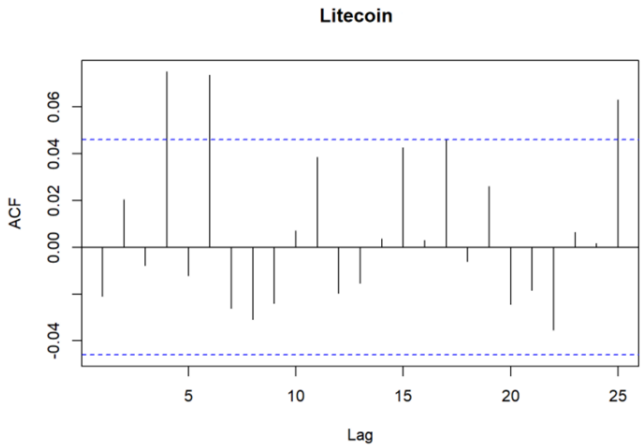
Litecoin
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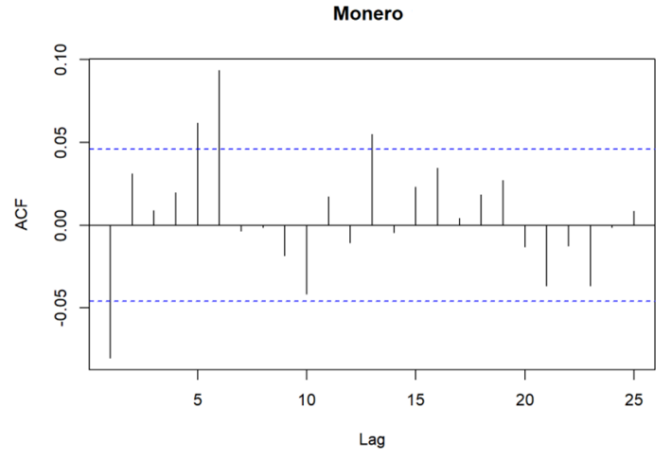
Monero
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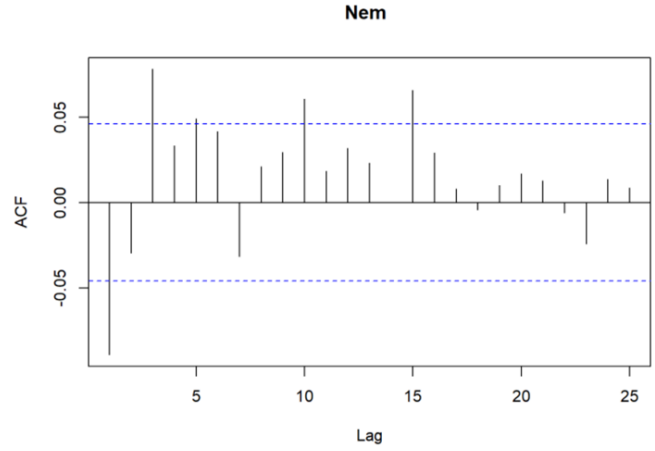
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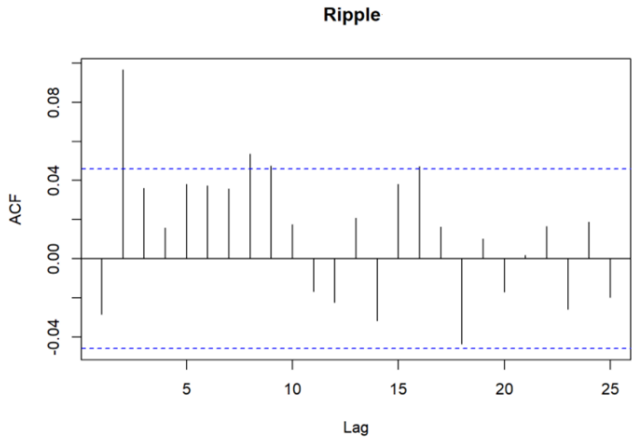
Ripple
ACF
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0.00
-0.04
5
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15
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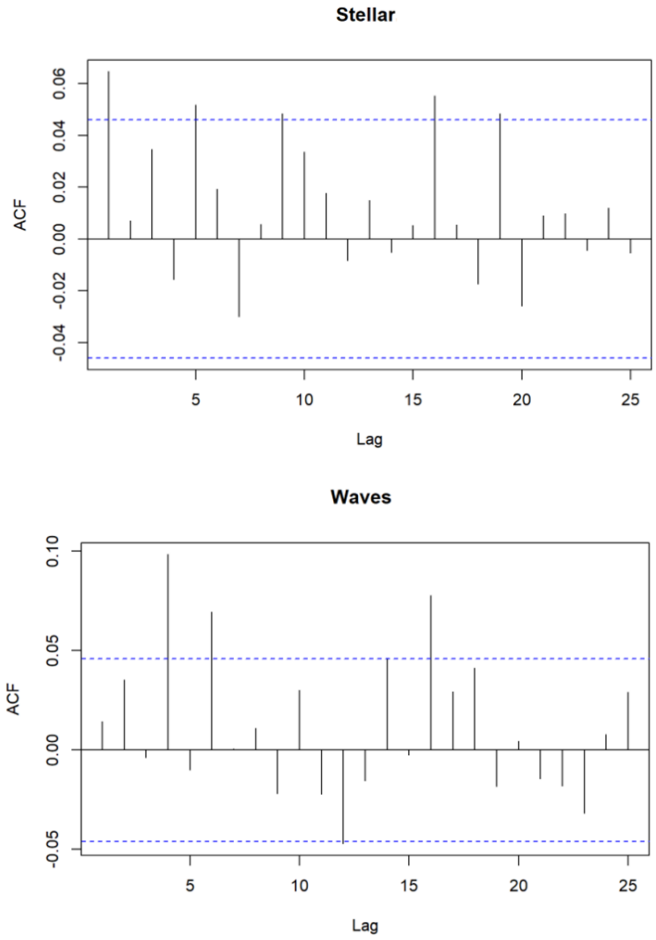
Lag



Notes

[1] Consulted on https://pt.investing.com/crypto/currencies on January 10th, 2021.

[2]The blockchain is a public ledger that stores all transactions since the creation of BTC (Prybila *et al.*, 2020).

[3]The mining algorithm translates into a process that keeps the BTC network stable and secure by adding newly validated blocks to the blockchain (Duong *et al.*, 2020).

[4]Global: Another Cryptocurrency Causes Ripples. Stratfor Geopolitical Diary, Dec 2017. http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=127187235&site=eds-live, consulted on March 19, 2021.

[5]Distinct currencies refer to the fact that a user can transfer, for example, dollars through XRP, and the recipient receives the value in euros.

[6] These are digital assets that can be used within a set of interdependent relationships within a specific project. While tokens utilize the blockchain of other currencies, cryptocurrencies have their own blockchain.

[7] It consists of a messaging system that informs banks where to send the money. It also includes a service that assists banks in settling transactions.

[8] Value consulted on the website https://pt.investing.com/crypto/ on March 13th, 2021.
[9] It is named as such due to its structure.
[10] As of October 27th, 2021, the website https://coinmarketcap.com/ listed a total of 13,242 virtual currencies.
[11] The cost value was obtained from the website https://pt.investing.com/crypto/currencies, accessed on April 17th, 2021 at 11:39 AM. The cryptocurrencies are highly volatile and due to their high number of transactions, the cost value is constantly changing. The USD used is the US dollar.
[12] 1 T = one billion of US dollars.
[13] The cost and market capitalization values of the cryptocurrencies Dash, Waves, Monero, and Nem were extracted on August 14th, 2021, at 16:24.
[14] 1 B = one thousand million US dollars.
[15] Skewness is the degree of deviation that a distribution exhibits from its axis of symmetry. If this deviation occurs on the left side, it is negative skewness, and if the deviation occurs on the right side, it is positive skewness.
[16] Kurtosis is a measure of dispersion that characterizes the "flattening" of the curve of the distribution function.
[17]Information consulted on https://www.moneytimes.com on October 5th, 2021, at 17:40.
[18] Dash Text is a Venezuelan platform that enables cryptocurrency transactions based on SMS. In other words, this application eliminates the need for users to have more sophisticated mobile phones with internet access to carry out their cryptocurrency transactions. With this application, users can transact, receive, and check the available balance of their business wallet via SMS.

Scientific Annals of Economics and Business
71 (3), 2024, 381-398
DOI: 10.47743/saeb-2024-0019

The Nexus between Illicit Financial Flows and Tax Revenue: New Evidence from Resource-Rich African Countries

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Abstract: Resource-rich economies, especially those in Africa, are plagued with the resource curse and Dutch Disease syndromes, which undermine the quest for effectively mobilizing domestic resources toward sustainable and inclusive development. Empirical evidence on the role illicit financial flow (IFF) plays in this regard is relatively scarce. Thus, this study evaluates the volume of IFF and its effect on tax revenue in seven resource-rich African countries. Panel data, sourced for the 2009-2021 period, were analysed using the fixed effect and random effect models while the Instrumental Variable Generalised Method of Moment (IV-GMM), a dynamic estimator, was used for robustness check. Findings revealed that IFF has been on the rise and has detrimental effects on the tax revenue of the sampled countries' national governments. This is inimical to sustainable development. Thus, the governments and policymakers in these countries must develop pragmatic policy and institutional approaches toward tackling the IFF menace.

Keywords: tax revenue; illicit financial flows; sustainable development; fixed and random effect models; Africa.

JEL classification: C23; F36; H20.

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Article history: Received 10 December 2023 | Accepted 22 September 2024 | Published online 25 September 2024

To cite this article: Afolabi, J. A., Taiwo, A. S., Sheu, N. A. (2024). The Nexus between Illicit Financial Flows and Tax Revenue: New Evidence from Resource-Rich African Countries. *Scientific Annals of Economics and Business*, 71(3), 381-398. https://doi.org/10.47743/saeb-2024-0019.

1. INTRODUCTION

Sustainable development has been largely elusive in Africa due to the limited available financial resources needed to drive development agendas in the continent. The impressive and sustained economic growth of many African countries as well as the increasing volume of foreign capital inflows to the continent prior to the emergence of the COVID-19 pandemic shone a ray of hope for economic transformation in the continent (Raifu, 2023). These increased the volume of tax revenue needed for development financing and made the achievement of sustainable development more feasible. However, the hope of actualizing sustainable and inclusive development in Africa has often been tainted by the colossal amount of financial resources that are illegally moved to foreign countries through various channels. There are growing concerns about the approximately US$50 billion that leaves Africa annually in the form of illicit financial flows (IFFs), as it drains the continent of the financial resources needed to finance development objectives (Signé, 2020; Muslim *et al.*, 2021).

Despite being a global phenomenon, the macroeconomic impact of IFF in developing regions, particularly Africa, is more severe and corrosive given their low financial base and weak institutional quality (Signé, 2020). The high volume of IFF from Africa aggravates the already precarious economic situations in the continent and hampers the capacity of the government to provide basic public goods and services. Empirical evidence has shown that IFF is pervasive in resource-rich countries, where multinational companies operate (Igbatayo, 2019; Cobham and Janský, 2020). Multinational companies have intricate structures with several subsidiaries, most of which operate in tax havens or countries with weak institutions (Babatunde and Afolabi, 2023). Profit allocation among multinational companies' subsidiaries is often done through internal trading, a structure that is complex and difficult to decipher even by domestic tax authorities (Ogunjimi and Amune, 2019).

In general, multinational companies often leverage the weak institutional quality in developing economies to engage in tax evasion, round-tripping, falsified invoicing and transfer mispricing (Cobham and Janský, 2020). These practices place an unbalanced burden on small domestic firms, which employ a large proportion of the African labour force. The burden could force some of these small firms out of business or compel them to lower their operative capacity, either of which will increase the number of labour force in the unemployment pool. It could also further overcrowd the already saturated labour market and worsen the unemployment rate in African countries. The dominance of multinational corporations in the extractive sectors of resource-rich African countries suggests the possibility of a reduction in government tax revenue and a low prospect for domestic resource mobilization. This could lead to exchange rate problems as there will be less demand for the domestic currency, a situation that causes exchange rate depreciation that hurts import-dependent countries (Ogunjimi, 2019, 2020a). Sadly, many resource-rich African countries are import-dependent, explaining the pervasive exchange rate misalignment across the continent and the far-reaching effects of IFF on the domestic economy.

There is a budding literature on the effect of IFF on revenue mobilization (UNECA, 2017; Muslim *et al.*, 2021; Thiao, 2021; Uzoechina, 2023; Afolabi, 2023a). However, there seems to be only a few studies on the subject matter in Africa, particularly studies with a specific focus on resource-rich African countries. Demystifying the link between IFF and tax revenue in resource-rich African countries is crucial because these countries have not been able to translate their huge resource endowment into economic prosperity due to economic leakages. This study,

therefore, attempts to fill this knowledge gap by evaluating the effect of these flows on tax revenue in resource-rich African countries. It is important because many African countries, including resource-rich countries, failed to achieve the Millenium Development Goals (MDGs) due to limited domestic resources (Afolabi, 2023a). Resource-rich countries are expected to be able to raise and mobilize the necessary financial resources required to achieve development agendas. So, to change the narrative, it then becomes important to map out plans for effectively mobilizing financial resources to achieve the United Nations' Sustainable Development Goals (SDGs) no later than 2030. With the set date for achieving the SDGs drawing closer, it is pertinent to devise strategic means of blocking all financial leakages from resource-rich economies and effectively mobilizing tax revenue to drive sustainable development. The fixed effect and random effect models are used as the primary estimation methods while the instrumental variable generalised method of moment (IV-GMM) method is used to test the robustness of the estimates. These estimation methods are complements and robust to the analysis of the IFF-tax revenue nexus in Sub-Saharan Africa.

This study is structured into five sections. Following the current section, Section 2 presents relevant stylized facts on selected resource-rich African countries with respect to their natural resources as well as the trend behaviour of IFF and the tax revenue of each country. Section 3 describes the methodology adopted in this study while Section 4 discusses the empirical findings and Section 5 draws conclusion based on the findings.

2. RELEVANT STYLIZED FACTS ON RESOURCE-RICH AFRICAN COUNTRIES

According to the World Bank report in 2018, there are 10 major resource-rich countries in Africa including Angola, Botswana, the Democratic Republic of Congo, Equatorial Guinea, Gabon, Nigeria, South Africa, Sudan, Tanzania and Zambia. However, stylized facts on all the countries, except Equatorial Guinea, Gabon and Sudan, are presented based on data availability. Each of these countries has numerous natural resources but there are specific natural resources they possess in abundance, which serve as the mainstay and major source of foreign exchange for each economy.

2.1 Overview of the Natural Resources in Resource-Rich African Countries

Angola

Angola, a country in the Southern African region, has large reserves of crude oil deposits, iron ore, copper, gold, manganese, feldspar, platinum, uranium and phosphates. However, the country is highly dependent on crude-oil deposits than other mineral resources. Specifically, Angola has a proven oil reserve of 9 billion barrels and natural gas reserve of 11 trillion cubic feet. Angola is a member of the Organization of Petroleum Exporting Countries (OPEC), producing about 1.3 million barrels of crude oil and 17,904.5 million cubic feet of natural gas daily (World Bank, 2019). The country is the largest oil-producing country in the Southern African region and the second-largest oil-producing country in Sub-Saharan Africa. Its oil and gas industry contributes significantly to aggregate output and it is a major source of foreign exchange and government revenue. The oil and gas industry has three key sectors – upstream, midstream and downstream sectors. However, the upstream sector is the most dominant among the three sectors. The top destinations of Angolan crude oil and gas are Brazil, China, France and South Korea.

Despite being an oil-exporting country, Angola has insufficient capacity to meet local demand for refined petroleum products (such as diesel, oil fuel, gasoline, asphalt, lubricants and aviation fuel). The country only produces about 20 percent of refined oil products locally and imports a whopping 80 percent of these refined petroleum products from foreign countries to meet local demands. However, the Angolan government has been making efforts toward reducing its heavy dependence on the importation of refined petroleum products by constructing three national refineries and expanding the existing refinery, which is located in Luanda with an installed capacity of 65,000 barrels per day. In addition, the government introduced legal reforms, created a national concessionaire and set up institutions and policies to ameliorate the prevailing situations in the oil and gas industry. Several projects have also been inaugurated to revamp the oil and gas industry in Angola. The top five oil and gas projects in Angola include the Kaombo project; the Angolan LNG project; Plutão, Saturno, Vênus, and Marte (PSVM) project; the Platina project; the east and west hub; and Cravo, Lirio, Violeta, and Orquidea (CLOV) Phase 2 project (Goosen, 2022).

Botswana

Botswana is endowed with mineral resources such as diamond, copper, gold, nickel, coal and soda ash, among others. It is adjudged one of the notable resource-abundant countries in Africa that have defied the resource curse syndrome and have been able to exploit its mineral resources for structural economic transformation (Biedermann, 2018). The extraction of these mineral resources makes the mining industry in Botswana very active and a major contributor to national output. It also constitutes a major source of foreign exchange for the national government with diamonds being the mainstay of the economy. Specifically, diamond export makes up about 80 percent of export earnings and 60 percent of government tax revenue in Botswana (Biedermann, 2018). Diamond has been the core mineral resource produced by Botswana since its large-scale production in 1972 and the country is ranked among the world-leading diamond producer. Specifically, Botswana has the second-largest diamond reserve in the world, totalling 300 million carats. The major diamond reserves are largely domiciled in the Central and Kgalagadi districts of the country.

The mining sector, and the diamond industry in particular, absorbs a large proportion of the labour force in Botswana. Thus, the country is highly dependent on the diamond industry, whose era is gradually coming to an end. The government has been putting measures in place to diversify the economy. Despite being a diamond-producing country, Botswana sorts, cuts, polishes and makes jewellery designs from its rough stones in countries like China, India, Israel, Belgium and the United States. The focus on sustainable development, instead of wholesale pillage of natural resources, has attracted multinational corporations to Botswana. Thus, different multinational companies extract different mineral resources in the Botswanan mining industry. Favourable government policies, good governance, strong institutions and political stability played key roles in helping the country attract foreign direct investment and maintain its upper middle-income nation status (Sebudubudu and Mooketsane, 2016).

The Democratic Republic of Congo

The Democratic Republic of Congo (DRC), like other resource-rich African countries, has a variety of natural resources in abundance. Some of these natural resources include copper, tantalum, tungsten, tin and cobalt, among others. These resources form the mainstay of the DRC's economy and serve as the main source of government revenue (World Bank,

2023). The prices of these natural resources in the international market greatly affect the revenue that accrues to the government through their exports and determines the government's capacity to adequately provide public goods and services to its citizens. Some of the factors that affect the exploration and processing of natural resources in the DRC include the pervasively weak institutional quality, incessant conflicts, inflation, and lack of political will, among others (Nichols, 2018). The top five export destinations of DRC's natural resources are China, Singapore, South Africa, Tanzania and Zambia.

Nigeria

Nigeria has a vast array of mineral resources located across the six geopolitical zones in the country. Some of these mineral resources include gold, copper, tin and columbite, crude oil and natural gas, among others. However, the contribution of the mining sector, excluding oil and gas, to the national gross domestic product (GDP) is negligible. Of all these mineral resources, Nigeria is heavily dependent on the exploitation, sales and exports of crude oil and natural gas such that a shock to oil price in the international market has a direct effect on fiscal buffers in the country (Aminu and Ogunjimi, 2019; Ogunjimi, 2020b). The country has a proven oil reserve of 37.1 billion barrels and natural gas reserve of about 5.8 trillion cubic feet. Nigeria became a member of the OPEC in 1971 and produces about 1.56 million barrels of crude oil and 1.3 million cubic feet of natural gas daily (OPEC, 2021). The country doubles as the largest oil-producing country in the West African region and the African continent at large. Nigeria is also among the top five liquefied natural gas (LNG) exporters in the world. The Nigerian oil and gas sector makes significant contributions to aggregate output, exports and employment in Nigeria and it earns the country's government huge foreign exchange (Afolabi and Oji, 2021; Bolaji *et al.*, 2021).

The Nigerian oil and gas sector has three main sectors – upstream, midstream and downstream sectors. Nigeria has four oil refineries, which are located in Warri, Kaduna and Port Harcourt, and are highly inefficient as they operate below par, having a combined installed capacity of producing 445,000 barrels daily. The country's refineries lack the capacity to meet the daily oil demands of its teeming population. The government, therefore, takes its crude oil abroad for processing and imports refined petroleum products (such as diesel, oil fuel, gasoline, asphalt, lubricants and aviation fuel) despite being a notable oil-exporting country. Oil importation takes a large chunk of the Nigerian import basket. All institutional, legal and policy efforts toward reducing oil importation and improving oil production by local refineries have been sabotaged by rent-seeking political elites (Ogunjimi, 2020b; Afolabi, 2024). However, the private sector, notably the Dangote Oil Refinery, is gradually wading into the exploration and refining of crude oil in Nigeria.

South Africa

South Africa, the most advanced and diversified African economy, has a wide range of mineral resources, which serve the domestic economy and the export market. These mineral resources include but are not limited to gold, diamond, platinum, chromium, coal, nickel, manganese, uranium and copper, among others (Joshua and Bekun, 2020). Even though the tertiary sector contributes the largest to national output, the primary sector also makes a significant contribution to the gross domestic product (GDP). The abundance of mineral resources in South Africa makes it holds some world records. For example, South Africa is the world's largest producer of platinum, which is mostly mined in *Platreef*, Upper Group 2

(UG2) Reef and *Merensky* Reef. It is also the world's largest natural reserve of manganese ore, chrome ore and gold as well as the world's largest diamond producer. In addition, South Africa has the second-largest vanadium, zirconium and titanium reserves in the world. The abundant availability of these precious stones makes the jewellery industry highly lucrative in South Africa.

The South African mining industry produces five major classes of mineral resources: precious metals and minerals (such as diamonds, andalusite, limestone and kyanite); ferrous minerals (such as gold, platinum and aluminium); non-ferrous metals and minerals; industrial minerals and energy minerals (such as coal). Generally, the South African mining sector comprises both domestic and foreign companies, that carry out various extractive operations and activities. Different legal, institutional and policy efforts put in place by the South African government and policymakers have contributed substantially to the development of the country's mining sector. The government used the mining sector as a platform for reducing the income gaps in South Africa. The current performance of the South African mining sector is impressive and it has a promising future as there are yet unexploited and newly discovered natural resource deposits (Nathaniel, 2021).

Tanzania

Tanzania, a lower middle-income country located in the Southern African region, is another major African country with abundant mineral resources such as diamond, gold, copper, kaolin, titanium, platinum, cobalt and gemstone, among others. The mining industry in Tanzania is very active and contributes largely to GDP, exports, employment and government revenue. Tanzania's gold reserve is about 10 million ounces. The country has several gold and diamond mines. The major companies in the Tanzanian mining sectors include Williamson Diamond Limited, *Geita* Gold Mining Limited, North Mara Gold Mine Limited, Pangea Minerals Limited, *Samaz* Resources Limited, *Shanta* Mining Company Limited, Pan African Energy Tanzania Limited, and *Tancoal* Energy Limited, among others. However, illegal mining pervades the sector due to the presence of weak institutions and pervasive corruption and poor political will. Tanzania's main export destinations are China, India, the European Union, Kenya, South Africa and the United States (High Commission of the United Republic of, 2024).

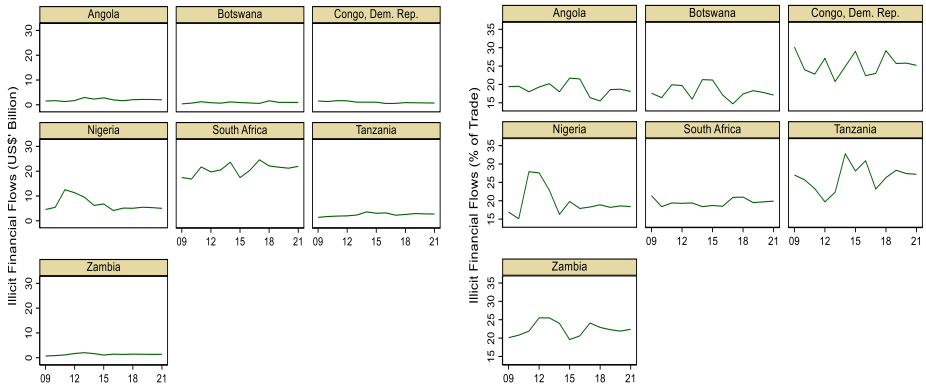
Zambia

Zambia is also abundantly rich in natural resources such as gold, tanzanite, diamonds, coal, nickel, cobalt, uranium and iron, among others. However, the country is heavily dependent on the extraction of copper and uranium together with a few industrial deposits, gold and nickel. The Zambian mining industry contributes about 12% to aggregate output and employs a large proportion of the Zambian labour force (Kolala and Dokowe, 2021). The industry is also a viable source of foreign exchange earnings for the government. Mining activities in Zambia are guided by the Mines and Minerals Development Act of 2015 and mining companies are regulated by the Zambian Ministry of Mines and Minerals Development, which gives operating licenses to mining companies. Zambia's main export products to countries like China, Singapore, Switzerland and Luxembourg include copper, cobalt, precious stones, and cotton. Given the enormity of mineral resource reserves in Zambia, there are several mines from where these mineral resources are extracted (Franks *et al.*, 2020).

2.2 Trend of IFF and Tax Revenue in Resource-Rich African Countries

Resource-rich countries are highly susceptible to having a high volume of illicit financial flow (IFF) due to the heavy presence of multinational companies, whose parent companies are often domiciled in developed economies (Cobham and Janský, 2020). This subsection, therefore, describes the trend of IFF in selected resource-rich African countries. Due to the difficulty in getting an accurate measure for IFF worldwide, Global Financial Integrity, a Washington DC-based organization, intervened and is renowned for publishing trade-based IFF reports and data annually. Trade-based IFF (trade value gap) is the difference in the reported trade value of two trade partners, which results from the deliberate falsification of trade invoices submitted by exporters and importers to customs authorities (Global Financial Integrity, 2021). The motive behind this illegal international money transfer includes tax or customs duties evasion, currency control circumvention and concealment of profits in offshore bank accounts, among others. Trade value gap reflects the inability of the extant institutional framework to charge/collect the accurate trade-related taxes and a loss of huge financial resources in uncollected trade-based tax revenues. According to the 2021 report of Global Financial Integrity, 80 percent of illicit financial outflows from African countries, among other developing countries, are channelled through trade mis-invoicing.

The volume of trade-based illicit financial flows (in US dollars and percentage of total trade) in resource-rich African countries between 2009 and 2021 is presented in Figure no. 1.



Illicit Financial Flows (US$' Billion) *Illicit Financial Flows (% of Trade)*

Figure no. 1 – Illicit Financial Flows in Selected Resource-Rich African Countries

Source: Global Financial Integrity (2021)

It shows that South Africa has the highest volume of trade-based IFF (in US dollars) among the seven selected countries while Nigeria follows distantly in the second position. These two countries are the largest economies in Southern and Western Africa, respectively. They are also the two largest economies in Africa in terms of GDP, international trade and other notable macroeconomic variables. Sadly, IFF has been added to their ranks. The narrative changed when the volume of trade-based IFF was expressed as a percentage of total trade. The trend of trade-based IFF appears volatile in all the countries. South Africa and Nigeria, which had the largest and second-largest average volume of trade value gaps among

the seven resource-rich countries under consideration, have relatively low trade-based IFF (% of total trade). Democratic Republic of Congo and Tanzania, which are among the countries with low trade-based illicit financial flows (US$), are the top two countries with the highest share of trade-based IFF in total trade, respectively. This shows that the volume of trade in Democratic Republic of Congo and Tanzania is low. It also gives credence to the earlier assertion that South Africa and Nigeria are the largest economies in Africa, particularly in terms of total trade. The high volume of trade of these two African giant economies made the volume of trade gaps in the countries look meagre. Overall, the trend suggests that IFF is prominent in resource-rich African countries and the menace needs to be addressed to actualize development agendas.

One of the notable sources of government revenue is taxation. It is often expressed as a percentage of GDP to assess the size and efficiency of a country's tax system relative to the overall economic output. Tax revenue (% of GDP) represents the proportion of total tax collections relative to the total value of goods and services produced within a country's borders over a specific period, typically a fiscal year. It provides insights into the extent to which a government relies on taxation to finance its expenditures and public services, as well as the level of fiscal capacity and revenue mobilization within the economy. A higher tax revenue-to-GDP ratio generally indicates a greater ability of the government to generate income through taxation, which can support public investments, social welfare programs, infrastructure development, and other government activities. Conversely, a lower tax revenue-to-GDP ratio may suggest lower revenue mobilization capacity, potentially leading to budget deficits, inadequate public services, or reliance on alternative sources of financing such as borrowing or external aid. The trend of tax revenue (% of GDP) of selected resource-rich African countries is presented in Figure no. 2.

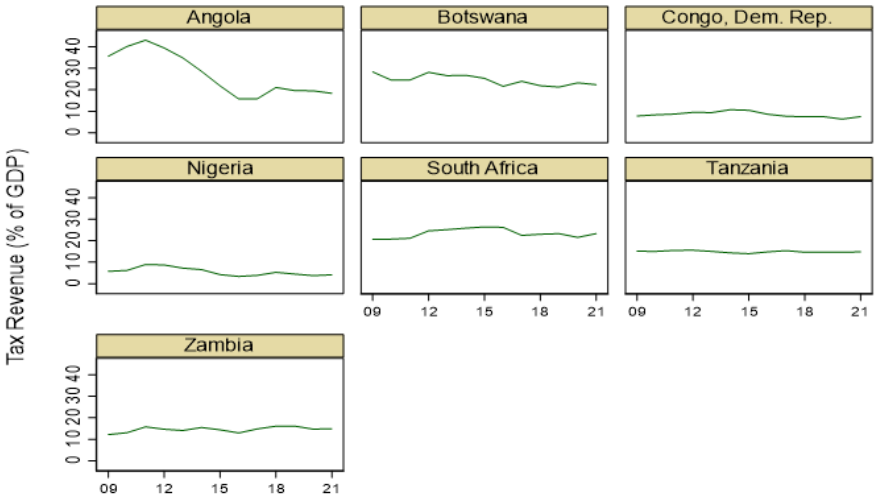


Figure no. 2 – Tax Revenue in Selected Resource-Rich African Countries (% of GDP)
Source: International Monetary Fund (2021)

It shows that Angola has the highest tax revenue (% of GDP) between 2009 and 2012 but its government has lost some ground on the control of the country's resources afterwards.

Despite having the second largest government revenue (% of GDP) among the seven selected countries in 2009, Botswana's government has a fairly good control over its country's resources in the subsequent years. Tax revenue (% of GDP) steadied in countries like Democratic Republic of Congo, Nigeria, Tanzania and Zambia for the period under consideration. Generally, there is a decline in tax revenue across the seven countries and this might not be unconnected from the high volume of IFF that leaves these countries regularly. The downward sloping scatterplot line, showing the inverse relationship between IFF and tax revenue (see Figure no. 3), confirms this notion. Simply, it indicates that tax revenue reduces with increasing volume of IFF and vice versa.

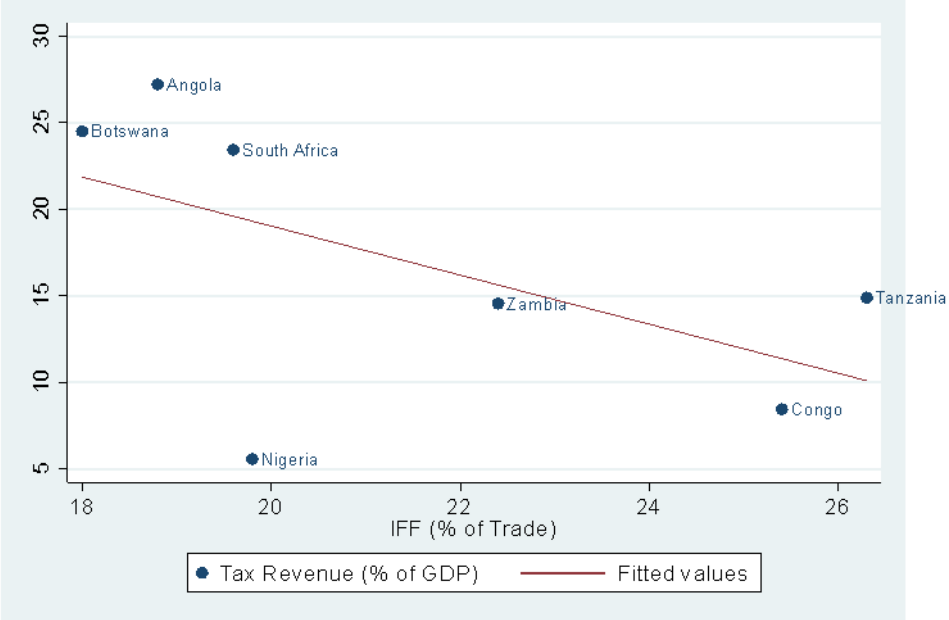


Figure no. 3 – Relationship between Average Values of IFF (% of Trade) and Tax Revenue (% of GDP)
Source: Global Financial Integrity (2021) and International Monetary Fund (2021)

3. METHODOLOGY

3.1 Model Specification

The empirical model is anchored on Wagner's law, which simply states that government expenditure and revenue rise when per capita income increases (Wagner, 1980). This suggests that tax revenue is an increasing function of per capita income. This is written mathematically as:

$$\text{Government Revenue} = f(\text{per capita income}) \quad (1)$$

This study extends Wagner's law by incorporating IFF and three control variables (trade openness, natural resource rent and inflation) into equation (1). This is to account for the effect

of IFF and other control variables on tax revenue. Thus, equation (1) is rewritten econometrically as follows:

$$DRM_{it} = \delta_0 + \delta_1 GDP_{it} + \delta_2 IFF_{it} + \delta_3 TRPN_{it} + \delta_4 NRR_{it} + \delta_5 INF_{it} + \delta_6 ECI_{it} + \varepsilon_{it} \quad (2)$$

where DR, GDP, IFF, TRPN, NNR, INF, ECI ε, δ, i and t represents domestic resource mobilization, gross domestic product growth rate, illicit financial flows, trade openness, natural resource rent, inflation, economic complexity, error term, parameters, individual countries and time period, respectively.

The inclusion of the control variables in the empirical model is based on their empirical links with tax revenue. Past studies revealed ambiguity in the revenue-trade nexus as trade openness could either boost or lower government revenue (Afolabi, 2022, 2023c). For net importing countries, government revenue tends to be drained when trade openness increases while the converse is true for net exporting countries because they earn more foreign exchange that boosts the government's revenue mobilization capacity. Therefore, the sign of the trade openness coefficient could either be positive or negative. The revenue that accrues to the government through natural resource rent increases with increasing natural resource exploitation (Aminu and Ogunjimi, 2019; Afolabi, 2023b). Thus, the sign of the natural resource rent coefficient should be positive. Inflation reduces real money balances and the purchasing power in a domestic economy, thereby lowering tax revenue in real terms (Afolabi, 2023c). So, inflation is expected to have an inverse relationship with tax revenue. While it is expected that GDP growth rate will have a positive effect on government revenue as predicted by Wagner's law, the coefficient of IFF is expected to be negative to show that IFF adversely affects tax revenue. The sophistication of an economy's products, measured using the economic complexity index, earns more revenue for such an economy (Boleti *et al.*, 2021). Thus, economic complexity is expected to have a positive effect on tax revenue.

The panel fixed effect and random effect estimation methods are adopted to examine the effect of IFF on tax revenue in selected resource-rich African countries. The key strengths of these estimation methods are threefold. First, they control for time-invariant omitted variables and are suitable in studies requiring small cross-sectional units. Second, it controls for country-level heterogeneity. Third, they allow for the correlation of individual or time specific effects with the independent variables (Fetai *et al.*, 2017). However, the fixed effect and random effect methods could not account for endogeneity, serial correlation and heteroscedasticity, which could result in the generation of bias estimates. The Instrumental Variable Generalised Method of Moments (IV-GMM) estimation method, a dynamic estimator, addresses these drawbacks (Baum *et al.*, 2007), and is therefore adopted for robustness and to generate reliable and efficient estimates.

3.2 Data Issues

The scope of this study covers seven of the ten resource-rich African countries identified by World Bank (2018). These countries include Angola, Botswana, the Democratic Republic of Congo, Nigeria, South Africa, Tanzania and Zambia with the exemption of Equatorial Guinea, Gabon and Sudan due to data unavailability. Annual data on key variables of interest covering 2009-2021 are obtained from reputable sources. Tax revenue data was obtained from

International Monetary Fund (2021)); trade-based illicit financial flows data was obtained from Global Financial Integrity (2021); economic complexity index data is sourced from the The Growth Lab at Harvard University (2019); and data on GDP growth rate, trade openness, natural resource rents and inflation were sourced from World Development Indicators (2021). For ease of result interpretation, IFF is expressed in natural logarithm since other variables are in percentages.

The description and summary statistics of the data are shown in Table no. 1. It shows a wide margin between the minimum and maximum values of tax revenue as a share of GDP in the sampled countries. This signals that despite their resource abundance, the share of tax revenue in GDP of the sampled countries differs significantly although it averaged 16.95 percent. A similar narrative is found for the share of natural resource rent of resource-rich Sub-Saharan African countries. The share averaged 11.89 percent but ranged between 0.63 percent and 41.09 percent. The range of IFF is equally high, which is a reflection of IFF being high in some countries but low in others. Similarly, the level of trade openness, GDP growth rate and inflation rate in each resource-rich country differ given the high disparity in the minimum and maximum values of these variables. The negative average value of economic complexity index suggests that the products of the countries under study are not sophisticated. This could be attributed to the raw form in which resource-rich African countries exports most of their primary export products.

Table no. 1 – Data Description and Summary Statistics

Variables	Description	Obs	Mean	Std. Dev.	Min	Max
TAX	Tax Revenue (% of GDP)	91	16.95	8.71	3.37	43.12
IFF	Trade Value Gaps (US$' Billion)	91	5.02	6.83	0.38	24.61
GDPGR	GDP Growth Rate (%)	91	3.60	3.96	-8.73	11.36
TROP	Trade (% of GDP)	91	64.02	24.19	20.72	122.55
NRR	Natural Resource Rent (% of GDP)	91	11.89	9.87	0.63	41.09
INF	Inflation, consumer prices (%)	91	8.73	6.13	0.74	30.70
ECI	Economic Complexity Index	91	-0.89	0.65	-2.11	0.38

Source: Author's Compilation

4. EMPIRICAL FINDINGS

4.1 Unit Root and Cross-Sectional Dependence Tests

Determining whether variables are stationary or not is important in time-series and panel studies. It guides the choice of appropriate estimation technique(s) that will produce unbiased estimates. The Levin, Lin and Chu (LLC) and Im, Pesaran and Shin (IPS) unit root test approaches developed by Levin *et al.* (2002) and Im *et al.* (2003), respectively, are used in this study. The results of the panel unit root test, reported in Table no. 2, indicate that all the variables are stationary at level. This implies that the variables have constant mean, variance and covariance and therefore, converge in the long-run. Furthermore, cross-sectional dependence (CD) test is important in panel studies. The CD test, developed by Im *et al.* (2003), is used in this study and its result is also reported in Table no. 2. The result confirms CD, implying that changes in any of the variables (such as IFF) in one country could have spillover effects on the other sampled countries.

Table no. 2 – Unit Root and Cross-Sectional Dependence Tests

Variable	IPS Z-t-tilde-bar	LLC Adjusted t Level	Pesaran CD-test
Tax Revenue	-1.880**	-4.715*	3.090*
Log of Illicit Financial Flows	-2.726*	-5.481*	2.960*
GDP Growth Rate	-4.282*	-1.359***	8.890*
Trade Openness	-2.234**	-2.546*	4.610*
Natural Resource Rent	-1.399***	-5.743*	11.880*
Inflation	-1.670**	-4.737*	2.170**
Economic Complexity	-3.506*	-3.709*	1.520

** p<0.01, ** p<0.05,*** p<0.1*

4.2 Main Estimation

The results of the unit root tests satisfy the condition for estimating the specified model using the fixed effect (FE) and random effect (RE) estimation methods. The models are estimated in a stepwise manner such that the baseline model (model without control variables) and the extended model (model with control variables) are estimated sequentially. This is to confirm whether the effect of IFF on tax revenue will remain unchanged (in terms of sign and significance) regardless of how the model is specified. The empirical results are presented in Table no. 3. The results of the baseline models show that IFF has an inverse but insignificant relationship with tax revenue. However, when control variables were introduced in the extended model, the coefficient of IFF became statistically significant but remained negative. The negative sign of the IFF coefficient indicates that IFF has a catastrophic and debilitating effect on tax revenue such that an increase in IFF by one percent will reduce tax revenue by about 2.6 percent. The result also suggests that reducing IFF by one percent will raise tax revenue by 2.6 percent, indicating that reducing the incidence of IFF is critical for improving tax revenue in resource-rich African countries. This shows that tax revenue is highly responsive to the dynamics of IFF.

This result corroborates the finding of Thiao (2021), which showed that IFF not only adversely affects government revenue but also diminishes the government's capacity to perform its constitutional duties of providing public products and services to its citizens. It also confirms the notion put forward by Muchala (2018); Afolabi (2023a), which alluded that the adverse impact of IFF on government revenue could compel the government to privatize public corporations and worsen the welfare of citizens, especially those in the low-income group who might not be able to access or afford patronizing private corporations. It also lends support to the finding of Brandt (2020), which showed that IFF reduces government revenue as multinational companies operating in countries in the Global South launder money to their parent companies. Interestingly, the probability value associated with the IFF coefficient indicates that IFF is a major determinant of tax revenue in resource-rich African countries.

There appears to be mixed findings with regard to the estimates of the control variables. While some variables have positive signs, some have negative which are either statistically significant or insignificant. For the estimate of GDP growth rate, the result suggests that Wagner's law does not hold in resource-rich African countries as the estimate is negative and statistically insignificant. This indicates that the observed economic growth in these countries

has not translated into an increase in their government tax revenue. While this finding appears counterintuitive, it confirms the earlier result that IFF has been hampering tax revenue in the sampled countries. On the other hand, trade openness has a significant positive relationship with tax revenue. This result is plausible as most resource-rich African countries export their natural resource abroad, which earns them foreign exchange and empowers the government to mobilize revenue for development purposes. Similarly, the coefficient of natural resource rent is positive and significant, indicating that natural resource exploitation plays an important role in boosting tax revenue in resource-rich African countries. This confirms the views of Aminu and Ogunjimi (2019); Afolabi (2023b), who showed that natural resource rent boosts government revenue in Nigeria and Sub-Saharan Africa, respectively.

However, inflation is found to adversely affect tax revenue in resource-rich African countries. A rise in the domestic general price level reduces tax revenue in real terms and lowers the number of development activities the government can embark on at a particular time. This explains why the monetary authorities in different countries often strive to keep inflation at bay through the deployment of different monetary policy measures, notably the inflation targeting measure. The coefficient of economic complexity is negative and not statistically significant. This implies that economic complexity does not contribute to improving tax revenue in the sampled countries. This contrasts the views of Boleti *et al.* (2021) and is unsurprising as these countries lack the capacity to produce sophisticated products and often export their natural resources in raw or unrefined form. This largely lowers the revenue that should accrue to government from the export of such products. The key difference in the results of the fixed effect and random effect models is their respective intercepts. The intercepts of the fixed effect baseline and extended models are lower than those of the random effect models. The similarity in the effects of IFF on tax revenue in both models signals that the results are robust and not sensitive to model specification. As expected, the coefficient of determination of the baseline model is less than that of the extended model, indicating that the confluence of IFF, GDP growth rate, trade openness, natural resource rent and inflation rate offer more explanation to the dynamics of tax revenue in resource-rich African countries than only IFF. Specifically, the coefficient of determination statistic shows that about 78.5 percent of changes in tax revenue is influenced by the confluence of the explanatory variables.

Table no. 3 – Effects of IFFs on Domestic Resource Mobilization

Variables	Fixed Effect		Random Effect	
	Coefficient	Coefficient	Coefficient	Coefficient
Log of Illicit Financial Flows	-2.518	-2.632***	-2.518	-2.632***
	(1.634)	(0.925)	(1.634)	(0.925)
GDP Growth Rate		-0.059		-0.059
		(0.096)		(0.096)
Trade Openness		0.151***		0.151***
		(0.026)		(0.026)
Natural Resource Rent		0.413***		0.413***
		(0.079)		(0.079)
Inflation		-0.295***		-0.295***
		(0.067)		(0.067)
Economic Complexity		-0.253		-0.253
		(1.053)		(1.053)

Variables	Fixed Effect		Random Effect	
	Coefficient	Coefficient	Coefficient	Coefficient
Constant	71.638**	61.273***	81.286**	65.342***
	(34.871)	(19.743)	(34.484)	(19.533)
Observations	91	91	91	91
R-squared	0.258	0.785	0.258	0.785
Country Dummies	YES	YES	YES	YES
Year Dummies	YES	YES	YES	YES

*Note: * p<0.01, ** p<0.05,*** p<0.1 while standard errors are in parentheses*

4.3 Robustness Check

To validate the previously reported fixed effect and random effect model estimates, a robustness check was carried out. This was done by re-estimating equation 2 using the dynamic instrumental variable generalised method of moments (IV-GMM) estimator with the share of IFF in total trade as the measure of IFF. The IV-GMM estimator addresses autocorrelation, heteroscedasticity and endogeneity problems; and produces unbiased estimates. The estimates generated by the estimator, shown in Table no. 4, lends support to the earlier results as they show that IFF (% of trade) and tax revenue move in opposite directions in resource-rich African countries. This implies that tax revenue will plummet when the share of IFF in total trade increases and vice versa. It also indicates that an increase in share of IFF in trade is at the detriment of tax revenue and tax revenue will surge when IFF is curtailed.

Table no. 4 – Effects of IFFs on Tax Revenue (IV-GMM Regression Estimates)

Variables	Coefficient	Coefficient
Illicit Financial Flows (% of Trade)	-0.769*	-0.417**
	(0.182)	(0.181)
GDP Growth Rate		-0.188
		(0.128)
Trade Openness		0.154*
		(0.019)
Natural Resource Rent		0.198***
		(0.115)
Inflation		-0.041
		(0.110)
Economic Complexity		6.138*
		(0.931)
Constant	33.467*	20.207*
	(4.503)	(4.156)
Observations	91	91
Mean dependent var	16.954	16.954
SD dependent var	8.714	8.714
R-Squared	0.124	0.571
Chi-square	17.879	287.998
Prob > chi2	0.000	0.000

*Note: * p<0.01, ** p<0.05, *** p<0.1 while standard errors are in parentheses*

Interestingly, the coefficient of IFF (% of trade) is statistically significant in both the baseline and extended models, which reveals that IFF is a major factor influencing tax revenue in the sampled resource-rich African countries. Despite the differences in the magnitude of IFF's impact on tax revenue revealed by the earlier and current estimators, IFF remains a major impediment to the revenue that accrues to the national governments of resource-rich African countries through tax. This is because the falsification of trade invoices to evade tax and enjoy tax incentives robs the government of its revenue accrual and limits its financial capability to fulfil its fiscal responsibilities. The IFF-induced tax revenue reduction has severe ripple effects on domestic resource mobilization; hence, the urgent need to expeditiously curtail the IFF menace. Overall, the IV-GMM estimates are similar to those of the fixed effect and random effect models, signifying that the results are valid and reliable for policymaking.

5. CONCLUSION

The primary focus of this study is the quantification of the volume of illicit financial flow (IFF) from selected resource-rich African countries and the investigation of how these illicit flows affect tax revenue. To achieve this purpose, panel data spanning 2000-2021 were sourced from various reputable databases. The fixed effect and random effect models were adopted for data analysis while the instrumental variable generalised method of moment (IV-GMM) estimation method was used to validate the results. The trend analysis revealed that South Africa and Nigeria, the two largest economies in Africa, are the top two countries with the highest IFF (in US dollars) among the seven sampled resource-rich African countries. However, the Democratic Republic of Congo and Tanzania are the top two countries with the highest share of trade-based IFF in total trade. The empirical results showed an overwhelming evidence of the negative effect IFF has on tax revenue, which could hamper domestic resource mobilization across the resource-rich African countries.

This finding has implications for policy formulation and implementation. Specifically, the result is crucial to the formulation of evidence-based policies to tackle IFF and foster effective domestic resource mobilization toward the realization of the Sustainable Development Goals (SDGs). First, there is a dire need to review extant anti-IFF policies and formulation as well as implement new ones that take cognizance of the modern ways through which domestic resources are illegally carted abroad. Second, countries need to synergize with their trade partners and other countries with whom they have economic and diplomatic relations in the sharing of financial information to detect culprits of IFF and penalize them accordingly. Anti-IFF agencies also need to be reinforced and their staffs need to be regularly trained on how to use modern tactics to detect and block IFF channels. These efforts will, to a large extent, reduce the incidences of IFF and substantially raise the volume of tax revenue. The key limitation of this study is that it focused mainly on the direct effect of IFF on tax revenue in resource-rich African countries. Future research can focus on exploring how IFF affects domestic resource mobilization in developing and developed regions through indirect channels.

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Scientific Annals of Economics and Business
71 (3), 2024, 399-416
DOI: 10.47743/saeb-2024-0008

The Analysis of Human Capital Development, Economic Growth and Longevity in West African Countries

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Abstract: Human capital is critical in directing all resources to serve people and influencing the productivity of an economy. Human capital can be increased through good health and education. This research examined the effects of human capital development on economic growth and longevity in West Africa. This study was concentrated on four West African countries: Nigeria, Ghana, Burkina Faso, and the Benin Republic. We used panel ordinary least squares (POLS), fully modified ordinary least squares (FM-OLS), and dynamic ordinary least squares (DOLS) for robust analysis to look at how human capital development affects economic growth and longevity over the long term. Life expectancy at birth was employed to evaluate longevity. Before the estimate, correlation, unit root, and cointegration tests were run. According to the findings of this study, human capital development has a 347.5% favorable and significant long-term effect on economic growth. This indicates that enhancing human capital can stimulate economic growth. According to the data, human capital development has a 26.8 percent positive and significant long-term effect on life expectancy at birth. Based on the findings, this study concluded that human capital development has a favorable impact on economic growth and life expectancy at birth in West Africa, demonstrating that developing human capital is advantageous to both growth and life expectancy. As a result, West African governments must increase health and education budgetary expenditures to strengthen human capital.

Keywords: Human Capital development; life expectancy at births; Education; Health; Economic growth.

JEL classification: I15; O15; O47.

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Article history: Received 23 October 2023 | Accepted 12 February 2024 | Published online 13 March 2024

To cite this article: Awoyemi, B. O., Makanju, A. A., Duru, C. (2024). The Analysis of Human Capital Development, Economic Growth and Longevity in West African Countries. *Scientific Annals of Economics and Business*, 71(3), 399-416. https://doi.org/10.47743/saeb-2024-0008.

1. INTRODUCTION

Human capital, as defined by Goldin (2016), consists of an individual's knowledge and abilities; its effective utilisation is crucial to advancing society and the economy at large. The findings of previous research conducted by Keji (2021), Akinlo and Oyeleke (2020), and Khan and Chaudhry (2019) have provided empirical evidence supporting the positive relationship between human capital and economic growth. According to the World Bank (2023), economic growth depends on investments in human capital via education, health, and social programs because of the correlation between human capital, good health, and quality education. A decreased level of human capital development causes poor health outcomes in terms of low life expectancy at birth and mortality rates, which reduces the productivity level of individuals due to poor economic growth. Some countries with developed human capital enjoy reduced poverty, good health, equitable income and sustainable economic growth due to superior technology and high R&D efforts (Dao and Khuc, 2023). Adeyemi and Ogunsola (2016) and Jaiyeoba (2015) stated that education and health are important and used to measure human capital development. They enhance economic growth and have a positive effect on a country's health sector. Although these selected West African countries have abundant natural resources, they are encumbered with challenges regarding economic and human capital development. As noted by Keji (2021), even though Nigeria, one of the four countries selected has human and physical resources, the nation faces significant challenges, such as the migration of skilled labour to developed countries, high unemployment and underemployment rates, poverty, and dilapidated healthcare systems. Due to the state of existing health facilities, they lack the capacity to participate in a market-driven economy because of bureaucracy and insufficient funding (Adenuga and Ibiyemi, 2012; Awoyemi and Olaniyan, 2021). On a more advanced level, investments in health structures, including personnel and infrastructure, are projected to improve health conditions at the macro level, leading to improved human capital and output. However, this proposition does not hold in some west African countries like Nigeria, Benin, and Burkina Faso. According to Awoyemi and Nwibe (2022) and Kojo Edeme *et al.* (2017), Nigeria's health status is still below the global average.

In 2021, the health situation in terms of life expectancy at birth was approximately 60, 59, 64 and 53 years in Benin, Burkina Faso, Ghana and Nigeria, respectively. The prevalence of HIV/AIDS infection, malaria, and tuberculosis infections have also contributed significantly to these countries' poor health conditions (WDI, 2023). The prevalence of HIV/AIDS infection was estimated to be 1.3% and 1.7% of the population aged 15-49 years in Nigeria and Ghana, respectively, which are higher than the global average (0.7%). These poor health conditions have hampered the countries' growth because adequate and effective healthcare services are critical to improving longevity (Anyanwu and Erhijakpor, 2009). Healthcare budgets have been a subject of debate in many West African countries due to scarce resources. World Bank (2023) noted that Sub-Saharan Africa remains the poorest region; its human capital indicators, such as out-of-school children, learning, and stunting, lag behind other regions. In 2020 specifically, the adult literacy rate percentage of people ages 15 and above in Benin, Burkina Faso, Ghana and Nigeria was estimated at 42%, 39%, 79% and 62%, which were far below the World average of 87% (WDI, 2023). UNESCO (2021) statistics showed that Nigeria spent 0.5% (2013), Ghana 3.9% (2018) and Benin 3% of GDP on education in 2020. These countries have spent less than 4-6% of the GDP established international benchmark that countries should spend on education to ensure that countries

have enough financial resources to provide education for all without pushing out anyone. These and many more are the challenges West African countries face, which affects economic growth in these countries. Akinlo and Oyeleke (2020) asserted that the level of economic development is pivotal to the accessibility of trained teachers, teaching manuals and infrastructure necessary to maintain the standards required for education. Countries with deficiencies in these areas may face prolonged economic growth because of a lack of competence in human capital. Both health and education as components of human capital make an individual productive. Therefore, this study focuses on the effects of human capital development on economic growth and longevity in West Africa. The empirical insights are expected to provide policy guidance for policymakers, economists, government stakeholders, and other social scientists and expand the frontier of knowledge in this area.

2. LITERATURE REVIEW

2.1 Human Capital Development, Economic Growth and Longevity in West Africa

West African countries face considerable challenges in human capital development as they are mainly developing countries. This is because of the divergence between the rest of the world and what is occurring in the region. Nigeria, for instance, is the most populous black country with diverse cultures and tribes and unstable political climates; however, its challenges are similar to those of other countries like Ghana, Burkina Faso, and the Benin Republic with relatively smaller populations. Chikwe *et al.* (2015) and Fagbemi *et al.* (2022) highlighted these challenges as low rating in human development indices (HDI), migration of skilled workforce, unemployment, and underemployment. Baah-Boateng (2013) further explained that a lack of public investment in education has contributed significantly to low human capital development in West Africa. In 2021, Ghana ranked 133rd, Nigeria ranked 163rd, Benin Republic ranked 165th, and Burkina Faso ranked 184th, the lowest amongst these four countries, respectively, on the Human Development Index and its components (UNDP, 2022). Only Ghana falls in the middle HDI group. The report factors in life expectancy at birth, mean and expected years of schooling, and gross national income per capita, amongst other variables. For these countries, life expectancy at birth is significantly better for women. Another critical issue is the migration of skilled workers, especially in the health sector, which has impacted these developing countries' systems. In Nigeria, Onah *et al.* (2022) found that 43.9 per cent of physicians were willing to migrate, while Nigerian physicians make up the largest number of foreign doctors in some countries. Similarly, in other West African countries such as Ghana, Burkina Faso, and the Benin Republic, brain drain among health workers and teachers, who build the human capital of any nation, is attributed to poor remuneration, inadequate housing, training and education, security, and political unrest (Adjei-Mensah, 2023).

Bloom *et al.* (2018) explained the relationship between health and economic growth; it depends on the health dimension examined. This research selected mortality rate and life expectancy at birth as health variables. Reducing the mortality rate dramatically helps increase human capital, especially in developing countries. Also, intervention to help children at the earliest stages has long-term effects on their adult lives and positively affects their learning ability. Valero (2021) explored various measures of education and their impact on the individual and economy on a grand scale using the following criteria: stages of education, its quality, and the type of education received. The primary research finding affirms that

education and its positive externalities contribute to economic growth. Similarly, Akpolat (2014) viewed education's impact on economic growth through labor efficiency and its improvements in science and technology with potential skills the citizens acquire. Furthermore, the study found a long-term relationship between education and health; educated people develop healthier habits, and a more educated generation maintains an economy's high human capital. Finally, health and education have significant effects on economic growth. Healthier individuals generally exhibit higher professional performance compared to individuals with lower levels of health. Furthermore, improvements in a nation's healthcare infrastructure contribute to the enhancement of investments in education and life expectancy.

2.2 Theory and empirical literature

Economic theories have been expanded to account for the importance of health and education as human capital inputs. In this regard, studies have focused on economic human capital theory to explain how human capital generates both higher income and individual well-being. They suggested that human and social capital investment should be increased for long-term economic growth because good health promotes high productivity levels (Acemoglu and Johnson, 2007; Li and Huang, 2009; Ponzetto and Troiano, 2018). Individuals with better health tend to exhibit extended life expectancies, providing them with greater motivation to allocate resources to enhance their life skills. Consequently, such investments are expected to yield more enduring effects. The correlation between healthcare and economic growth has been categorised across different dimensions, including methodology, data sources, nation groupings, periods, and outcomes. In their study, Narayan *et al.* (2010) examined the correlation between health and economic growth in five Asian nations. Their findings revealed a statistically significant and positive association between health and investment, which augments per capita income. Bloom *et al.* (2019) analyzed how health investments have improved longevity and labor force participation in developed countries, suggesting that West African countries should model health systems after these developed countries to prolong life. Acemoglu and Johnson (2007) provided empirical evidence favouring neoclassical growth theory, positing that a rise in life expectancy leads to population growth. This, in turn, results in a decline in the ratios of capital-to-labor and land-to-labor, thus reducing per capita income. The effect of health on economic growth, as measured by life expectancy at birth, has no significant impact on total GDP. In nations with a substantial increase in life expectancy, there has been a corresponding reduction in both GDP per capita and GDP per working-age population. There needed to be more per capita income convergence among countries previously classified as low, middle-income, and wealthy.

Howitt (2005) proposed a straightforward framework for Schumpeterian growth theory, which centres on innovation. This model identifies six potential pathways by which improvements in a nation's population health can impact its long-term economic growth. All of these impacts exhibit a consistent trend, except a potential anomaly. Their primary objective is to significantly enhance the productivity and per-capita GDP of an already economically prosperous nation, enabling it to maintain a growth trajectory comparable to that of global technological frontrunners. They enhance the per-capita GDP growth rate of nations with weaker growth rates compared to technology leaders, enabling certain countries to achieve relative stability in closing the gap in living standards that separates them from the

technology leaders. This research enhanced the current theoretical framework by examining the influence of health on economic growth within the context of West African nations.

Extensive empirical evidence and scholarly literature have been dedicated to examining the impact of human capital development on both economic growth and health outcomes in Africa and developed economies. The empirical study by Eggoh *et al*. (2015) examined the relationship between education, health, and economic growth in African countries. The research utilized secondary time series data from 1996 to 2010 and employed a panel technique for analysis. The Generalized Method of Moments (GMM) was applied for the analysis. The findings indicate a positive relationship between public expenditure on education and health and economic growth in African economies. The study revealed that a specific threshold of health expenditure is necessary to observe favourable outcomes from investments in education and vice versa. Consequently, it is recommended that efficiency be considered when making public investments in education and health, as this will enable the development of human capital to impact economic growth positively in African nations.

Shuaibu and Popoola (2016) analyzed the determinants of human capital development in African economies. The research utilized a panel technique and evaluated data from 33 African countries, covering the period from 2000 to 2013. The data underwent analysis through the application of the Pedroni and Kao cointegration approach and the panel Granger Causality test. The Pedroni and Kao cointegration test results provide evidence supporting a long-term equilibrium relationship among the variables. This finding suggests that the variables examined in this study play a significant role in influencing human capital development over the long term. The findings of the Granger Causality analysis indicate the presence of a reciprocal causal relationship between the human capital development and economic growth, wherein the former influences the latter and vice versa, with feedback effects from economic growth. Furthermore, it was seen that there is a one-way causal relationship, specifically from the human capital development to economic growth, with no reciprocal influence. This suggests that human capital development has a causal relationship with improving health, education infrastructure, and institutional quality. The study recommends that African countries should prioritize the continuation and expansion of their investments in education and human health. Additionally, efforts should be made to improve infrastructure and institutional quality.

Hu and Yao (2021) examined the possible unequal impacts of investing in human capital and technical innovation on the health of populations in the BRIC countries. The study employed data from 1991 to 2019 and used a panel non-linear autoregressive distributed lag pooled mean group (NARDL-PMG) approach to examine the long-term and short-term relationships among the variables. The variables under investigation were found to exhibit integration of orders I(0) and I(1) based on the use of the Levin, Lin, Chu (LLC) test, the Im, Pesaran, Shin (IPS) test, and the Fisher-ADF stationarity tests. According to long-term estimates derived from the NARDL model, it is evident that positive shocks in government sector education expenditure have a substantial effect on life expectancy. Furthermore, it is worth noting that the reduction in government-sector education expenditure has a detrimental impact on life expectancy in BRICS economies. In the context of the BRICS economies, it has been observed that a 1 percent increase in public education expenditure leads to a corresponding increase of 0.804 percent in life expectancy. Conversely, a 1 percent increase in public education expenditure results in a decrease of 3.1 percent in life expectancy. The report suggests that it would benefit governments in BRIC countries to augment their funding

for the education and health sectors. Mulia and Saputra (2021) established a practical and theoretical view of human capital improvement from 2011-2021 using data from eighty-three empirical literature. They employed visualisation tools like bar charts, pie charts, and tables to analyse data. Findings confirm declining human capital development in Indonesia and attribute this to the government's neglect of the education and health sectors. They propose that the government should improve the educational quality and public health services to enhance human capital development.

An assessment of human capital from a global corporate perspective was the primary concern of the study by Danaeefard and Babashahi (2021), which concentrated on human capital development and national well-being. The paper aimed to ascertain whether human capital development promotes national well-being and competitiveness. Data from 135 countries worldwide from 2009 to 2011 were analyzed using Pearson's correlation and Structural Equation Modeling (SEM). The results confirm a positive relationship between human capital development and national well-being. However, further study is required using recent data for a more elaborate finding consistent with recent human health and economic developments.

From 1981 to 2017, Keji (2021)'s study looked into the connection between output growth and human health in Nigeria. The Johansen cointegration technique was utilised in this study to identify cointegrating correlations among the variables examined. The Vector Error Correction (VECM) analysis revealed a statistically significant and positive association between human capital and economic growth in Nigeria. The study's findings indicate that human capital indicators, such as the rate of student enrolment, labour participation rate, and total labour force, significantly influence economic growth. The study further suggests that one effective strategy for maintaining sustained economic growth is for the government to allocate a larger budget to the education and health sectors. Gumbau Albert (2021) examined the relationship between human health indicators and regional economic performance in Spain. The research conducted a comparative analysis by utilising data to estimate the association between health, education, and growth variables across seventeen areas in Spain from 2000 to 2016. The econometric analysis involved the application of the Generalized Method of Moments (GMM) estimation technique. The study employed various criteria to assess health status, including life expectancy at birth, life expectancy at age 65, an individual's self-perceived health condition, and the proportion of individuals with long-term health issues. The measurement of the education component of human capital relied on the count of workers who had attained higher education. The fixed effects (FE) outcomes analysis provided strong evidence supporting the positive and statistically significant relationship between health status and regional output. The study suggests that policymakers should prioritise augmenting investments in the health sector to foster sustained economic growth in the Spanish region.

Kia *et al.* (2021) examined how the growth of human capital affects both health and economic systems. This study analysed primary data obtained through a sample survey of 302 respondents from the health sector in Iran. The research utilised statistical techniques, including analysis of variance (ANOVA), t-tests, and partial least squares (PLS), to analyse the collected data. The study identified several variables that significantly influence the development of the healthcare system. These variables include the need for financial resources to support human capital, effective management of health services, efficient internal processes, and active participation of human capital. The study suggests that in-service training should be provided to the workforce to address the country's present and future human resource requirements.

3. METHODOLOGY

The study's scope spans the years 1990–2022 to cover the decades before and after the epidemic, and four West African countries were chosen, two of which were English-speaking (Nigeria and Ghana) and two French-speaking (Burkina Faso and Benin). The data was sourced from the World Bank and Central Bank's annual report. Panel ordinary least squares (POLS) was used to estimate the stated model while, fully modified ordinary least squares (FM-OLS) and dynamic ordinary least squares (DOLS) were also used for robust analysis. Economic growth was quantified using the log of real gross domestic product (RGDP). However, longevity was measured using a frequently used indicator in the literature, life expectancy at birth, which measures health outcomes. Other control variables include gross fixed capital formation, which measures domestic investment, government spending on education and health, human capital development index (HDI) and labour force participation. These variables were included given their influence as the determinants of longevity and economic growth in line with previous studies and theory (Howitt, 2005; Ben Yedder *et al.*, 2023; Roffia *et al.*, 2023). Summary statistics such as mean, minimum, maximum, and standard deviation were used prior to estimation to describe the features of the data. A unit root test (Augmented Dickey-Fuller, or ADF) was also used to determine if the related data series were stationary, and correlation analysis was used to determine if there was multicollinearity. The existence of a long-run relationship among the variables was tested with the cointegration method.

Model 1: Human capital development and economic growth

$$RGDP_{it} = f(GEE\_GDP_{it}, CHE\_GDP_{it}, GFCF\_GDP_{it}, HDI_{it}, \varepsilon_t) \quad (1)$$

$$ln\, R\, GDP_{it} = \alpha_0 + \alpha_1 GEE\_GDP_{it} + \alpha_2 CHE\_GDP_{it} + \alpha_3 GFCF\_GDP_{it} + \alpha_4 HDI_{it} + \varepsilon_{it}$$

Model 2: Human capital development and life expectancy at birth

$$LEB_{it} = f(GEE\_GDP_{it}, CHE\_GDP_{it}, GFCF\_GDP_{it}, HDI_{it}, RGDP, LTLF, \varepsilon_t) \quad (1)$$

$$LLEB_{it} = \alpha_0 + \alpha_1 GEE_{GDP_{it}} + \alpha_2 CHE_{GDP_{it}} + \alpha_3 GFCF_{GDP_{it}} + \alpha_4 HDI_{it} + \alpha_5 LRGDP_{it} + \alpha_6 LTLF_{it} + \varepsilon_{it} \quad (2)$$

where $\alpha_0$is the intercept of the model, and $\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6$what are the coefficients?

$RGDP_{it}$ = Real gross domestic product for each country i over a period of time t

GEE_GDP_{it} = education expenditure as % of GDP for each country i over a period of time

CHE_GDP_{it}= expenditure on health as % of GDP for each country i over a period of time t

$GFCF\_GDP_{it}$= gross fixed capital formation as % of GDP for each country i over a period of time t

HDI_{it} = Human Development index for each country i over a period of time t

$LTLF_{it}$= Total labour force for each country i over a period of time t

LEB_{it} = Life expectancy at birth for each country i over a period of time t

ε_t= Error term

4. RESULTS

4.1 Descriptive Statistics

This section analyzes the characteristics of key variables over 32 years (1990–2022) by providing brief descriptions of the data series using the most widely used descriptive statistical tools, correlation, and summary statistics to understand better the data set utilized in this study. Table no. 1 shows the variable summary statistics. It demonstrates that the mean of real gross domestic product (RGDP) in the selected West African countries is $109.12 billion, with a standard deviation of $134.1 billion, demonstrating a considerable variation in RGDP among the countries. The average human development index (HDI) is 0.468, with a standard deviation of 0.076, indicating that the HDI data series has minimal variability. The average GEE_GDP is 4.03%, with a deviation of 1.530%; the result indicates that the data are scattered around the mean, and it may be deduced that government expenditure on education accounts for approximately 4% of the countries' GDP.

Furthermore, the mean of gross fixed capital formation as a percentage of GDP (GFCF_GDP) is 21.49%, with a low of 11.76% and a high of 53.12%. It demonstrates that gross fixed capital formation accounts for approximately 22% of a country's GDP. The average value of CHE_GDP is 3.71%, and the standard deviation is 0.894%, showing that CHE_GDP varies little between countries. The total labour force (TLF) is 357.5 million on average, with a variation of 808.77 million, indicating heterogeneity in TLF values among nations. Finally, the average LEB is 55 years old, with minimum and highest values of 45 and 64 years, respectively. In general, variables like the human capital index, public education spending as % of GDP, gross fixed capital formation as % of GDP, current spending on health as % of GDP, and life expectancy at birth all show low variability. In contrast, variables such as real GDP and the total labour force are widely dispersed.

Table no. 1 – Summary Statistics

	RGDP	HDI	GEE_GDP	GFCF_GDP	CHE_GDP	TLF_M	LEB
Mean	109.120	0.467	4.033	21.489	3.706	357.513	55.01
Median	58.648	0.481	3.679	19.722	3.419	22.576	55.64
Max	502.942	0.611	8.140	53.122	6.029	4012.093	64.07
Min	3.042	0.293	1.440	11.764	2.388	3.899	45.84
Std. Dev.	134.082	0.077	1.530	7.7228	0.894	808.778	5.13
Skewness	1.684	-0.343	0.896	1.7731	0.744	2.881	-0.30
Kurtosis	4.939	2.526	3.515	6.4513	2.599	11.008	2.014
Obs.	123	98	53	123	80	124	120

Source: Author's computation based on the data from the World Bank (2023)

4.2 Correlation analysis

This section covers the degree of connection and the potential correlation between the response and the explanatory variables. It also demonstrates how variables are related and determines whether the explanatory variables are highly correlated. The correlation analysis is shown in Table no. 2. The correlation coefficient between real gross domestic product (RGDP) and the human capital index (HCI) is 0.303, indicating that RGDP has a weak but positive relationship with HCI. Furthermore, the correlation coefficient between RGDP and GEE_GDP is 0.567. Similarly, RGDP has correlation coefficients of 0.846 and 0.813 with CHE_GDP and

TLF, respectively. TLF and CHE_GDP have a strong and positive association with RGDP. The correlation value between HDI and LEB is 0.831, indicating a strong positive association between the two variables. The results reveal that as RGDP increases, so do HDI, GEE_GDP, GFCF_GDP, and CHE_GDP.

Table no. 2 – Correlation analysis

	RGDP	HDI	GEE_GDP	GFCF_GDP	CHE_GDP	TLF_M	LEB
RGDP	1.000	0.303	0.57	0.11	0.81	0.846	0.116
HDI	0.303	1.000	0.324	0.218	-0.34	0.188	0.831
GEE_GDP	0.567	0.324	1.000	0.143	0.408	-0.49	0.320
GFCF_GDP	0.105	0.218	0.143	1.000	-0.04	0.103	0.284
CHE_GDP	0.813	-0.33	0.408	-0.04	1.000	-0.68	0.026
TLF_M	0.846	0.188	-0.49	0.103	-0.68	1.000	0.144
LEB	0.116	0.831	0.320	0.284	0.026	0.144	1.000

Source: Author's computation based on the data from the World Bank (2023)

4.3 Unit root test

To avoid estimating a spurious regression, the ADF Fisher, Im Pearson, and Shin W-stat unit root tests are presented in Table no. 3 so that the stationary condition of the series can be determined before further estimation is carried out. The ADF-Fisher Chi-Square unit root test result shows that LRGDP, HDI, GEE_GDP, GCFC_GDP, LTLF, and LEB are stationary at first difference. The Im Pearson and Shin W-stat show that CHE_GDP is stationary at level, while LRGDP, HDI, GEE_GDP, GCFC_GDP, LTLF, and LEB are stationary at first difference. Overall, the result shows that variable CHE_GDP is stationary at a level, while other variables are stationary at first difference.

Table no. 3 – Unit root test

ADF Test	Level		First Difference		
	Trend and Intercept Stat	**Prob**	**Trend and Intercept Stat**	**Prob**	**Remark**
LRGDP	0.7126	0.9995	24.5453	0.0019	I(1)
HDI	2.46634	0.9633	23.0942	0.0032	I(1)
GEE_GDP	4.31136	0.6346	32.9391	0.0000	I(1)
GCFC_GDP	10.4839	0.2327	68.7903	0.0000	I(1)
CHE_GDP	12.0533	0.1488	66.3112	0.0000	I(1)
LTLFT	3.93100	0.8633	38.5071	0.0000	I(1)
LLEB	2.67977	0.9528	35.3666	0.0000	I(1)
IPS TEST	**Trend and intercept Stat**	**Prob**	**Trend and intercept Stat**	**Prob**	**Remark**
LRGDP	2.00812	0.9777	-4.98540	0.0000	I(1)
HDI	2.31062	0.9896	-1.89415	0.0291	I(1)
GEE_GDP	0.26027	0.6027	-4.53592	0.0000	I(1)
GCFC_GDP	-0.85962	0.1950	-8.36190	0.0000	I(1)
CHE_GDP	-1.30338	0.0962	-8.81231	0.0000	I(0)
LTLFT	2.62733	0.9957	-4.49650	0.0000	I(1)
LLEB	1.34817	0.9112	-10.0582	0.0000	I(1)

Source: author's computation

4.4 Cointegration Test

The Kao test result for model 1 indicates cointegration and a long-run relationship between all variables with statistics -1.928 and a p-value of 0.0267. As a result, the null hypothesis (H0) of no cointegration is rejected at the 5% significance level. Table no. 4 shows that using the Pedroni test, the H0 in a panel pp is rejected with statistics -1.7406(0.0409) at a 5% significance level. Also, with -3.8168(0.0001) and -3.6822(0.0001), respectively, group PP and group ADF indicate that there is a long-run link between the variables, and the null hypothesis of no cointegration may be rejected at a 1% level of significance. According to Kao and Pedroni's findings, there is a long-run relationship between human capital development and economic growth. At a 1% significance level, the Kao statistics of -3.474 and probability value of 0.0003 indicate a stable long-run association in model 2. Panel PP statistics of -3.242 and probability value of 0.0006 and panel ADF statistics of -3.242 and probability value of 0.0006 reject the non-cointegration hypothesis in the case of the Pedroni statistics. Also, with -3.538(0.0002) and -1.7766(0.0378), respectively, group PP and group ADF indicate that there is a long-run link between the variables, and the null hypothesis of no cointegration may be rejected at a 1% level of significance. As a result, the research suggests a long-run equilibrium relationship between human capital development and health.

Table no. 4 – Cointegration test

	Model 1		Model 2	
Test	**Stat (P-Value)**	**Weighted Stat (P-Value)**	**Stat (P-Value)**	**Weighted Stat (P-Value)**
Kao Test	-1.928 (0.027)		-3.474 (0.000)	
Pedroni Test				
Panel v-Stat	0.2656 (0.395)	1.787 (0.037)	2.931 (0.002)	2.985 (0.001)
Panel rho-Stat	1.331 (0.908)	1.272 (0.898)	1.1368 (0.872)	1.136 (0.872)
Panel PP-Stat	-1.741 (0.041)	-2.097 (0.018)	-3.242 (0.000)	-3.243 (0.000)
Panel ADF-Stat	1.743 (0.041)	-2.094 (0.018)	2.737 (0.003)	-2.735 (0.003)
Group rho-Stat	1.693 (0.955)		1.578 (0.943)	
Group PP-Stat	-3.817 (0.000)		-3.5388 (0.000)	
Group ADF-Stat	-3.682 (0.000)		-1.776 (0.038)	

Source: author's computation

4.5 Long-Run Effect of Human Capital Development on Economic Growth

The coefficient of determination, or R2, from the panel least squares (POLS) results suggests that human capital development and other explanatory variables account for around 85.7% of the changes in economic growth. When more variables are added to the model, the modified R-squared value of 84.4% reveals that the selected explanatory factors still explain 84.4% of the variances. Table no. 5 demonstrates that at the 1% significance level, the F-statistic (64.63) is hugely significant. The model's outcomes are validated, showing they are highly predictive and applicable. These findings demonstrate, at the 1% significance level, that human development has a positive and significant effect on economic growth over the long term, with a unit rise in HDI increasing LRGDP by 361.8 percent. Government spending on education has a positive and significant effect on long-term economic growth, as shown by a 10.7 percentage

point rise in LRGDP for every percentage point increase in GEE_GDP at the 1% level of significance. Long-term economic growth is positively impacted by current health expenditure at the 1% significance level, as shown by the 26.8% increase in LRGDP for a 1% increase in CHE_GDP. According to fully modified least squares (FMOLS) panel results, R2 estimates that human capital development and other explanatory factors account for about 85.2% of changes in economic growth. In addition, the model's adjusted R-square of 82.75 indicates that the chosen explanatory variables still account for 82.75% of the variation, even when all other explanatory variables are accounted for. The FMOLS result shows that an increase of one unit in HDI raises LRGDP by 305.3 percent (at the 1% significance level), demonstrating how human development positively and significantly impacts long-term economic growth. Further, at the 10% significance level, a rise in GEE_GDP by a percentage point leads to an increase in LRGDP of 21.9%, indicating that government spending on education has a positive and significant effect on economic growth over the long term.

Human capital development and other explanatory variables account for around 82.3% of the variability in economic growth, as shown by the R2 value from the panel dynamic least squares (DOLS) results. If more explanatory factors are added to the model, the adjusted R-squared value of 81.9 still indicates that the selected explanatory variables adequately explain 81.9% of the variation. The finding demonstrates that at the 1% significance level, human capital development positively and significantly affects LRGDP growth, with a unit increase in HDI increasing LRGDP by 347.5 percent. Gross fixed capital formation has a positive and significant effect on economic growth over the long term; an increase of one percentage point in GFCF_GDP results in an increase of 0.4% in LRGDP at the 5% level of significance. Similarly, a 1% increase in CHE_GDP results in a 3.9% increase in LRGDP, demonstrating that current health expenditure positively and significantly affects economic growth at the 5% significance level. The influence of human capital development on economic growth is determined using the DOLS model, which has the highest R-squared value and the lowest long-run variation relative to the POLS and FM-OLS. According to the underlying data, it works best for cointegrated panel regressions. Thus, the analysis shows that the human development index, gross fixed capital formation, and government spending on health have a positive and significant long-run effect on economic growth.

Table no. 5 – Long-run effect of human capital development on economic growth

Variables	Panel (POLS) Coefficient(t-Stat)	Panel (FMOLS) Coefficient(t-Stat)	Panel (DOLS) Coefficient(t-Stat)
HDI	3.618 (10.882) ***	3.053 (82.238) ***	3.475 (33.124) ***
GEE_GDP	0.107 (3.062) ***	0.219 (1.807) *	0.011 (1.602)
GFCF_GDP	0.014 (1.465)	-0.022 (-0.558)	0.004 (2.413) **
CHE_GDP	0.268 (4.805) ***	-0.149 (-0.981)	0.039 (2.422) **
Constant	24.313 (71.275)		
R-squared	0.857393	0.852781	0.862742
Adjusted R-squared	0.844128	0.827544	0.849485
F-statistic	64.63213(0.000)		
Long-run variance		0.003085	0.001031

Note: ***, ** and * represent 1%, 5% and 10% levels of significance
Source: author's computation

4.6 Long-Run Effect of Human Capital Development on Life Expectancy at Birth

The panel least squares (POLS) finding demonstrates that human capital development and other explanatory variables account for around 86.2% of the variability in life expectancy at birth. Additionally, the adjusted R-square of 84.2 shows that the selected explanatory variables will still explain 84.2% of the changes even after including all other explanatory variables in the model. At the 1% significance level, the F-statistic (42.67) is highly significant. These results prove the model's impressive predictive power and practical use. At the 1% significance level, the panel least squares show that a unit increase in HDI improves LLEB by 23.5%, demonstrating that human capital development has positive and significant long-term benefits on life expectancy at birth. Additionally, at the 5% significance level, an increase of one percentage point in GFCF_GDP boosts LLEB by 0.1%, indicating that gross fixed capital formation has long-term positive and significant effects on life expectancy at birth. Similarly, a 1% rise in CHE_GDP leads to a 2.9 percentage point increase in LLEB, showing that current health expenditure positively and significantly affects life expectancy at birth. The R squared value of 74.3 from the panel Fully Modified Least Squares (FMOLS) analysis indicates that human capital development and other explanatory variables account for 74.3% of life expectancy at birth variability. When more variables are added to the model, the adjusted R-squared value remains at 70.7%, indicating that the selected explanatory variables adequately describe the observed variation. The FMOLS results reveal that an increase in LRGDP raises LLEB by 13.6%, suggesting that LRGDP positively and significantly influences LLEB at the 1% significance level. Human development has a positive and considerable long-term effect on life expectancy at birth; a unit increase in HDI improves LLEB by 26.8 percent. This is significant at the 1% level. Furthermore, a percentage point rise in GFCF_GDP results in a percentage point increase in LRGDP, suggesting at the 0.1% significance level that gross capital fixed formation positively and significantly affects life expectancy at birth. Additionally, at the 10% significance level, an increase in current health spending (CHE_GDP) leads to an increase in long-term real GDP growth (LLEB) of 3.5 percent. There is a positive and statistically significant relationship between the labour force and LLEB; for example, a 1% rise in LTLF results in a 3.1% increase in LLEB.

Human capital development and other explanatory variables account for around 76.8% of the variation in life expectancy at birth, according to the R2 value from the panel dynamic least squares (DOLS) analysis. The adjusted R-square 74.1 implies that the selected explanatory variables will still explain 74.1 percent of the variations even when all other explanatory factors are included in the model. The finding demonstrates that a 1% rise in LRGDP leads to a 13.7% increase in LLEB, indicating that economic growth positively and significantly affects LLEB. Additionally, a unit increase in HDI improves LLEB by 25.6%, revealing that human development positively and significantly affects life expectancy at birth at the 1% significance level. Long-term real GDP growth is positively affected by current health expenditure at the 10% significance level, as measured by a 3% rise in LLEB for a 1% increase in CHE_GDP. Similar to how a rise in LTLF raises LLEB by 3.1%, the labour force has a positive and statistically significant impact on LLEB at the 1% level. The FMOLS model has the highest R-squared value and the lowest long-run variance compared to the POLS, FM-OLS, and DOLS in determining the impact of human capital development on economic growth. Based on the underlying data, it is most appropriate for cointegrated panel

regressions. Thus, the findings demonstrate that real GDP, HDI, GFCF, health spending, and the labour force have positive and significant long-term effects on life expectancy at birth.

Table no. 6 – Long-run results of the effect of human capital development on LEB

Variables	Panel (POLS) Coefficient(t-Stat)	Panel (FMOLS) Coefficient(t-Stat)	Panel (DOLS) Coefficient(t-Stat)
LRGDP	0.011 (0.426)	0.136 (559.763) ***	0.137 (41.683) ***
HDI	0.235 (2.202) **	0.268 (95.223) ***	0.256 (7.793) **
GEE_GDP	-0.003 (-1.184)	0.0003 (-1.338)	0.002 (0.628)
GFCF_GDP	0.001 (2.143) **	0.001 (12.552) ***	0.001 (0.759)
CHE_GDP	0.029 (6.105) ***	0.035 (48.198) ***	0.03 (3.655) ***
LTLF	0.006 (1.135)	0.031 (150.013) ***	0.031 (12.691) ***
C	3.751 (4.68) ***		
R-squared	0.861965	0.872654	0.768607
Adjusted R-squared	0.841765	0.856911	0.74106
F-statistic	42.67(0.000)		
Long-run variance		2.73E-06	0.000773

Note: ***, ** and * represent 1%, 5% and 10% levels of significance
Source: author's computation

4.7 Diagnostic Test

The diagnostic test results for verifying the ARDL model are shown in Table no. 7. We employed the Breusch-Godfrey serial correlation LM test and the normality tests. The results of the Breusch-Pagan LM test show that F-statistics with corresponding p-values are not statistically significant. This means there is a significant rejection of the (H0) null hypothesis of no serial correlation at the 1% significance level. The normal distribution of the error term test shows that the Jarque-Bera test statistics (4.902) and the related p-values (0.086) are not significant for Model 1. Furthermore, Table 7 displays an insignificant F-statistic and p-value of 4.332 (0.228) for the Breusch-Pagan LM test results. Therefore, the lack of a serial correlation (H0) is accepted at a 5% significance level. The normal distribution of the error term test implies that the Jarque-Bera test statistics (0.887) and p-values (0.642) for Model 2 are insignificant. This analysis accepts the null hypothesis of a normal distribution and finds that the error terms in Models 1 and 2 follow a normal distribution.

Table no. 7 – Diagnostic test

Statistic	Breusch-Pagan LM:	Normality test
F-statistic (Model 1)	6.5597 (0.0873)	4.902(0.086)
F-statistic (Model 2)	4.332(0.228)	0.887(0.642)

Source: author's computation

5. DISCUSSION

The study's findings about the impact of human capital development on economic growth indicate a favourable and statistically significant relationship between human capital development and long-term economic growth. This suggests that enhancing education and

health, the primary constituents of human capital can stimulate economic growth. Additionally, factors like domestic investment, as measured by gross fixed capital formation, have a positive and significant impact on economic growth trajectory. Similarly, the allocation of government funds towards healthcare exhibits a favourable and noteworthy impact on long-term economic growth. Numerous scholarly investigations have elucidated the significance of human capital as a crucial element in the optimisation of viable resources for the betterment of humanity. Moreover, these studies underscore the pivotal role of human capital in shaping the productivity levels of an economy (Jaiyeoba, 2015; Lawanson, 2015; Somé *et al.*, 2019; Haini, 2020; Sarpong *et al.*, 2020; Ogbeifun and Shobande, 2021). According to the study by Jaiyeoba (2015), evidence suggests a favourable correlation between investments in human capital development, tertiary education enrolment, and economic growth. Lawanson (2015) conducted a study to examine the impact of education and health components of human capital on economic growth. The study's findings indicated that the education and health components of human capital positively and significantly affected economic growth in the West African region. In their study, Sarpong *et al.* (2020) investigate the impact of health on long-term economic growth within sub-Saharan African (SSA) nations. Their findings reveal that a proportional increase in human capital leads to a corresponding 0.21 percent rise in economic growth. The study by Ogbeifun and Shobande (2021) examines the correlation between human capital accumulation and economic growth, revealing a statistically significant positive association between human capital and economic growth. Additionally, the research outcomes about the impact of human capital development on life expectancy at birth in West Africa indicate that human development exerts a favourable and substantial influence on life expectancy at birth over an extended period. Enhancing human capital development via education and health interventions can extend individuals' lifespans. Furthermore, several additional factors positively contribute to longevity, as indicated by life expectancy at birth over an extended period. These factors encompass enhancements in economic growth, gross fixed capital creation, health expenditure, and the labour force.

The study's main implications are that the human development index, domestic investment (gross fixed capital formation), and government health spending all have positive and significant long-run effects on economic growth. This means that increased human capital development, domestic investment, and health-care spending are all beneficial to economic growth. Fostering domestic investment in a country, according to Ben Yedder *et al.* (2023), boosts job creation, promotes innovation, and increases output and productivity, all of which spur economic growth. Investing in productive assets can improve infrastructure and boost production capacity, resulting in increased productivity and efficiency. Similarly, supporting human capital development is frequently related to improved health and education, both of which can add to productivity; a healthier and more educated population is generally more productive and innovative, fostering economic progress. An increase in government expenditure, according to Keynes (1936), is expected to enhance employment and investment through multiplier effects on aggregate income. According to Aboubacar and Xu (2017), proper and effective health care spending is often seen as vital to economic growth since government health investment adds health infrastructure for illness prevention, helps retain a productive work force, and improves productivity. Intuitively, this study identifies that a healthy and educated population, together with targeted investments in capital formation and healthcare, can provide an ideal environment for sustained economic growth in West African

countries. Nevertheless, the efficacy of these factors is contingent upon how well they are put into practice and other contextual circumstances specific to each nation.

Our findings also innovatively demonstrate that economic growth, HDI, health spending, and the labor force have positive and significant long-term effects on life expectancy at birth. Economic growth frequently leads to higher income levels, which can enhance people's access to basic necessities like food, clean water, and shelter, as well as allow for investments in healthcare infrastructure, resulting in better-equipped hospitals, clinics, and healthcare services. Similarly, countries with higher HDI ratings tend to have better healthcare and educational systems, which can enhance living standards, contribute to better overall well-being and access to healthcare, and influence life expectancy. Furthermore, appropriate health spending enables preventative interventions such as immunization programs, disease surveillance, and public health campaigns, which can lower illness incidence and enhance general health. Increased health spending can result in greater healthcare infrastructure, more medical experts, and easier access to healthcare services. A healthier labor force is more productive in general, resulting in higher economic output (Ben Yedder *et al.*, 2023; Roffia *et al.*, 2023). In essence, increased economic levels in the selected West African countries can translate into better living circumstances, improved access to healthcare, and longer lives. Human capital development and employment also contribute to general well-being by lowering stress and increasing mental health, both of which improve life expectancy.

6. CONCLUSION AND RECOMMENDATIONS

The following conclusion is reached from the findings: West Africa's health performance continues to lag behind many other countries worldwide. This is due to poor life expectancy at birth, which is still lower than in many other countries worldwide. This demonstrates that some West African countries have yet to meet the WHO's suggested 4-6% health spending as a percentage of GDP; some countries still spend less than 4% of their GDP on health, preventing them from meeting the essential health interventions required to approach universal health coverage. Furthermore, human capital development in West Africa has been found to impact economic growth positively. This study supported the notion that cultivating human capital is pivotal in fostering economic progress. The knowledge and skills acquired through education, training, and job experience impact labour productivity.

Furthermore, investment in health tends to increase an individual's labour-market productivity, contributing to economic growth. Furthermore, government spending on health and domestic investment, as measured by gross fixed capital formation, among other things, has the potential to boost West African economic growth. Increasing domestic investment creates jobs and improves well-being and productivity, promoting economic growth. Aside from human capital development, other important drivers of West African life expectancy and economic growth include labour force participation, gross fixed capital formation (a measure of domestic investment), and public health spending. According to the conclusions of this study, the government and stakeholders in West African countries need to enhance budgetary allocations for health and education to attain universal health coverage while strengthening the educational system. Furthermore, efforts should be increased to increase domestic investment in locally produced goods to reduce the number of imported goods significantly and encourage local consumption to stimulate employment; this will improve people's welfare, thereby increasing life expectancy, productivity, and economic growth.

Acknowledgements

The author acknowledges the support of John O. Awoyemi for proofreading this work and the staff of the Economics Department, Afe Babalola University Ado-Ekiti. They provided comments for the improvement of this work.

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Scientific Annals of Economics and Business
71 (3), 2024, 417-447
DOI: 10.47743/saeb-2024-0011

Shelter in Uncertainty: Evaluating Gold and Bitcoin as Safe Havens Against G7 Stock Market Indices During Global Crises

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Abstract: This paper investigates the hedging and safe haven capacity of gold and Bitcoin against the G7 stock market indices during the COVID-19 pandemic, the Russia-Ukraine military conflict, and the Silicon Valley Bank collapse. Using a novel Quantile-VAR connectedness approach, the results show that, at the median quantile, both gold and Bitcoin act as effective hedges during normal market conditions and strong safe-haven assets during the three crises. Gold emerges as the most prominent safe haven asset, outperforming Bitcoin, especially during the war and the SVB collapse. Among the G7 stock market indices, the Japanese and the American stocks may be used as risk diversifiers during crises. As for the rest of the G7 stocks, they are regarded as "risk-on" investments. Next, we assessed the robustness of our results at various quantiles. We found them to be generally consistent with the outcomes obtained at the median quantile, with one exception related to the S&P500.The results show that the repercussions of the COVID-19 pandemic and the war are much stronger than the American banking crisis.

Keywords: COVID-19 health crisis; Russia-Ukraine war; SVB collapse; safe haven assets; G7 stock market indices; Quantile-VAR.

JEL classification: C58; G01; G10; G11; G15; G21.

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Article history: Received 15 December 2024 | Accepted 15 January 2024 | Published online 19 January 2024

To cite this article: Snene Manzli, Y., Jeribi, A. (2024). Shelter in Uncertainty: Evaluating Gold and Bitcoin as Safe Havens Against G7 Stock Market Indices During Global Crises. *Scientific Annals of Economics and Business*, 71(3), 417-447. https://doi.org/10.47743/saeb-2024-0011.

1. INTRODUCTION

In the last decade, we have witnessed numerous crises, including the latest COVID-19 pandemic detected in Wuhan, China on December 31st, 2019, and the ongoing geopolitical tensions observed in the Russia-Ukraine conflict since February 24, 2022. Both of these crises have exerted significant and complex influences on global stock markets (Baker *et al.*, 2020; Jeribi and Snene-Manzli, 2020; Boungou and Yatié, 2022; Thorbecke, 2022; Fakhfekh *et al.*, 2023; Florian and Sascha, 2023). In the initial stages, the pandemic initiated an intense and widespread decline in the market due to the enormous economic disturbances it generated. Governments across the globe enforced rigorous measures to contain the virus's transmission, resulting in the shutdown of businesses, reduced consumer expenditures, and the disruption of global supply networks. These factors, combined with investor concerns, contributed to increased market instability and significant drops in global stock markets, particularly in the G7 stock markets (Caporale *et al.*, 2022). For instance, the American stock index (S&P500) plunged by more than 9% in March 2020. Similarly, Asian stocks experienced a substantial decline, as evidenced by Japan's key NIKKEI index concluding with a 4.4% decrease on March 12, 2020. In addition to the meltdown in the American and Asian stock markets, European stock markets also experienced significant downturns. For example, the FTSE100, the main stock index in the United Kingdom, registered a decline exceeding 10% on its most challenging day since 1987. Stock indices in France and Germany also recorded declines exceeding 12%[1].

On the other hand, the ongoing conflict between Russia and Ukraine has initiated geopolitical instability and raised worries about global security and energy supplies. Consequently, stock markets in G7 countries have experienced periodic changes in response to escalating war events, affecting investor sentiment and market performance (Boungou and Yatié, 2022; Fakhfekh *et al.*, 2023; Kayral *et al.*, 2023). Ahmed *et al.* (2023) reveal that European stock markets responded negatively to the Russia-Ukraine crisis due to heightened political uncertainty, geographic proximity, and the consequences of recent sanctions imposed on Russia. Alam *et al.* (2023) state that the Russian-Ukrainian war had a significant impact on the volatility spillover from and to commodities in G7 stock markets. Also, Boubaker *et al.* (2022) discovered that the 2022 Russian invasion of Ukraine resulted in negative returns for global stock market indexes.

More recently, on March 10, 2023, Silicon Valley Bank (SVB), the sixteenth most prominent financial institution in the United States, experienced its most significant breakdown since the 2008 global financial crisis, resulting in the loss of billions of dollars in deposits and financial holdings. SVB's collapse occurred against the backdrop of an expanding technology sector during the COVID-19 pandemic, coinciding with a significant surge in customer deposits, totaling billions of dollars. SVB directed substantial portions of its surging deposits into investments such as U.S. government bonds and securities backed by mortgages. This, coupled with rising interest rates, resulted in a severe reduction in the bank's investment value. In fact, this decline sparked fear among depositors and a rush to withdraw their money. As reported by Yousaf and Goodell (2023), Silicon Valley Bank (SVB) customers withdrew $42 billion in funds in a single day. This withdrawal trend continued for a duration of 10 hours, resulting in a loss of $4.2 billion per hour, which translates to over $1 million per second (Yousaf *et al.*, 2023).

The collapse of financial institutions has the potential to exert a substantial influence on global stock markets, causing disruptions within the financial system and impacting investor confidence. For instance, on that particular day, the S&P500 declined by 1.4%, concluding the week with a 4.5% decrease, making it the most challenging week of the year for the index. This decline was led by SVB's fellow banks, such as Western Alliance Bancorp, which plummeted by more than 20%, and Signature Bank in New York, which experienced a nearly 23% decline[2]. Additionally, the British stock index (FTSE100) concluded with a 1.67% decrease following this crisis[3]. Pandey *et al.* (2023) studied the repercussions of Silicon Valley Bank's (SVB) collapse on global stock markets, finding that it had adverse effects, especially in advanced markets compared to emerging ones. Aharon *et al.* (2023) state that stock markets in the Middle East, Europe, Latin America, and Africa negatively reacted to the SVB crisis. Meanwhile, Akhtaruzzaman *et al.* (2023) explored whether the collapse of Silicon Valley Bank triggered financial contagion in the G7 nations. They found that this contagion was of brief duration and primarily affected international banks, with restricted effects on other sectors.

The ongoing health and political crises, along with the recent American banking crisis, exhibit a heightened level of complexity compared to preceding financial crises. This has motivated investors to actively seek uncorrelated assets to mitigate risk and safeguard their investment portfolios. In fact, gold and Bitcoin have garnered acknowledgment as safe-haven assets in the financial sphere. Gold has a long-standing reputation as a store of value and a reliable safe haven asset during times of turmoil (Baur and Lucey, 2010; Baur and McDermott, 2010; Baur and McDermott, 2016; Shahzad *et al.*, 2019; Azmi *et al.*, 2023; Fakhfekh *et al.*, 2023; Nekhili *et al.*, 2023). On the other hand, Bitcoin, a relatively more recent addition to the safe haven classification, has demonstrated potential as a digital substitute. It has piqued the interest of numerous investors as a tool for hedging against declines in the stock market (Baur *et al.*, 2018; Al-Yahyaee *et al.*, 2019; Bouri *et al.*, 2020a; Bouri *et al.*, 2020b; Fakhfekh and Jeribi, 2020; Aloui *et al.*, 2023; Fakhfekh *et al.*, 2023; Jlassi *et al.*, 2023).

Apart from the significant impact displayed by the COVID-19 pandemic and the ongoing Russia-Ukraine conflict on global stock markets, the SVB bankruptcy is also expected to have substantial consequences for worldwide stock markets, considering the global importance of the banking industry. In fact, a large number of studies have concentrated on the impact of the COVID-19 pandemic on financial markets and the hedging and safe haven ability of different asset classes during this health crisis. However, the existing literature still lacks studies that specifically concentrate on the effects of military conflicts and banking system collapses on the global financial markets.

So, motivated by these high-volatility periods and following Baur and Lucey (2010); Rizvi *et al.* (2022); Wang *et al.* (2022), we aim to reinvestigate the hedging and safe haven abilities of gold and Bitcoin against the G7 stock market indices during the COVID-19 pandemic, the Russia-Ukraine military conflict, and the SVB bankruptcy. In fact, we concentrate our attention on the G7 stock markets for various reasons. These markets belong to the most advanced economies globally and frequently exhibit divergent economic conditions and responses during challenging periods, such as the European debt crisis, wherein Bitcoin and gold may demonstrate distinct reactions (Shahzad *et al.*, 2019). This encourages us to examine these stocks' responses during more recent crises such as the COVID-19 pandemic, the Russia-Ukraine military conflict, and the SVB collapse. Moreover,

numerous studies indicate the diversity in dynamic interconnections across each G7 country, rendering the analysis of equity responses to Bitcoin and gold particularly intriguing.

In this paper, we applied the novel Quantile-VAR approach of Chatziantoniou *et al.* (2021) to examine the connectedness among these assets at the median quantile and then across different quantiles. The findings demonstrate that Bitcoin and gold are net receivers of shocks. This suggests that they are perfect hedging tools during normal times and strong safe haven assets against the G7 stock market indices during the three crises. The yellow metal is found to be the most resilient safe haven asset in our study, and it outperforms Bitcoin, especially during the war and the SVB failure. Among the G7 stock market indices, NIKKEI is the most significant net receiver of shocks during the three crises, followed by the S&P500, suggesting their possible use as risk diversifiers during periods of crises. As for the rest of the G7 stock market indices, they are considered significant net transmitters of shocks and typically experience price variations during periods of crises. The results also show that the repercussions of the COVID-19 pandemic and the war are much stronger than those of the American banking crisis. Additionally, the contagion among digital and financial assets during the SVB crisis was of brief duration, as the collapse exhibited relatively restricted effects in other markets compared to the banking sector (Akhtaruzzaman *et al.*, 2023).

Our study contributes to the literature in several ways. It makes a substantial contribution to the understanding of financial markets during turbulent times by investigating the hedging, diversifying, and safe haven attributes of Bitcoin and gold against G7 stock market indices. Utilizing the quantile-VAR methodology at both the median quantile and various quantiles, this research offers a nuanced analysis that goes beyond conventional approaches. By examining the distinct periods of the COVID-19 pandemic, the Russia-Ukraine war, and the SVB collapse, the study provides a comprehensive examination of the resilience of Bitcoin and gold across different geopolitical and economic challenges. The findings of this research shed light on the effectiveness of these assets in mitigating risk and enhancing portfolio performance, contributing valuable insights to both academic and practical perspectives on portfolio management during times of crisis.

The rest of our paper is structured as follows: Section 2 provides an overview of the relevant literature. Section 3 outlines the data and descriptive statistics. Section 4 presents the empirical methodology. Section 5 provides the empirical findings. Finally, Section 6 concludes the paper.

2. LITERATURE REVIEW

Black swan occurrences have the ability not only to disrupt the stable growth of the worldwide economy but also to pose a significant danger to financial market participants. Recently, global financial markets have experienced substantial stress, volatility, and significant uncertainties due to the COVID-19 health crisis, the ongoing Russia-Ukraine military conflict, and the Silicon Valley Bank crisis (Ghabri *et al.*, 2022; Ghorbel *et al.*, 2022a; Ghorbel *et al.*, 2022b; Frikha *et al.*, 2023; Pandey *et al.*, 2023; Yousaf and Goodell, 2023; Yousaf *et al.*, 2023). Unlike previous economic and financial downturns, the dynamics driving these recent crises have presented a variety of difficulties and risks, pushing investors to search for uncorrelated assets to safeguard their stock market portfolios (Wang *et al.*, 2022; Wen *et al.*, 2022).

In fact, Baur and Lucey (2010) were the first to define hedging, diversifying, and safe-haven assets. According to them, hedging assets are the financial assets that allow investors to protect their portfolios during normal times. Diversifying assets are the financial assets that allow investors to reduce portfolio risk and enhance diversification during both normal times and periods of stress. Whereas, safe-haven assets are financial assets that enable investors to protect their portfolios during times of economic uncertainty, market volatility, or geopolitical turmoil.

2.1 The diversifying, hedging, and safe haven ability of gold

Gold is the most frequently mentioned asset in the literature when it comes to hedging and finding a secure refuge during periods of turmoil. Its uncorrelated nature with other financial assets makes it an appealing option for investors seeking to diversify their stock market portfolios and protect against market volatility (Baur and McDermott, 2010; Chkili, 2016; Ghorbel *et al.*, 2022a; Ghorbel *et al.*, 2022b; Shahzad *et al.*, 2022). In the context of the COVID-19 pandemic, Ghabri *et al.* (2022) found that gold stands out as the most promising hedging and safe-haven asset when compared to Bitcoin. According to Wen *et al.* (2022), gold serves as a safe haven asset that provides a mitigating refuge for both the oil and stock markets during the COVID-19 pandemic. Ali *et al.* (2021) reassessed the diversification ability of the yellow metal during the COVID-19 outbreak. Their findings reveal that gold reduces the downside risk of Islamic equity portfolios during this health crisis. Abdullah (2023) studied gold and Bitcoin's performance as hedging and safe haven assets for the US Islamic stock index during the COVID-19 outbreak and the Russia-Ukraine conflict. Their research revealed that gold, given its stability and negative correlation with the stock index, is better for diversification and hedging, reducing overall portfolio risk.

Widjaja and Havidz (2024) assessed the safe haven properties of gold and cryptocurrency in conventional and Islamic markets. Their findings show that gold is a strong safe haven asset for both stocks and bonds in both types of markets, especially during market declines. Gold is considered a reliable safe haven in both emerging and developed nations. On the other hand, cryptocurrency demonstrates better safe haven qualities in developed countries compared to emerging ones. The authors confirm that gold is the preferred choice as safe haven during economic instability, particularly for investors seeking Sharia-compliant options. Employing the T-GARCH-ADCC framework, Fakhfekh *et al.* (2023) analyzed gold's hedging, diversifying, and safe-haven properties in connection with G7 stock markets amidst the Russian-Ukrainian military conflict. Their findings lend support to gold's potential as a robust safe-haven asset for G7 investors during this political crisis. Using the event study methodology, Azmi *et al.* (2023) examined the consequences of the collapse of Silicon Valley Bank on 11 major international assets, including gold. They asserted that the yellow metal served as a safe haven on the day of the event. Furthermore, Baur (2023) states that gold acts as a safe haven during this American banking crisis.

However, only a limited number of studies question the capacity of gold to serve as a hedge and a safe haven. For instance, Hood and Malik (2013) assessed the function of gold as a safe haven for the US stock market during periods of significant stock market downturns. Their investigation reveals that gold plays a limited safe haven role for the US stock market. Shahzad *et al.* (2019) compared the safe haven abilities of gold and Bitcoin for global stock markets. Their findings suggest that, in some cases, both assets act as poor safe havens. Jeribi and Snene-Manzli (2020) examined the hedge and safe haven abilities of gold for the Tunisian

stock market during the COVID-19 pandemic. They suggest that gold does not exhibit hedging or safe haven characteristics during the pandemic.

Będowska-Sójka and Kliber (2021) investigate the safe haven attributes of gold in relation to stock markets. They observe that the protective quality of gold against stock market indices diminished during the crisis triggered by the COVID-19 pandemic. Using the DCC-GARCH approach, Choudhury *et al.* (2022) investigate the efficacy of gold as a safe haven for stock markets during various health crises, including the COVID-19 pandemic. Their findings suggest that gold does not exhibit strong safe haven characteristics for investors during different health crises. Gambarelli *et al.* (2023) used ARDL and NARDL techniques to assess gold's safe haven ability in relation to European stocks during the COVID-19 market downturn. Their findings surprisingly show that gold did not perform as the expected protective haven during this crisis.

2.2 The diversifying, hedging, and safe haven ability of cryptocurrency

In addition to the yellow metal, cryptocurrencies have also captured the attention of investors as hedging and safe haven instruments. For instance, Bitcoin, characterized by its lack of correlation with conventional assets (Baur *et al.*, 2018; Bouri *et al.*, 2020) and its independence from the monetary policy climate (Narayan *et al.*, 2019), has the capacity to mitigate portfolio risk and offer hedging advantages during times of financial market turbulence (Dyhrberg, 2016; Bouri *et al.*, 2020b; Gil-Alana *et al.*, 2020; Bouri *et al.*, 2020 ; Frikha *et al.*, 2023). Mokni *et al.* (2021) explore Bitcoin's hedge and safe-haven characteristics in relation to U.S. economic policy uncertainty, confirming its safe-haven status during bearish Bitcoin market conditions. Koutmos *et al.* (2021) assess cryptocurrencies as hedging instruments, highlighting Bitcoin's effectiveness in hedging during the COVID-19 pandemic. Abdullah (2023) also underscores Bitcoin's status as a reliable safe haven and hedging instrument, particularly within the context of the COVID-19 pandemic. Jlassi *et al.* (2023) employed a copula methodology to investigate the tail dependence between the returns of G7 stock markets and the returns of various cryptocurrencies during the recent health and geopolitical crises. The findings emphasize the potential of cryptocurrencies to contribute to risk diversification within stock markets, particularly during times of crisis.

Kayral *et al.* (2023) used the DVECH-GARCH model to assess the hedging capacity of Bitcoin and gold for the G7 stock indices during the COVID-19 pandemic and the Russian-Ukrainian military conflict. Their findings show that prior to the COVID-19 outbreak, Bitcoin and gold were effective hedging tools. However, during the pandemic and the conflict, they showed diversification properties. The study also indicates that both gold and Bitcoin can be considered safe-haven assets. Abdelmalek and Benlagha (2023) used a smooth transition regression model to analyze the hedge and safe-haven attributes of Bitcoin against a diverse array of traditional assets, both before and during the COVID-19 pandemic. Their investigation demonstrates Bitcoin's ability to function as a safe-haven instrument during the pandemic and as a hedging instrument before the COVID-19 outbreak. Fakhfekh *et al.* (2023) also assert that Bitcoin serves as an excellent diversifier for the Tunisian stock market indices during the COVID-19 pandemic.

In a more recent study, Wang *et al.* (2023b) investigated the impact of the Silicon Valley Bank's (SVB) downfall on cryptocurrency markets. Their findings revealed that the SVB

failure did not lead to the deterioration of digital currencies; instead, they demonstrated resilience. Jin and Tian (2023) conducted an examination of Bitcoin's safe haven performance during the SVB crisis. Their findings support Bitcoin's role as a safe haven during this American banking crisis. They also assert that Bitcoin outperformed gold in terms of both returns and volatility stability.

In contrast, due to the heightened degree of volatility associated with Bitcoin (Cheema *et al.*, 2020; Fakhfekh and Jeribi, 2020; Jeribi and Masmoudi, 2021), effectively managing its risk becomes inherently complex for investors (Yermack, 2015), potentially making it less suitable as a safe haven asset (Shahzad *et al.*, 2019; Conlon *et al.*, 2020; Jusoh *et al.*, 2023). For example, Conlon and McGee (2020) stated that Bitcoin failed as a safe haven against the S&P500 stock index during the COVID-19 pandemic. Conlon *et al.* (2020) also revealed that Bitcoin lost its safe haven status against stock markets during the pandemic. Likewise, Corbet *et al.* (2020) reported that gold exhibited significantly superior performance compared to Bitcoin in mitigating the risk associated with the Chinese financial market. Selmi (2022) revealed that the efficacy of Bitcoin as a hedge showed signs of decline following the occurrences of the COVID-19 pandemic and the Russia-Ukraine conflict.

By applying the Markov regime-switching regression approach, Rashid *et al.* (2023) conducted a comprehensive analysis of Bitcoin's diversification, hedging, and safe-haven capabilities for financial investors. Their empirical findings indicate that Bitcoin does not serve as a safe haven for any of the studied assets. Jeribi *et al.* (2020) also state that cryptocurrencies were unsuccessful as safe havens during the COVID-19 outbreak when considering the BRICS and GCC stock markets.

Additionally, Ghorbel *et al.* (2022a) indicated the limited ability of cryptocurrencies to function as a safe haven against the G7 stock markets during the COVID-19 pandemic. Wen *et al.* (2022) also compared the safe haven abilities of gold and Bitcoin against oil and stock markets during the COVID-19 pandemic and found that Bitcoin is not a safe haven. Jusoh *et al.* (2023) investigated the correlation between Bitcoin and regional Islamic stock indexes during the COVID-19 pandemic and the Russian-Ukrainian conflict, concluding that Bitcoin does not serve as a reliable safe haven. Béjaoui *et al.* (2023) studied the correlation between cryptocurrencies and G7 stocks during the same crises, also finding that cryptocurrencies were not effective as safe havens.

Ali *et al.* (2023) used the TVP-VAR model to study the spillover of returns and volatility among major cryptocurrencies after the Silicon Valley Bank's downfall. Their findings indicate increased interconnectedness in terms of returns, while volatility interconnectedness remained constant. Conventional cryptocurrencies were identified as the primary sources of transmitting both return and volatility spillovers, suggesting their failure as safe havens. Additionally, Yousaf *et al.* (2023) reported that the Silicon Valley Bank's failure resulted in substantial and unfavorable abnormal returns for Bitcoin. Galati and Capalbo (2023) examined the extent to which the collapse of the Silicon Valley Bank transmitted contagion throughout cryptocurrency markets. Their research shows signs of volatility spillover between prominent stablecoins and Bitcoin.

Based on the information stated above, although both gold and Bitcoin show significant adaptability during periods of instability, the recent health, political, and financial crises have raised doubts about their ability to diversify, hedge, and serve as safe-haven assets. This has intensified the necessity to reassess these attributes and evaluate their effectiveness, particularly against stock markets.

3. DATA AND DESCRIPTIVE STATISTICS

3.1 Data

Our research timeframe spans from January 4, 2016, to July 5, 2023, encompassing the COVID-19 pandemic, the Russia-Ukraine military conflict, and the recent Silicon Valley Bank downfall. Our data consists of 1939 daily observations of the two most recognized safe haven assets, namely gold and Bitcoin, and the most developed stock market indices, namely the G7 stocks, which correspond to the United States (S&P500), the United Kingdom (FTSE), Japan (NIKKEI), France (CAC 40), Germany (DAX 40), Italy (FTSE MIB), and Canada (S&P TSX). Data regarding Bitcoin was collected from the website www.coindesk.com, while data for the G7 stock indices and gold prices were obtained from DataStream. All the price sequences have been converted into natural logarithms and are calculated as follows:

$$r_{it} = log\left(\frac{p_{i,t}}{p_{it-1}}\right)$$

where $p_{i,t}$ represents the closing price of asset i at time t.

3.2 Descriptive statistics

The descriptive statistics summary of the return series is presented in Table no. 1. The statistical summary of the variance elucidates that gold displays the lowest volatility, thus maintaining its status as the most secure asset compared to Bitcoin, particularly during a crisis. Additionally, it shows superior mean yields. This finding aligns with the research of Ghabri *et al.* (2022); Abdullah (2023); Fakhfekh *et al.* (2023); Wang *et al.* (2023a); Widjaja and Havidz (2024), all of whom assert that gold demonstrates a more pronounced safe-haven capacity than Bitcoin during the COVID-19 crisis and the Russia-Ukraine military conflict.

Among the array of the G7 stock market indices, FTSE and FTSE.MIB exhibit the highest mean returns, while the S&P 500 shows the lowest yield. Moreover, the FTSE demonstrates the highest volatility; conversely, the remaining G7 stock benchmarks exhibit lower volatility, establishing them as the most secure indices, with the FTSE stock index standing out as the most volatile.

The skewness metrics illustrate leftward asymmetry in the marginal distributions of all digital and financial assets, as they are characterized by negative values. Subsequently, kurtosis measures are used to assess the presence of either leptokurtosis (heavy-tailed) or platykurtosis (light-tailed) distributions concerning a Gaussian distribution. The obtained elevated figures validate the presence of fat tails in return distributions, except for gold and NIKKEI, which exhibit small values. Furthermore, the hypothesis of a Gaussian distribution is invalidated by the Jarque-Bera examination, suggesting that all digital and financial assets deviate from a normal distribution. As indicated by the ERS unit root test, all the returns exhibit stationarity at the 1% significance level. The outcomes of the Ljung-Box assessment reject the null hypothesis of no autocorrelation within both return and squared return sequences, implying the potential presence of volatility clustering within each respective return dataset.

The descriptive statistics presented in Table no. 1 have been thoroughly analyzed, revealing several specific statistical characteristics for the financial variables under consideration. These characteristics include volatility measures, mean returns, skewness,

kurtosis, deviations from normality, and indications of stationarity and autocorrelation within the return series. Additionally, leftward asymmetry in marginal distributions and elevated kurtosis suggest non-normality and the presence of fat tails in return distributions, findings corroborated by the Jarque-Bera examination. This justifies our later choice of the quantile vector autoregression (Q-VAR) approach which is used to model the dynamic interactions among assets at different quantiles of the distribution. This methodology accounts for potential asymmetries and nonlinearities in asset relationships, aligning with the observed statistical characteristics such as skewness and kurtosis. Moreover, the ERS unit root test confirms the stationarity of returns. At the same time, the Ljung-Box assessment addresses autocorrelation and volatility clustering within the dataset, ensuring that the chosen method appropriately captures the underlying characteristics of the financial variables.

The Kendall correlations between Bitcoin, gold, and the G7 stock indices are presented in Table no. 2. This table offers an initial glimpse into the safe haven ability of the different assets until further examination. The results indicate that the correlation between Bitcoin and the G7 stock market indices is significantly positive, except in the case of NIKKEI, suggesting the diversifying ability of this digital asset (Bouri *et al.*, 2017; Bouri *et al.*, 2020a; Fakhfekh *et al.*, 2023; Jlassi *et al.*, 2023; Kayral *et al.*, 2023; Rashid *et al.*, 2023). As for gold, its correlation with the G7 stock markets is significantly negative only for the German (DAX40), French (CAC40), Italian (FTSE-MIB), and Canadian (SP-TSX) stocks. This supports the hedge ability of the yellow metal during periods of stability and its safe-haven ability during periods of crisis (Baur and Lucey, 2010; Baur and McDermott, 2010; Ghabri *et al.*, 2022; Wang *et al.*, 2022; Abdullah, 2023; Wang *et al.*, 2023a).

4. EMPIRICAL METHODOLOGY

Building on the definitions of Baur and Lucey (2010) and based on the works of Rizvi *et al.* (2022) and Wang *et al.* (2022), we aim to investigate the hedging and safe haven capabilities of gold and Bitcoin against the G7 stock market indices. This will involve examining the connectedness among these assets during the COVID-19 pandemic, the Russia-Ukraine military conflict, and the Silicon Valley Bank crisis. In this case, we applied the novel quantile vector autoregression (Q-VAR) methodology[4] of Chatziantoniou *et al.* (2021), which is established based on the pioneering works of Diebold and Yilmaz (2009, 2012, 2014) in their series of papers and further developed by Ando Ando *et al.* (2022)[5]. This methodology is used in our work to examine the quantile propagation mechanism and, consequently, to inspect the asymmetric dynamic relationships and spillovers among Bitcoin, gold, and the G7 stock market indices and reevaluate and confirm the concept of a safe haven investment. For instance, the works of Baur and McDermott (2010) and Baur and Lucey (2010) that examine the relationships and causality between gold and stock markets primarily rely on traditional time series techniques (such as vector autoregression (VAR) and Granger causality tests) and linear modeling approaches that do not explicitly consider potential nonlinear or asymmetric effects. Compared to these methodologies, the Q-VAR methodology offers a more flexible and comprehensive framework for capturing the dynamic and potentially nonlinear relationships between assets, making it well-suited for analyzing complex and evolving market dynamics.

Table no. 1 – Descriptive statistics

	Bitcoin	*Gold*	*SP500*	*FTSE*	*Nikkei*	*DAX.40*	*CAC.40*	*FTSE.MIB*	*S.P.TSX*
Mean	0.002**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Variance	0.002***	1.38E-05***	2.12E-05***	0.006***	2.84E-05***	3.00E-05 ***	2.93E-05***	4.05E-05***	1.87E-05***
Skewness	-0.840***	-0.248***	-0.868***	-0.254***	-0.169***	-0.721***	-1.028***	-1.879***	-1.829***
Ex.Kurtosis	10.984***	3.343***	16.779***	937.694***	5.471***	12.835***	13.428***	21.913***	45.691***
JB	10052.145***	929.994***	23166.883***	71587310.838***	2446.379***	13582.239***	15023.690***	40244.760***	171062.109***
ERS	-4.622***	-15.410***	-12.406***	-19.574***	-17.636***	-19.565***	-18.035***	-20.508***	-17.839***
Q(20)	11.876	4.305	11.402	0.320	10.498	12.405	10.927	12.491	8.108
Q2(20)	9.776	9.730	3.862	0.022	16.477*	19.428**	15.553*	7.995	1.346

Note: ***, **, and * means significant at the 1%, 5%, and 10% level of significance, respectively. JB refers to the Jarque Bera normality test. ERS refers to Elliott, Rothenberg and Stock unit root test. Q and Q2, respectively, refer the return and squared return sequences of the Ljung-Box text.

Table no. 2 – Kendall correlation matrix between Bitcoin, gold, and the G7 stock indices

kendall	*Bitcoin*	*Gold*	*SP500*	*FTSE*	*Nikkei*	*DAX.40*	*CAC.40*	*FTSE.MIB*	*S.P.TSX*
Bitcoin	1.000***	0.063***	0.104***	0.047***	-0.001	0.064***	0.063***	0.063***	0.112***
Gold	0.063***	1.000***	-0.006	-0.021	-0.024	-0.052***	-0.049***	-0.039***	0.070***
SP500	0.104***	-0.006	1.000***	0.285***	0.094***	0.325***	0.325***	0.296***	0.461***
FTSE	0.047***	-0.021	0.285***	1.000***	0.127***	0.480***	0.521***	0.431***	0.320***
Nikkei	-0.001	-0.024	0.094***	0.127***	1.000***	0.141***	0.138***	0.108***	0.109***
DAX.40	0.064***	-0.052***	0.325***	0.480***	0.141***	1.000***	0.731***	0.623***	0.373***
CAC.40	0.063***	-0.049***	0.325***	0.521***	0.138***	0.731***	1.000***	0.643***	0.393***
FTSE.MIB	0.063***	-0.039***	0.296***	0.431***	0.108***	0.623***	0.643***	1.000***	0.364***
S.P.TSX	0.112***	0.070***	0.461***	0.320***	0.109***	0.373***	0.393***	0.364***	1.000***

Note: ***, **, and * means significant at the 1%, 5%, and 10% level of significance, respectively.

The quantile vector autoregression (Q-VAR) approach involve the utilization of a generalized VAR approach that incorporates dynamic analysis using rolling-window methodology (Diebold and Yilmaz, 2009). Hence, the variance decomposition of forecast errors elucidates the impact of structural shocks on the returns of individual variables within a network. Elevated total connectedness values indicate robust interdependencies among network variables, thereby indicating the presence of a contagion effect, which is assessed through directional connectedness measures.

Quantile interconnectedness examines the association between variables in the presence of profound structural perturbations, encompassing both upper and lower quantiles. Accordingly, it detects the presence of robust or weak interconnectedness given the magnitude of the shock, subsequently offering insights into the anticipation of whether heightened connectedness would be accompanied by positive or negative returns. The Q-VAR approach is developed as follows.

$$y_t = \mu_t(\tau) + \Phi_1(\tau)y_{t-1} + \Phi_2(\tau)y_{t-2} + \cdots + \Phi_p(\tau)y_{t-p}\mu_t(\tau) \quad (1)$$

In this context, y_t and y_{t-i} (i = 1,…, p) are vectors representing endogenous variables, each possessing dimensions of $N \times 1$. The parameter τ falls within the interval [0, 1] and signifies the quantile of pair return-volume, while p denotes the lag duration of the Q-VAR approach. $\boldsymbol{\mu}(\tau)$ represents an $N\times1$ dimensional vector indicating the conditional average, Φ_j (τ) corresponds to an $N \times N$ dimensional matrix comprising Q-VAR coefficients, and μ_t (τ) is an $N \times 1$ dimensional error vector with an $N\times N$ dimensional error variance-covariance matrix denoted as $\boldsymbol{\Sigma}(\tau)$. the QVAR (p) model can be transformed into its quantile vector moving average representation, denoted as QVMA (∞) by applying Wold's theorem such that:

$$y_t = \mu_t(\tau) + \sum_{j=1}^{p} \Phi_j(\tau)y_{t-j} + u_t(\tau) = \mu(\tau) + \sum_{i=0}^{\infty} \Psi_i(\tau)u_{t-i} \quad (2)$$

Subsequently, we compute the H-step-ahead Generalized Forecast Error Variance Decomposition (GFEVD) based on the works of Koop *et al.* (1996) and Pesaran and Shin (1998) which assesses the impact of a disturbance in series j on series i. It can be presented as follows:

$$\theta_{ij}^{g}(H) = \frac{\sum(\tau)_{jj}^{-1}\sum_{h=0}^{H-1}(e_i' A_h(\tau)\sum(\tau)e_j)2}{\sum_{h=0}^{H-1}(e_i' A_h(\tau)\sum(\tau)A_h'(\tau)e_i)} \quad (2)$$

$$\tilde{\theta}_{ij}^{g}(H) = \frac{\theta_{ij}^{g}(H)}{\sum_{j=1}^{k}\theta_{ij}^{g}(H)}$$

e_i is a selection vector that takes on a value of one for the ith element and zero for all other elements. Since the row summing of the decomposed variance matrix is not always equivalent to 1, each item in the matrix $\tilde{\theta}_{ij}^{g}(H)$ gets normalized by the row sum, and therefore the row sum will always equal 1. Normalization results in the emergence of the two subsequent equations:

$$\sum_{i=1}^{N} \tilde{\theta}_{ij}^{g}(H) = 1 \ \ and \sum_{j=1}^{N} \tilde{\theta}_{ij}^{g}(H) = N$$

Hence, each row of $\tilde{\theta}_{ij}^{g}$ sums to one, illustrating how a disturbance in sequence i has influenced both that sequence and all other sequences j.

Furthermore, we compute the measures of interconnectedness. Initially, we calculate the net pairwise connectivity in the following manner:

$$NPC_{ij}(\mathrm{H}) = \tilde{\theta}_{ij}^{g}(\mathrm{H}) - \tilde{\theta}_{ji}^{g}(\mathrm{H}) \tag{3}$$

If $NPC_{ij}(\mathrm{H}) > 0$ ($NPC_{ij}(\mathrm{H}) < 0$), it indicates that series i exerts a stronger (weaker) impact on series j compared to the reverse influence.

To examine the extent to which a disturbance in variable i influences all other variables j, we calculate the total directional connectedness TO others as follows:

$$TO_i(H) = C_{i\rightarrow j}^{g}(H) = \sum_{i=1, i\neq j}^{N} \tilde{\theta}_{ij}^{g}(H) \tag{4}$$

To examine the extent to which a variable i is influenced by disturbances in all other variables j, we calculate the total directional connectedness FROM others as follows:

$$FROM_i(H) = C_{i\leftarrow j}^{g}(H) = \sum_{i=1, i\neq j}^{N} \tilde{\theta}_{ij}^{g}(H) \tag{5}$$

The disparity between the total directional connectedness TO other variables and the total directional connectedness FROM other variables yields the net total directional connectedness, which can be interpreted as the net impact that variable i exerts on the examined network.

$$\begin{aligned} NET_i(H) &= TO_i(H) - FROM_i(H) \\ C_i^{g}(H) &= C_{i\rightarrow j}^{g}(H) - C_{i\leftarrow j}^{g}(H) \end{aligned} \tag{6}$$

The final measure of interconnectivity is the modified total connectedness index (TCI) developed by Chatziantoniou and Gabauer (2021) and described in Gabauer (2021), which evaluates the extent of network interconnectivity, can be calculated as follows:

$$TCI(H) = N - 1 \sum_{i=1}^{N} TO_i(H) = N - 1\, FROM_i(H) \tag{7}$$

This measure is frequently employed as a proxy for market risk, as a greater TCI value indicates a heightened level of network interdependence.

5. EMPIRICAL RESULTS

5.1 Median Q-VAR static and dynamic connectedness results

5.1.1 Static examination of the interconnectivity framework between Gold, Bitcoin, and the G7 stock market indices at the median quantile

Table no. 3 compiles the findings of the static interconnectedness metrics pertaining to every G7 stock index, Bitcoin, and gold. These results arise from the median Q-VAR model, which was employed to investigate the interconnectedness of risk and the transmission of shocks. The overall interconnectivity (TCI) within this framework is 63.61%, suggesting the existence of a strong correlation between digital and financial assets. This signifies the presence of contagion effects within this structure, implying that both Bitcoin and gold are not separated from the financial system (Ghorbel and Jeribi, 2021; Ghorbel *et al.*, 2022a; Ghorbel *et al.*, 2022b; Ali *et al.*, 2023; Béjaoui *et al.*, 2023). The mean impact of the G7 stock market indices is 67.11%, whereas the effects of Bitcoin and gold are above 19%. Indeed, the substantial mean value of the equity indices highlights greater shock transmissions to the system originating from global stock markets in comparison to those originating from the cryptocurrency and gold markets as contributors to market fluctuations.

The examination of net connectivity reveals that Bitcoin contributes 19.08% to the overall system's fluctuations, whereas the system itself is responsible for 26.58% of the fluctuations observed in Bitcoin returns. This suggests that Bitcoin serves as a substantial recipient of shocks, with a relatively smaller role in transmitting shocks to other entities. The same result is also observed with gold, which transmits 19.96% and receives 33.45% from the system.

Indeed, when considering the stock indices, the CAC 40 emerges as the most substantial shock contributor to the overall system connectedness, accounting for 92.97%. Simultaneously, it also receives the highest share from the system, tallying at 73.28%, thereby resulting in favorable net connectedness with respect to the system, standing at 19.69%. Conversely, the NIKKEI index ranks as the least significant shock contributor to the system, contributing merely 19.32%. In contrast, it receives approximately 53% of the system's contribution. As a result, the NIKKEI serves as a substantial recipient of shocks and exhibits a greater increase in spillovers compared to other entities.

The static interconnectedness findings show that Bitcoin and gold are the least shock receivers from the system while at the same time, they play a smaller role in transmitting shocks to the system. This can explain their use as hedging or safe haven tools for the different portfolio combinations (Wang *et al.*, 2022). On the other hand, the G7 stock market indices are considered the most shock receivers from the system while at the same time, they are considered the most contributors, surging the need to hedge their related risk. In fact, the static connectedness analyses are considered general to formulate meaningful and significant conclusions. These results will be further checked through the forthcoming examination of the dynamic interconnectedness.

Table no. 3 – Static interconnectedness between Bitcoin, gold, and the G7 stocks

	Bitcoin	*Gold*	*SP500*	*FTSE*	*Nikkei*	*DAX.40*	*CAC.40*	*FTSE.MIB*	*S.P.TSX*	*FROM*
Bitcoin	73.42	3.31	4.93	2.68	2.09	3.10	3.05	2.98	4.44	26.58
Gold	3.52	66.55	4.77	3.21	2.44	5.32	4.99	4.53	4.67	33.45
SP500	3.08	2.44	43.09	7.18	2.48	9.37	9.19	8.06	15.11	56.91
FTSE	1.94	1.63	8.43	38.71	2.58	12.93	14.64	11.52	7.63	61.29
Nikkei	2.67	3.32	9.89	5.45	47.01	8.63	8.55	7.17	7.32	52.99
DAX.40	1.63	2.33	7.66	11.06	2.49	27.76	21.39	17.62	8.07	72.24
CAC.40	1.53	2.22	7.44	12.24	2.59	20.67	26.72	17.88	8.70	73.28
FTSE.MIB	1.78	2.20	6.81	10.40	2.15	18.74	19.73	30.08	8.10	69.92
S.P.TSX	2.93	2.53	14.85	7.98	2.48	10.22	11.42	9.76	37.82	62.18
TO	19.08	19.96	64.78	60.20	19.32	88.98	92.97	79.51	64.05	508.84
Inc.Own	92.50	86.51	107.88	98.90	66.32	116.73	119.69	109.59	101.87	cTCI/TCI
NET	-7.50	-13.49	7.88	-1.10	-33.68	16.73	19.69	9.59	1.87	63.61/56.54
NPT	2.00	1.00	4.00	4.00	0.00	7.00	8.00	6.00	4.00	

5.1.2 Dynamic examination of the interconnectivity framework between Gold, Bitcoin, and the G7 stock market indices at the median quantile

Even though the examination of the entire dataset effectively described interconnectedness from a static point of view, the transformations that transpired within the financial market amid the spread of the COVID-19 pandemic, the Russia-Ukraine conflict, and Silicon Valley Bank collapse demand a more precise and dynamic examination. In this case, we applied Diebold and Yilmaz (2009) rolling-window methodology to expand the static interconnectedness framework encompassing the entire dataset and examine the dynamic time-varying interconnectedness during different market conditions. In fact, the occurrences of the COVID-19 pandemic, the Russian-Ukrainian military conflict, and the recent American banking crisis significantly impacted worldwide stock market indices and the performance of different safe-haven assets (i.e., gold and cryptocurrency), necessitating a deep examination of the repercussions caused by these crises.

For enhanced comprehension, we graph the overall interconnectedness across time segments before and during the COVID-19 pandemic, the Russia-Ukraine conflict, and the SVB collapse, aiming to assess its tendency and different variations. Figure no. 1 illustrates the total dynamic connectedness throughout the sample period to gain a deeper understanding of the dynamic market risk. From this figure, we can identify the three shocks related to the COVID-19 pandemic, the Russian-Ukrainian war, and the SVB failure. In fact, it becomes apparent that the interconnectedness within this framework exhibits temporal variability, ranging from approximately 50% before the outbreak to a heightened level of 78% during the COVID-19 outbreak. This level then decreases to a relatively lower value of 62% during the war and further declines to 58% during the banking crisis. It is worth noting that the interconnectedness between Bitcoin, gold, and the G7 stock indices witnessed its highest peak during the COVID-19 pandemic. This surge may be explained by the contagion measures adopted by different countries, such as city and border closures, curfews, etc., and the negative

response of digital and financial assets to this health crisis (Jeribi and Snene-Manzli, 2020; Zhang *et al.*, 2020; Yarovaya *et al.*, 2021; D'Amato *et al.*, 2022; Selmi, 2022). After that, the interconnectedness returned to average levels until the occurrence of the Russia-Ukraine war and the banking crisis.

In conclusion, the aforementioned findings suggest that significant unforeseeable events could heighten the risk transmission connections among Bitcoin, gold, and the G7 equity markets, amplifying the overall spillover effects between potential safe-haven assets and stock markets. As global economic interconnection deepens, and as information technology continually advances, the exchange of information and risks between diverse worldwide markets is becoming more robust. Therefore, when a severe risk event occurs within a market, its detrimental consequences swiftly spread to other markets via multiple ways like trading, speculations, and investments, thereby strengthening the interconnectedness among potential safe-haven assets and stock markets.

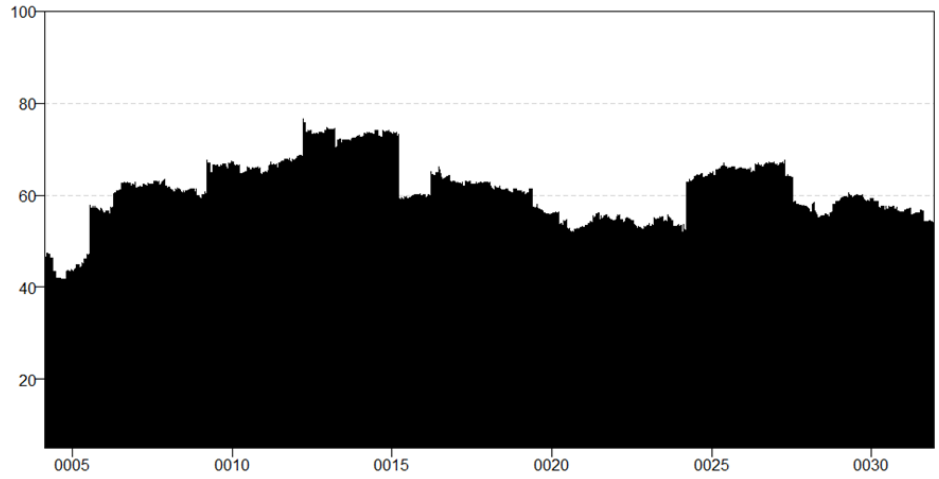

Figure no. 1 – Total dynamic connectedness

From Figure no. 2, we depict the dynamic total directional connectedness emanating from each of the seven stocks, Bitcoin, and gold towards the rest (i.e., directional influence or spillover from one asset TO others). From this figure, we can observe that the TO-spillover from Bitcoin was low and did not exceed 15% before the COVID-19 pandemic. However, it fluctuated between 45% and 50% during this health crisis. During the Russia-Ukraine conflict period and the SVB crisis, the TO-spillover from Bitcoin returned to a low degree of about 10%. This reduced transmission of shocks can suggest decreased interdependencies or associations between Bitcoin and other assets, potentially leading to a reduction in systemic risk within a portfolio, making Bitcoin an effective safe haven during the war (Tut, 2022; Kayral *et al.*, 2023) and the banking crisis (Jin and Tian, 2023).

The TO-spillover from gold was the lowest before and during the three crises, as it did not exceed 10%. This suggests its low association with other assets and its possible use as a perfect hedge during normal times and a safe haven tool during periods of crisis (Baur and Lucey, 2010; Baur and McDermott, 2010). This finding indicates that gold outperforms

Bitcoin as a hedging and a safe haven asset, confirming the findings of Ghabri *et al.* (2022); Kayral *et al.* (2023).

In regard to the G7 stock market indices, the TO-interconnection degrees exhibit notable values throughout the entire period and sometimes exceed 100%, except for the NIKKEI index. The most elevated levels of spillover are observed within the G7 stock markets (excluding the NIKKEI), indicating their high responsiveness to disturbances compared to cryptocurrencies and gold. The G7 equity market indices are considered "risk-on" investments and typically undergo increased price fluctuations during the COVID-19 health crisis, the ongoing Russia-Ukraine military conflict, and the SVB crisis, highlighting the need to hedge against their associated risks (Ghorbel *et al.*, 2022a; Fakhfekh *et al.*, 2023).

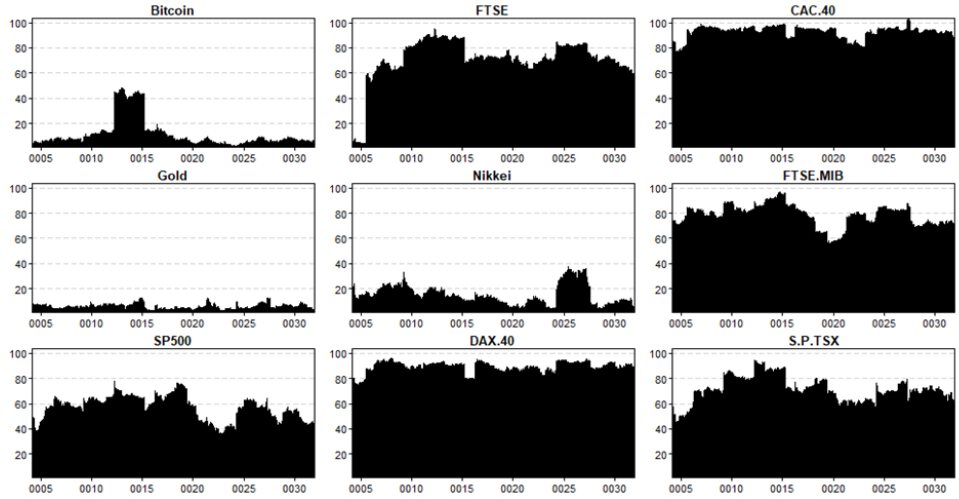

Figure no. 2 – Total directional connectedness– TO the system

Figure no. 3 illustrates the dynamic total directional connectedness originating from the system towards each of Bitcoin, gold, and the G7 stock markets (i.e., directional influence FROM others to one asset). It is noteworthy that the spillover FROM the global system to digital and financial assets displays substantial fluctuations, particularly evident amid the COVID-19 pandemic and the timeframe of the Russian-Ukrainian conflict. It is also evident during the banking crisis for the G7 stock market indices. From this figure, we can see that gold is the least shock receiver during the entire period. Also, the spillover FROM the global system to Bitcoin was more pronounced during the COVID-19 pandemic than during the war. As for the G7 stock market indices, they are considered the most shock receivers from the system, with a level of about 80% in most cases. This might be explained by the fact that the G7 stocks are regarded as the most developed economies and among the most likely to respond dramatically to severe market situations (Ghorbel *et al.*, 2022a; Ghorbel *et al.*, 2022b; Fakhfekh *et al.*, 2023) and due to their elevated degree of integration and interconnection with the global economy (Pandey *et al.*, 2023).

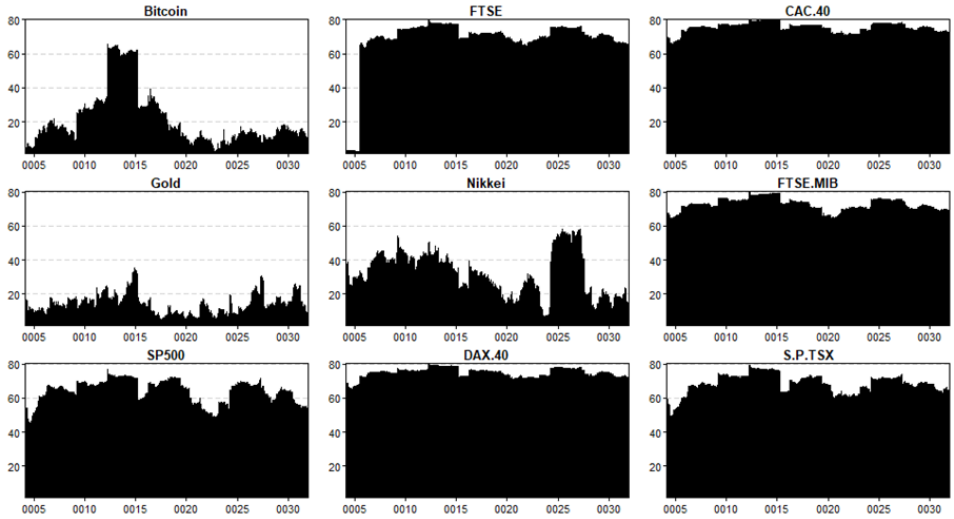

Figure no. 3 – Total directional connectedness– FROM the system

Figure no. 4 illustrates the total net directional connectedness which corresponds to the difference between the TO-connectivity and the FROM-connectivity. According to Rizvi *et al.* (2022); Wang *et al.* (2022), when an asset has a negative value, it implies not just the asset's function as a shock receiver but also its role as a hedging mean and thus as a safe haven during times of crises. Concerning the two recognized safe haven assets, it is evident that the values for Bitcoin and gold remains (almost) consistently negative throughout the entire period. Both assets are considered net receivers of shocks, with a substantial increase in their net reception during the three crises. Bitcoin is considered the most significant shock receiver, particularly during the COVID-19 pandemic, while gold outperforms Bitcoin during the war and the banking crisis. This suggests their hedging ability during normal times and their safe haven ability against the G7 stock market indices during periods of crises (Rizvi *et al.*, 2022; Wang *et al.*, 2022) with gold being the most resilient safe haven asset. These results align with Ghabri *et al.* (2022); Abdullah (2023); Widjaja and Havidz (2024), who found that gold is a more suitable hedging and safe haven asset than Bitcoin, and its inclusion within a stock market portfolio leads to a reduction in overall portfolio risk. The findings are also consistent with Azmi *et al.* (2023); Baur (2023), who assert that gold acts as a safe haven during the SVB failure. The results further support those of Abdelmalek and Benlagha (2023), who discovered that Bitcoin is a hedge before the COVID-19 pandemic and a safe haven during this health crisis.

Among the G7 stock market indices, the Japanese stock index (NIKKEI) is the most significant net receiver of shocks during the three crises, followed by the American stock index (S&P500). Typically, investors aim to hedge the risks associated with their stock market indices. However, in this case, NIKKEI and the S&P500 present the possibility of serving as assets for risk diversification. On the other hand, the French (CAC.40) and German (DAX.40) stock market indices are the most significant net transmitters of shocks. As for the rest of the G7 stock market indices (FTSE, FTSE.MIB, and SP.TSX), they are considered mostly net transmitters of shocks during the COVID-19 pandemic. Besides, we note that the net

transmission of shocks of these stock markets exhibited a modest decline after the COVID-19 pandemic followed by a subsequent resurgence coinciding with the occurrence of the Russian-Ukrainian military conflict and the SVB collapse. This signifies a noteworthy alteration in their attributes owing to instability.

In summary, it can be inferred that the degree of interconnectedness among these digital and financial assets is contingent upon the extent of economic and financial disruptions, as exemplified by the transmission dynamics of the COVID-19 pandemic and the development of the Russia-Ukraine conflict and the SVB crisis. It is also worth noting that the repercussions of the COVID-19 pandemic and the war are much stronger than the American banking crisis. In fact, the contagion among these assets during the SVB crisis was of brief duration, as the collapse exhibited relatively restricted effects in other markets in comparison to the banking sector (Akhtaruzzaman *et al.*, 2023).

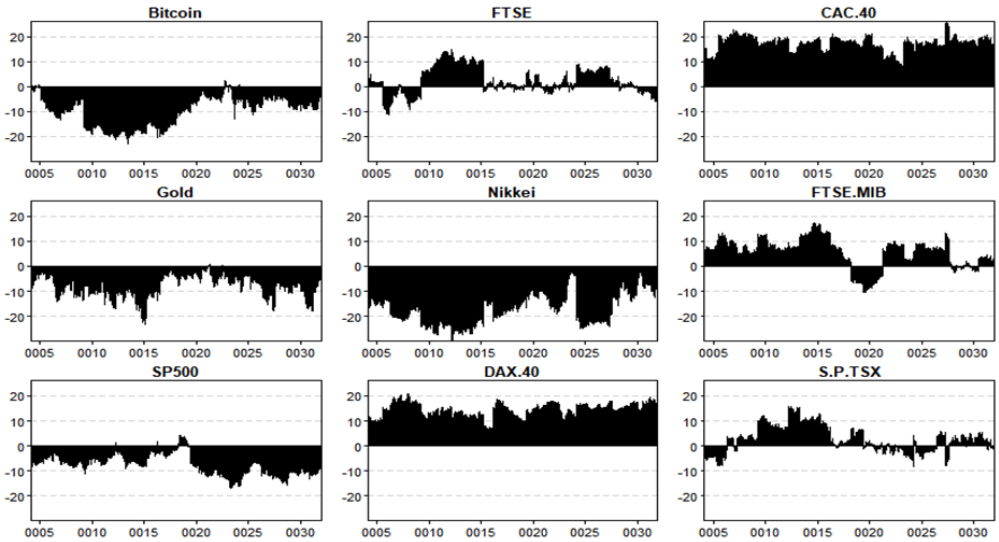

Figure no. 4 – Total net directional connectedness – (net = to-from)

Subsequently, we formulate the directional connectivity framework using the net pairwise interconnection in Figure no. 5 through a graphical representation depicting the interconnections among each stock index, Bitcoin, and gold over the entire dataset. Each of these entities is designated as a node that represents Bitcoin, gold, and one of the G7 stocks, and a directional connection from one entity to another is established using arrows. The nodes with the golden-yellow color are the net shock receivers; whereas, the nodes with the blue color are the net shock transmitters. This also can be observed by the number of arrows received and transmitted by each node. From Figure no. 5, it becomes evident that the Japanese stock index (NIKKEI) stands as the foremost recipient of shocks emanating from the overall system followed by the American stock index (S&P500) and Bitcoin, while gold is the least shock receiver from the system. This is also evidenced by the thickness and number of the arrows received by these assets. In fact, gold is not only the least receiver of shocks (receives only from the SP.TSX stock index), but it is also the least transmitter of shocks and

it is uncorrelated with Bitcoin and the rest of the G7 stock indices, implying its plausible role as a safe haven tool against uncertainties derived from these assets during the COVID-19 pandemic, the Russian-Ukrainian military conflict, and the banking crisis.

Furthermore, DAX.40 and CAC.40 are the most shock transmitters followed by FTSE, FTSE.MIB, and SP.TSX stock indices. The G7 stock market indices also exhibit a strong correlation with each other which can be evidenced by the thickness of their connecting arrows whether they are receivers or transmitters. This result surges the need for uncorrelated assets (such as gold) to safeguard against the risk related to stock markets (Jeribi and Snene-Manzli, 2020; Ghorbel *et al.*, 2022a).

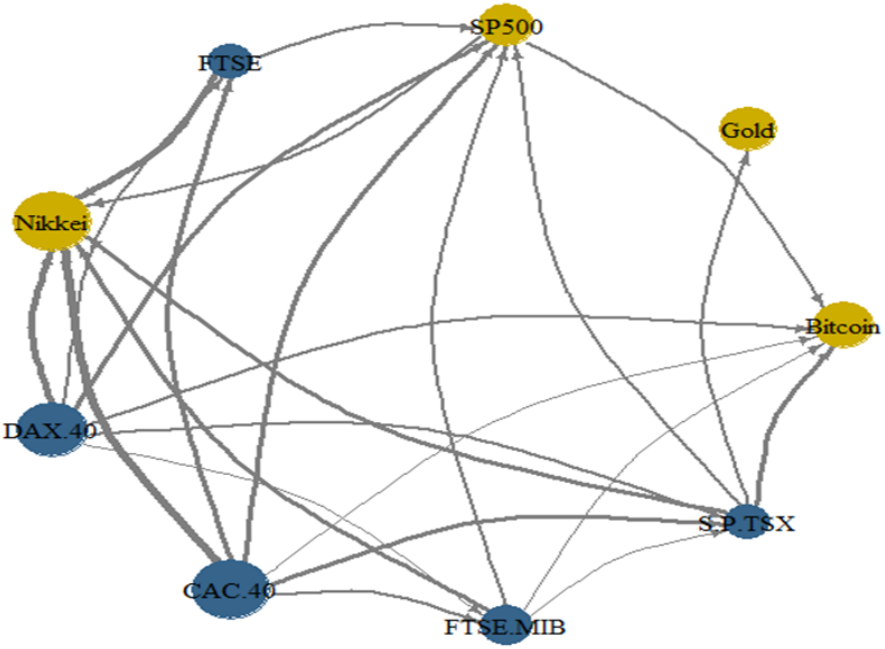

Figure no. 5 – Net pairwise directional connectivity framework between Gold, Bitcoin, and the G7 stocks

5.2 Total and net dynamic connectedness between Gold, Bitcoin, and the G7 stock market indices across different quantiles

Finally, to check the robustness of our results and better understand market dynamics, we concentrate on the connectedness across different quantiles. Figure no. 6 exemplifies the outcomes pertaining to the total dynamic connectedness among Bitcoin, gold, and the G7 stock market indices across different quantiles. The horizontal axis depicts the timeline, while the vertical axis illustrates quantiles, which span from 0.05 to 0.95 with increments of 1%. The warmer hues depicted on the graph are indicative of elevated degrees of interconnectedness. It is clear that the interconnection exhibits considerable robustness for both significantly negative shocks (below the 20% quantile) and significantly positive shocks (exceeding the 80% quantile). In other words, the influence seems to be symmetrical.

Moreover, the 50% quantile aligns with the overall mean level of interconnectedness throughout the entire timeframe, displaying noteworthy values spanning the onset of the COVID-19 pandemic to the outbreak of the Russian-Ukrainian military conflict and the SVB crisis. As for the period before the announcement of the pandemic (period of stability), it is characterized by low interconnectedness. This finding suggests that the level of interconnectedness is profoundly reliant on significant occurrences or incidents (Blanka and Karolina, 2020).

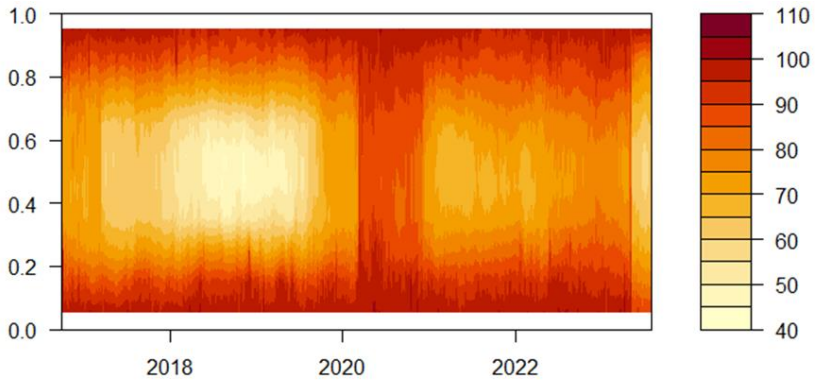

Figure no. 6 – Total dynamic connectedness between Bitcoin, gold, and the G7 stock market indices across different quantiles

Next, we present the total net directional connectedness of all the assets across different quantiles in Figures no. 7-15. Red color shades (higher quantiles) on these figures indicate that the asset is a net transmitter of shocks. Whereas, blue color shades (lower quantiles) indicate that the asset is a net receiver of shocks. Figures no. 7 and no. 8, respectively, illustrate the net directional connectedness for gold and Bitcoin. We can see that both assets act as net receivers of shocks during the three crises, with gold being the most important shock receiver, especially during the COVID-19 pandemic. These findings confirm the above-mentioned results of the net directional connectedness based on the median Q-VAR approach. In fact, the negative correlations between gold (respectively, Bitcoin) and the system became more robust during the crises periods (blue color shades). Thus, gold and Bitcoin are considered hedging assets during normal times and strong safe haven assets during the three crises (Rizvi *et al.*, 2022; Wang *et al.*, 2022) with gold being the strongest safe haven asset.

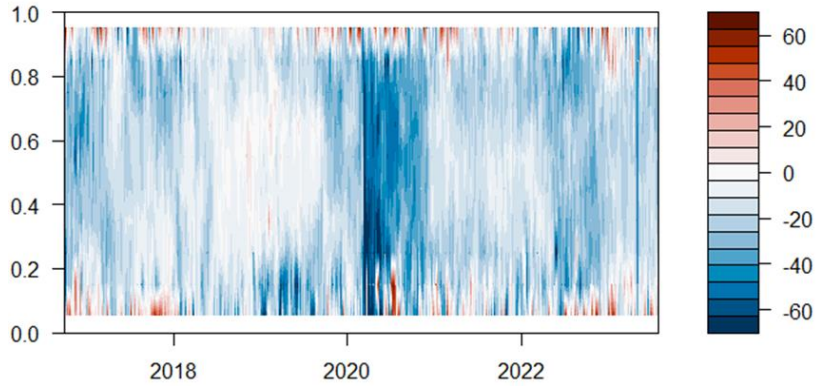

Figure no. 7 – Total net directional connectedness for Gold across different quantiles

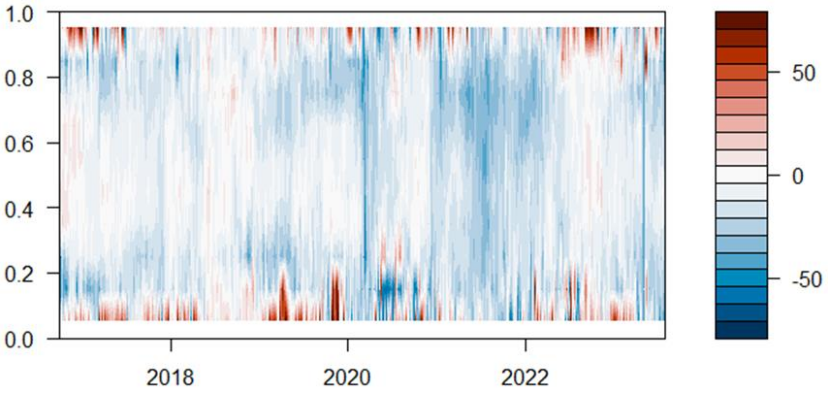

Figure no. 8 – Total net directional connectedness for Bitcoin across different quantiles

As for the G7 stock market indices, we can observe that the SP.TSX, FTSE.MIB, CAC.40, and DAX.40 stock market indices (Figures no. 9-12) shifted from being net receivers of shocks before the announcement of the COVID-19 pandemic to being net transmitters of shocks during the pandemic and the Russia-Ukraine war, and then to becoming very weak net receivers of shocks during the SVB crisis. This indicates their high vulnerability to risks and losses when market conditions deteriorate. As for the FTSE stock index (Figure no. 13), it predominantly acted as a net transmitter of shocks, especially during the American banking crisis.

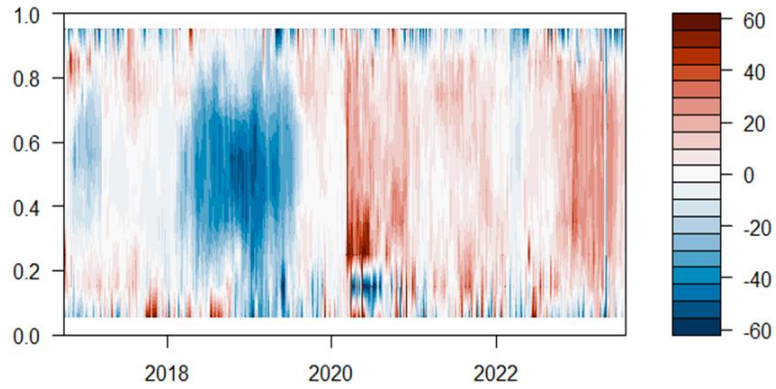

Figure no. 9 – Total net directional connectedness for the Canadian stock index across different quantiles (S.P.TSX)

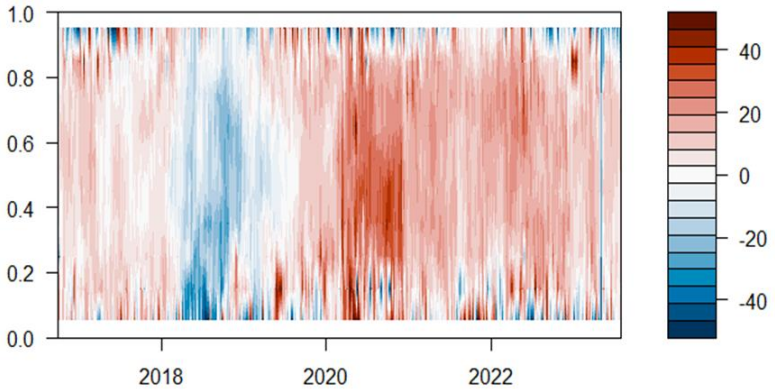

Figure no. 10 – Total net directional connectedness for the Italian stock index across different quantiles (FTSE.MIB)

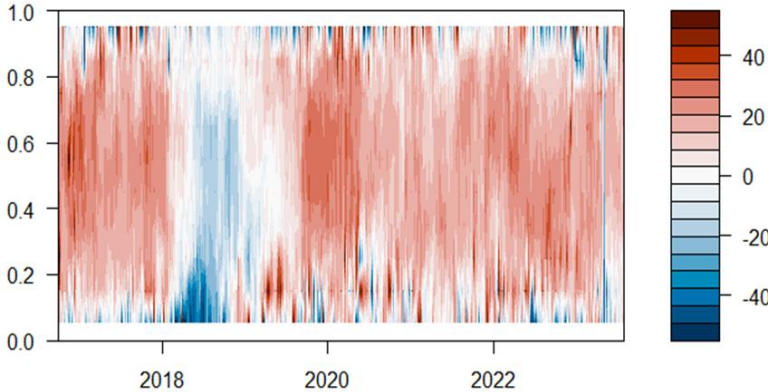

Figure no. 11 – Total net directional connectedness for the French stock index across different quantiles (CAC.40)

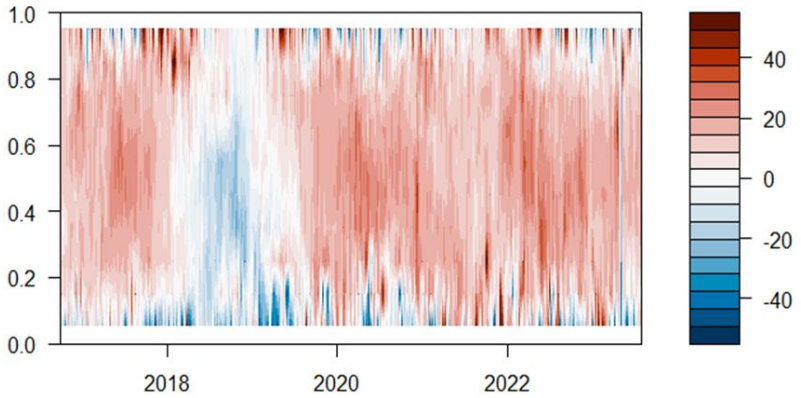

Figure no. 12 – Total net directional connectedness for the German stock index across different quantiles (DAX.40)

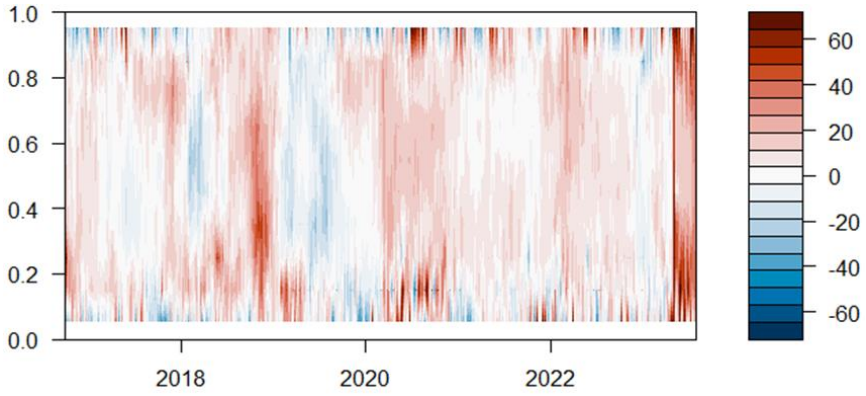

Figure no. 13 – Total net directional connectedness for the British stock index across different quantiles (FTSE)

Moreover, Figure no. 14 shows that the Japanese stock market index (NIKKEI) transitioned from being a net transmitter of shocks before the outbreak to becoming a strong net receiver of shocks during the outbreak, and an even more pronounced net receiver during the war and the banking crisis. This result implies that NIKKEI's role changed from being a risky asset before the COVID-19 crisis to becoming a strong risk diversifier during the three crises. Also, Figure no. 15 illustrates that the American stock market index (S&P500) served as a significant transmitter of shocks before the COVID-19 pandemic, and it maintained this role throughout the period, albeit with lower degrees, indicating its failure as a diversifier during the entire period.

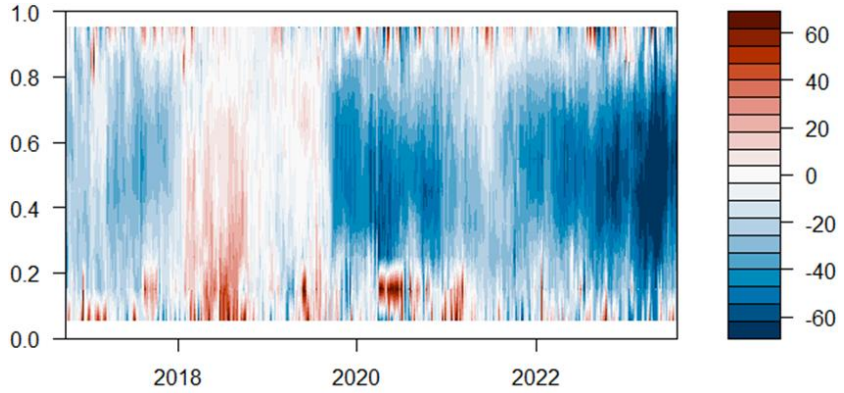

Figure no. 14 – Total net directional connectedness for the Japanese stock index across different quantiles (Nikkei)

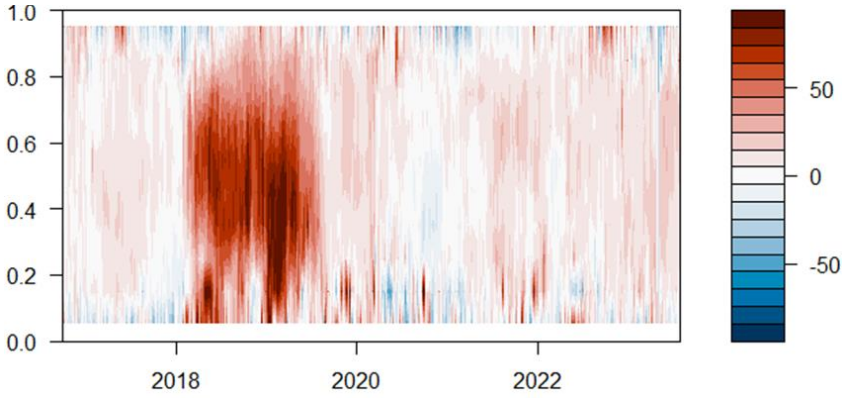

Figure no. 15 – Total net directional connectedness for the American stock index across different quantiles (SP500)

6. CONCLUSION AND DISCUSSION

The global financial markets have been significantly shaken by the COVID-19 pandemic, the ongoing Russo-Ukrainian conflict, and the recent American Silicon Valley Bank (SVB) crisis. This turmoil has disrupted investor confidence in financial markets, prompting the need to explore alternative investment options that can withstand these crises. In this paper, we investigate the hedging and safe haven abilities of gold and Bitcoin against the G7 stock market indices by examining the connectedness among these assets during the COVID-19 pandemic, the Russia-Ukraine war, and the SVB collapse. To do so, we applied the novel Q-VAR approach of Chatziantoniou *et al.* (2021) which is based on the works Diebold and Yilmaz (2009, 2012, 2014) and further developed by Ando *et al.* (2022).

At the median quantile, the results show that the total connectedness (TCI) is 63.61%, suggesting the existence of a strong correlation between digital and financial assets and the presence of contagion effects. In fact, the total dynamic connectedness results reveal that spillover varies over time, starting at around 50% before the outbreak, increasing to 78%

during COVID-19, relatively decreasing to 62% during the war, and further reducing to 58% during the banking crisis. Also, the total net directional connectedness results reveal that Bitcoin and gold are net receivers of shocks with a substantial increase in their net reception during the three crises. Bitcoin is considered the most net receiver of shocks in comparison to gold, particularly during the COVID-19 pandemic. Whereas, gold outperforms Bitcoin during the war and the banking crisis. This suggests their hedging ability during normal times and their safe haven ability against the G7 stock market indices during periods of crises, with gold being the most significant safe haven asset (Cheema *et al.*, 2020; Ghabri *et al.*, 2022; Ghorbel *et al.*, 2022b; Abdullah, 2023).

Among the G7 stock market indices, the Japanese stock index (NIKKEI) is the most significant net receiver of shocks during the three crises, followed by the American stock index (S&P500), suggesting their possible use as risk diversifiers. As for the rest of the G7 stock market indices, they are considered mostly net transmitters of shocks during the entire period, with the French (CAC 40) and German (DAX 40) stock market indices being the most significant net transmitters of shocks. These results are also confirmed by the net pairwise directional connectivity between gold, Bitcoin, and the G7 stocks using nodes. In fact, gold is found to be the least transmitter and receiver of shocks, confirming that it is the most resilient safe haven asset in our study.

Afterward, to assess the robustness of our results, we examined the connectedness and transmission of shocks across different quantiles. The findings are consistent with those observed at the median quantile, except in the case of the S&P500. Our results indicate that the degree of interconnectedness among these digital and financial assets is contingent upon the extent of economic and financial disruptions observed. It is also worth noting that the repercussions of the COVID-19 pandemic and the war are much stronger than those of the American banking crisis. In fact, the contagion among digital and financial assets during the SVB crisis was of brief duration, as the collapse exhibited relatively restricted effects in other markets in comparison to the banking sector (Akhtaruzzaman *et al.*, 2023).

Our results have policy ramifications that could be advantageous for stock investors in developed countries and guide them in making various choices concerning investments during turbulent times. By highlighting the significance of gold and Bitcoin as reliable safe-haven assets, our research provides investors with crucial insights into constructing resilient and diversified investment portfolios. Policymakers may consider utilizing these insights to develop frameworks and regulations that encourage the inclusion of these alternative assets into investment strategies, thus enhancing portfolio resilience and improving risk management practices. Moreover, our findings highlight the significance of incorporating dynamic market risk considerations into investment decision-making. This emphasizes the need for policymakers to prioritize efforts directed at enhancing investor understanding and awareness of how safe-haven assets can help mitigate market uncertainties. Additionally, policymakers may explore avenues for fostering innovation and infrastructure development within the digital asset space to facilitate greater accessibility and adoption of Bitcoin and other cryptocurrencies as viable investment options. On the other hand, investors in stocks within developing and emerging economies find themselves compelled to turn to gold as a safe haven asset, primarily because Bitcoin lacks this particular attribute within these countries (see, for instance, Jeribi *et al.* (2020); Widjaja and Havidz (2024). This situation is further exacerbated by the diverse regulatory measures imposed by the governments of some

of these nations, which inhibit the operation of Bitcoin exchanges and the associated trading activities.

Furthermore, given that the SVB collapse has a more significant impact on the banking sector and a limited effect on stock markets, this situation offers an opportunity for future research to conduct a comprehensive analysis of the crisis's influence on bank stocks. It is also crucial to assess whether Bitcoin and gold can act as safe havens for these stocks during the SVB collapse.

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Notes

[1] https://www.bbc.com/news/business-51829852.

[2] https://www.nytimes.com/2023/03/10/business/stock-market-jobs-report.html

[3] https://www.telegraph.co.uk/business/2023/03/10/ftse-100-markets-live-news-uk-gdp-economy-budget/#:~:text=US%20regulators%20last%20night%20took,down%201.67pc%20in%20London.

[4]The extension of the numerous identification strategies proposed in the VAR literature (Ramey, 2016) to the QVAR context constitutes an important area of research, https://www.simonemanganelli.org/Simone/Research_files/QVAR_May_2021_07.pdf

[5] White *et al.* (2015) have been the first to put forward the idea of a quantile VAR.