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Evaluating Dynamic Connectedness Among Economic Sanctions Sentiment, Uncertainty Factors, and Financial Assets: A Quantile VAR Approach

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Abstract: This paper investigates the dynamic connection between investor sentiment and a range of asset classes during the Russia-Ukraine conflict. Using daily data from January 1, 2022, to April 20, 2023, we employ the Quantile Vector Autoregressive (QVAR) connectedness framework to examine the connectedness of investor sentiment, financial stress, geopolitical risk, on commodities, fiat currencies, and stock markets. Our results reveal a time-varying and quantile-dependent pattern of connectedness, with RUWESsent consistently emerging as the primary net transmitter of shocks across all quantiles. Furthermore, the net directional connectedness highlights persistent and robust spillovers between RUWESsent, the Financial Stress Index (FSI), the Geopolitical Risk Index (GPR), and key financial assets throughout most of the sample period, highlighting a high level of interdependence between sentiment-driven uncertainty and asset price dynamics. These results offer important insights for investors, portfolio managers, regulators, and policymakers, underscoring the importance of monitoring sentiment and geopolitical developments when designing financial strategies during periods of heightened uncertainty.

Keywords: connectedness; economic sanctions; investor sentiment; Urals oil; RussiaCoin Bitcoin; QVAR.

JEL classification: HD53; G15.

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1. INTRODUCTION

Over the past decade, global markets have experienced significant disruptions, accompanied by a series of international crises, such as the global financial crisis of 2007–2008, the great pandemic COVID-19, regional divisions like Brexit in 2020, and several other regional conflicts, such as the US–China strategic trade war and the recent Russia–Ukraine conflict, that have reshaped the financial landscape (Basdekis *et al.*, 2022; Ahmed *et al.*, 2023; Basdekis *et al.*, 2024; Muddasir and Camino Ramon-Llorens, 2025; Nafisi-Moghadam *et al.*, 2025). These events have sparked extensive research on the integration, co-movements, and connectedness of financial markets, offering crucial insights with wide-reaching implications for policy formulation and portfolio diversification strategies, (Soltani *et al.*, 2021; Chowdhury *et al.*, 2022; Nguyen *et al.*, 2022; Hanif *et al.*, 2024; Tong, 2024). While the global financial crisis continued to reverberate long after its initial onset, the unprecedented emergence of the COVID-19 pandemic in 2019 marked a new phase of global disruption. As the world continues to navigate the lasting effects of COVID-19, with many economies still in recovery, the onset of Russia's invasion of Ukraine on February 24, 2022, further exacerbated global uncertainty. The Russia-Ukraine conflict has triggered a sharp rise in geopolitical risk, which has had profound effects on both regional and international financial markets. Notably, the conflict has severely strained the economic stability of the Russian and Ukrainian stock markets, turning them into epicenters of both physical and financial contagion. Given Russia's pivotal role in global energy markets and the size of its economy, the ongoing conflict holds significant implications for global commodity and capital markets. Hence, these uncertainties generate tensions and anxiety about the future, leading investors to either delay spending or engage in frantic asset accumulation or sales. As a result, this highly volatile environment significantly affects financial performance (Smales, 2020). Consequently, it is essential to understand how these geopolitical events influence the interconnectedness of various assets. In this context, investors face heightened concerns over potential market disruptions, which may affect their investment strategies. As a result, many investors have turned to diversification across industries and asset classes as a means of mitigating risk and protecting their portfolios from potential losses. Yuan *et al.* (2022) explore the relationship between EPU, oil and stock markets in the BRIC countries under different market conditions. Their findings indicate that Stock markets are more sensitive to negative oil returns, whereas oil markets are more responsive to positive stock returns. Furthermore, Le and Luong (2022) investigate the dynamic spillovers between oil price shocks, stock market returns and investor sentiment in the US and Vietnam. Their findings reveal that the relationship between oil price, stock market returns and investor sentiment is time-varying and quite driven by time-specific developments and events. Abid *et al.* (2023) conduct a comparative risk spillover analysis between Bitcoin and fiat currencies across various financial markets, using daily data from October 2010 to December 2022. This period encompasses several stress events, including the COVID-19 pandemic and the war in Ukraine. Their findings reveal that, under bearish market conditions, Bitcoin and fiat currency markets exhibit similar relationships with fixed-income and gold markets, showing insensitivity to downside risks. However, they diverge in their interactions with stock and crude oil markets, particularly in terms of both upside and downside risk spillovers. Boungou and Yatié (2024) examine the impact of the Russia- Ukraine war on global uncertainties and its effects on world stock market indices and commodity prices. Their findings reveal that the conflict exacerbates

uncertainties, which in turn negatively impacts the performance of global financial markets while driving up commodity prices.

This study aims to examine the dynamic network connectedness between commodities, fiat currencies, and stocks, with a particular focus on the role of investor sentiment during the Russo-Ukrainian conflict. Specifically, we investigate how investor sentiment shapes market behavior across these asset classes. To achieve this, we introduce a proxy for measuring investor sentiment in Russia, capturing the underlying anxiety that affects these markets. Additionally, we incorporate the financial stress index and the geopolitical risk index to account for broader uncertainty factors that may exacerbate market volatility. By analyzing these interconnected elements, this study seeks to provide a deeper understanding of how external shocks, such as geopolitical tensions, influence the dynamics of various asset classes and, in turn, shape investor decision-making.

The structure of the paper is as follows: Section 2 provides a comprehensive review of the literature. Section 3 outlines the data used in the analysis. Section 4 details the methodology employed. Section 5 presents the empirical findings and finally Section 6 concludes.

2. LITERATURE REVIEW

The complex network of global financial markets needs a comprehensive understanding of connectedness, particularly the transmission mechanisms through which shocks originating from sentiment shifts, geopolitical tensions, policy changes, propagate across diverse asset classes such as stocks, commodities, and cryptocurrencies. Initial investigations into these spillovers often relied on methods like Granger causality and basic VAR models, but the development of the Diebold and Yilmaz (2009, 2012, 2014) connectedness framework, based on generalized forecast error variance decomposition, marked a significant leap forward, enabling the quantification of both total system-wide interdependence and directional spillovers between specific market segments, a methodology widely applied to study volatility and return transmission across international stock markets, commodity-financial market relationships, and cryptocurrency dynamics. Within this context, economic sanctions represent an important source of disruption; while primarily aimed at target nations, their effects ripple outwards, impacting global supply chains, influencing major commodity prices like oil (Aalto and Forsberg, 2016), elevating broader geopolitical risk perceptions (Caldara and Iacoviello, 2022), and affecting investor sentiment. A large number earlier studies have proposed different proxies to capture investor sentiment during the dispute between Russia and Ukraine. These include Twitter Sentiments, Google Trend, Wikipedia Trend, and News Sentiments. For instance, Li *et al.* (2024) introduced a proxy for investor attention based on Google Trends designated the Russia-Ukraine investor attention index. Additionally, Ghosh *et al.* (2024) suggested using Reddit sentiment related to the Russia-Ukraine conflict as a measure of investor sentiment. However, specific research incorporating an economic sanctions sentiment index, distinct from general geopolitical risk, into these dynamic connectedness networks remains notably unexplored. Understanding these effects are various dimensions of uncertainty, prominently including Economic Policy Uncertainty (EPU) as measured by Baker *et al.* (2016), which is linked to increased volatility and flight-to-quality movements (Chiang, 2021), Geopolitical Risk (GPR) capturing threats from conflicts and terrorism (Caldara and Iacoviello, 2022), and market-based uncertainty proxies like the VIX, all of which are known to influence market stability and asset correlations, although studies

exploring their combined nexus within a broad network alongside sanctions sentiment are limited. However, a critical limitation of the standard Diebold-Yilmaz approach is its focus on average connectedness, which can obscure the potentially dramatic intensification or alteration of spillover patterns during periods of extreme market stress or tail events, such as those potentially triggered by sanctions imposition or severe uncertainty shocks. Recognizing this, recent methodological advancements have extended the connectedness framework into a quantile setting (Chatziantoniou *et al.*, 2021), employing quantile regression or Quantile VAR techniques (Koenker and Bassett, 1978; White *et al.*, 2015) analyze spillovers conditional on different points of the variables' distributions, thereby allowing a distinction between system behavior during normal market conditions (e.g., median quantiles) and extreme conditions (e.g., lower or upper quantiles). While this powerful quantile connectedness approach has begun to be applied to areas like energy-stock market linkages (Zhang *et al.*, 2020; Zhang and Hamori, 2021) and crisis periods like the COVID-19 pandemic (Soltani and Boujelbene Abbes, 2023), there remains a significant research gap in applying it to the specific, simultaneous dynamic nexus between economic sanctions sentiment, multiple uncertainty factors (FSI and GPR), major commodities (oil, gold), major fiat currencies, and stock market returns. Consequently, this research aims to fill this critical gap by utilizing the quantile connectedness methodology to provide a nuanced, state-dependent analysis of the interconnectedness structure among these vital global economic and financial indicators, shedding light on how risk transmission varies significantly between calm and turbulent market regimes driven by geopolitical tensions, policy uncertainty, and sentiment surrounding economic sanctions.

3. METHODOLOGY

We investigate the impact of the Russia-Ukraine War Economic Sanctions News Sentiment Index (RUWESsent) and uncertainty factors such as the Financial Stress Index (FSI) and Geopolitical Risk (GPR) on the dynamic connectedness between the assets under study (namely MOEX, Natural Gas, Urals Oil, Wheat, the Russian Ruble (RUB), and the cryptocurrency RussianCoin) across multivariate distributional tails, including the lower, median, and upper quantiles, during the Russia-Ukraine conflict. This analysis is conducted using the Quantile Vector Autoregression (QVAR) approach at the median and extreme quantiles (0.05, 0.5, and 0.95). The QVAR framework, as introduced by Chatziantoniou *et al.* (2021), is both flexible and well-suited for capturing market shocks across different quantile levels. The corresponding $VAR(p)$ model for the econometric framework is specified as follows:

$$X_t = \mu(\tau) + \sum_{j=1}^{p} \varphi_j(\tau) X_{t-j} + \varepsilon_t(\tau) \quad (1)$$

where:

X_t and X_{t-j} represents the $k \times 1$ dimensional endogenous variable vectors;

$\mu(\tau)$: defines the conditional mean vector of $k \times k$ dimensions,

$\varphi_j(\tau)$: is the $k \times k$ dimensional matrix coefficients of the VAR model,

$\varepsilon_t(\tau)$: depicts the $k \times 1$ dimensional error vector with a $k \times k$ dimensional variance-covariance matrix, $\sum(\tau)$.

For re-expressing the $QVAR(p)$ model in Equation (1) to a Quantile Vector Moving Average ($QVMA(\infty)$), we apply the Wold's representation. Thus, the model can be expressed as:

$$X_t = \mu(\tau) + \sum_{i=0}^{\infty} \Psi_i(\tau)\varepsilon_{t-1} \tag{2}$$

Moreover, following the methodology outlined by Koop *et al.* (1996) and Pesaran and Shin (1998), the H H-step-ahead Generalized Forecast Error Variance Decomposition (GFEVD) can be derived as Equation (3), then, scaled – see Equation (4):

$$\Psi_{ij}^{\tau} H = \frac{\sum \tau_{ii}^{-1} \sum_{h=0}^{H-1} \left(e_i' \Psi_h(\tau) \sum(\tau) e_j\right)^2}{\sum_{h=0}^{H-1} \left(e_i' \Psi_h(\tau) \sum(\tau) \Psi_h'(\tau) e_j'\right)} \tag{3}$$

where: e_i in Equation (3) is a zero vector that equates to unity on the i-th position.

$$\tilde{\Psi}_{ij}^{\tau}(H) = \frac{\Psi_{ij}^{\tau}(H)}{\sum_{j=1}^{k} \Psi_{ij}^{\tau}(H)} \tag{4}$$

In Equation (4), the conditions, $\sum_{j=1}^{k} \tilde{\Psi}_{ij}^{\tau}(H) = 1$, and $\sum_{i,j=1}^{k} \tilde{\Psi}_{ij}^{\tau}(H) = k$, which are two necessary conditions, must be satisfied. The term $\tilde{\Psi}_{ij}^{\tau}(H)$ renders the influence of variable j on all other variables i in terms of its share of forecast error variance/shocks. This measure is commonly referred to as the total directional connectedness TO others:

$$C_{itoj}^{\tau}(H) = \sum_{i=1, i\neq j}^{k} \tilde{\Psi}_{ij}^{\tau}(H) \tag{5}$$

Nevertheless, the directional spillovers received by variable j from all other variables i represent the total directional connectedness FROM others. This is formally expressed as:

$$C_{ifromj}^{\tau}(H) = \sum_{i=1, i\neq j}^{k} \tilde{\Psi}_{ij}^{\tau}(H) \tag{6}$$

Accordingly, the net directional connectedness is determined by calculating the difference between the total spillovers transmitted to others and those received from others :

$$NET_i^{\tau} = C_{itoj}^{\tau}(H) - C_{ifromj}^{\tau}(H) \tag{7}$$

More interestingly, NET_i^{τ} which represents the net connectedness for variable i in the network of variables (i, j). A value of $NET_i^{\tau} > 0$, suggests that variable i serves predominantly as a shock transmitter**,** exerting greater influence on other variables than it absorbs. A value of $NET_i^{\tau} < 0$, the variable is classified as a net receiver**,** indicating it is more impacted by shocks originating from other components of the system. The overall degree of

connectedness across the entire network is captured by the Total Connectedness Index (TCI), which is defined in Equation (8) as:

$$TCI^{\tau} = \frac{\sum_{i,j=1}^{k} \widetilde{\Psi}_{ij}^{\tau}(H)}{k-1} \tag{8}$$

The TCI indicates the strength of the connectedness between a variable i and other variables j, and higher TCI implies high risk between (i, j) variable set and low TCI implies low market risk among the variables.

Additionally, we concentrate our analysis on the connectedness across the 0.05, 0.5, and 0.95 quantiles. This quantile-based empirical strategy allows us to capture the dynamics of interconnections among financial assets under varying market conditions, lower (bearish, 0.05), median (normal, 0.5), and higher (bullish, 0.95) tails.

4. DATA AND DESCRIPTIVE STATISTICS

This study utilizes a range of financial and sentiment-related variables to analyze market dynamics and connectedness during the Russia-Ukraine conflict. Specifically, to proxy sentiment related to the Russia-Ukraine war and associated sanctions, we utilize a recently developed indicator namely the Russia-Ukraine War Economic Sanctions News Sentiment Index (RUWESsent)[1], introduced by Abakah *et al.* (2023). Moreover, we consider the Financial Stress Index (FSI), the Geopolitical Risk Index (GPR), the Moscow Exchange Index (MOEX), three major commodities (Natural Gas, Urals Oil[2], and Wheat), as well as fiat currency exchange rates expressed as the dollar price of the Russian Ruble (RUB) and the cryptocurrency RussianCoin (RC). The dataset covers daily observations from January 1, 2022, to April 20, 2023, a period selected based on the availability of RUWESsent data. The data were sourced from Investing.com and Refinitiv DataStream. Daily returns for each variable are computed using the standard logarithmic return formula for two consecutive prices, $P_{i,t}$ and $P_{i,t-1}$ as follows:

$$RET_{i,t} = ln\frac{P_{i,t}}{P_{i,t-1}} \tag{9}$$

The Russia-Ukraine War Economic Sanctions News Sentiment Index (RUWESsent) illustrates the public sentiment surrounding economic sanctions related to the conflict. Figure no.1 shows a significant spike at the beginning of the war in early 2022, reflecting intense media coverage and heightened public concern about the implications of these sanctions on both economies. Following this initial surge, the index quickly declines, indicating that while the news sentiment was initially very high, it stabilized as the situation became more predictable and media coverage normalized. After this period, the index shows minor fluctuations, suggesting that while the topic remains relevant, the urgency and dramatic nature of news related to sanctions have lessened. Overall, the trend indicates a low level of sentiment after the initial spike, highlighting that economic sanctions have become a regular topic rather than a crisis point. This pattern underscores the media's role in shaping public perceptions and demonstrates how interest in the topic has evolved over time.

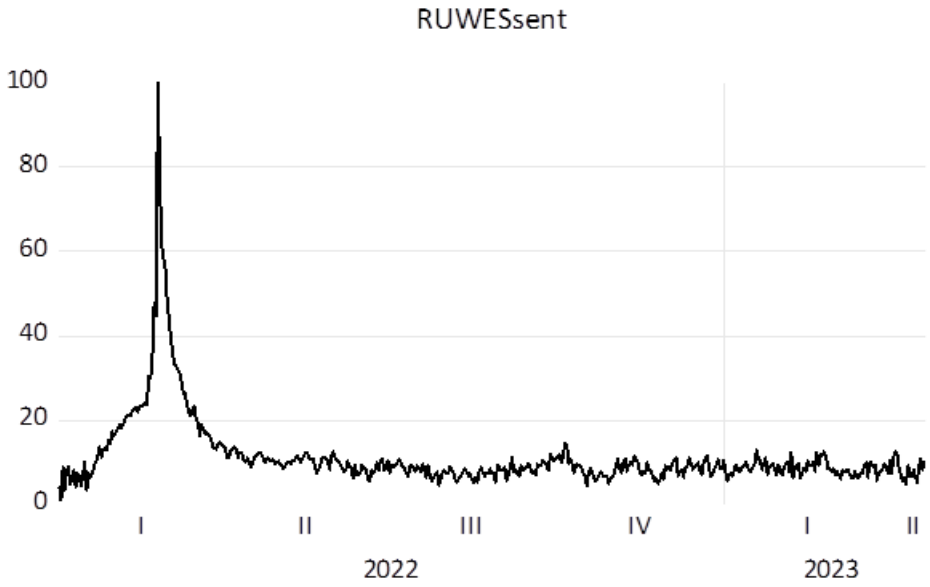


Figure no.1 - The evolution of Russia-Ukraine War Economic Sanctions News Sentiment Index (RUWESsent)

Table no. 1 reports the results of the descriptive statistics for the returns. The mean returns are positive for RUWESSENT; FSI_RUS; GPR; RUB and Urals Oil, while negative mean returns are observed for MOEX, RC_USD, Natural Gas, and Wheat. The Russian sentiment index (RUWESsent) exhibits the highest standard deviation, reflecting the greatest level of volatility among the variables. The kurtosis values for all series exceed the threshold for normal distribution, and the Jarque–Bera (JB) test is statistically significant at the 1% level, indicating strong evidence against the assumption of normality. Moreover, all series display asymmetry and leptokurtic behavior, further confirming the presence of non-Gaussian characteristics in the data.

Table no. 1 – Descriptive statistics

	Mean	Max	Min	Std. Dev.	Skewness	Kurtosis	J-B	Probability
RUWESSENT	11.220	100.000	1.000	8.809	5.062	37.814	25960.790	0.000
FSI	2.542	10.000	0.183	2.360	1.885	5.517	405.734	0.000
GPR	4.838	6.293	2.915	0.491	-0.154	3.995	21.445	0.000
MOEX	-0.001	0.183	-0.389	0.030	-4.411	66.002	79929.000	0.000
RC	-0.001	0.136	-0.173	0.033	-0.447	7.468	410.027	0.000
RUB	0.000	2.305	-2.301	0.153	0.034	219.837	928607.900	0.000
N_GAS	-0.001	0.941	-0.186	0.067	5.774	85.673	137621.200	0.000
URALS_OIL	0.000	0.150	-0.131	0.036	0.211	5.421	119.232	0.000
WHEAT	-0.001	0.197	-0.113	0.028	0.727	9.108	778.593	0.000

Notes: Std. Dev and J-B denotes standard deviation and Jarque-Bera test, respectively. GPR: Geopolitical risk index, FSI: Financial stress index, MOEX: Moscow Exchange market, RC: RussiaCoin, RUB: Russian Ruble, N_GAS: Natural Gas.

Source: authors' elaboration

5. EMPIRICAL FINDINGS

In this section, we apply the quantile-frequency connectedness approach to analyze the static, normal, and extreme interdependencies between Russian investor sentiment, global factors, and various assets. Specifically, we assess connectedness across different market conditions by focusing on three key quantiles: the 0.05 quantile represents extreme downside risk, the 0.50 quantile captures normal market behavior, and the 0.95 quantile reflects extreme upside dynamics. This framework allows us to capture the heterogeneous nature of market spillovers under varying levels of stress and optimism.

5.1 Connectedness under lower, middle, and upper quantiles

Table no. 2 presents a detailed breakdown of connectedness across different quantiles, with Panel A corresponding to the lower quantile (τ = 0.05), Panel B to the median quantile (τ = 0.50), and Panel C to the upper quantile (τ = 0.95). In fact, Panels A and C explore the extreme lower ($\tau = 0.05$) and extreme upper ($\tau = 0.95$) tails, respectively. Notably, the Total Connectedness Index (TCI) reaches significantly higher levels at these tails, 75.46% and 74.34%, respectively, compared to the median quantile (11.79%). This pattern highlights the high connectedness and systemic interdependence that arises under extreme market conditions, where traditional diversification strategies may become less effective. These results offer crucial insights for investors and policymakers, particularly in understanding how risk transmission intensifies during market turmoil, challenging the assumption of stable relationships across asset classes.

This elevated tail dependence suggests that extreme downside or upside movements in one market are likely to trigger disproportionate responses in others, amplifying systemic risk. This observation aligns with the findings of Barunik and Krehlik (2016), who emphasize that financial connectedness strengthens under stress, and with Abakah *et al.* (2023) who highlight the nonlinear and quantile-dependent spillovers across global markets during the Russia-Ukraine conflict. Similarly, Hu *et al.* (2024) demonstrate that identify that the conflict significantly increased tail risk connectedness among G7 stock markets, with the highest estimated levels observed two- and three months thereafter during the implementation of international targeted sanctions packages, signalling the strong persistence of short-term and total connectedness, respectively. The increase in connectedness can be attributed to factors such as heightened geopolitical and economic uncertainty, increased interconnectivity due to elevated risk and concomitant safe-haven behaviour, financial contagion, disrupted supply chains, and shifts in investor sentiment.

Furthermore, the analysis of directional spillovers reveals that both contributions to others (TO) and contributions from others (FROM) are more pronounced in the extreme tails than at the median quantile, underscoring the heightened vulnerability and contagion effects at the extremes. Moreover, Panel B reveals that the Total Connectedness Index (TCI) is 11.79%, indicating a moderate to low level of interconnectedness among Russian investor sentiment (RUWESsent), uncertainty factors (FSI and GPR), and various financial and commodity markets within this quantile. Notably, in the “TO” row, RUWESsent (27.82%) and the Russian stock market (MOEX) (19.73%) exhibit the highest spillovers to the system, underscoring their dominant influence on other variables. In contrast, wheat (6.00%) and natural gas (4.12%) contribute the least to the overall spillover, suggesting relatively limited

influence. This pattern highlights the pivotal role of investor sentiment and domestic equity market dynamics in shaping cross-market interactions during this market condition. The strong spillover from RUWESsent can be attributed to the heightened sensitivity of investor behavior to geopolitical tensions and economic sanctions, particularly during conflict-driven uncertainty, as documented by Abakah *et al.* (2023) and Boungou and Yatié (2024).

Table no. 2 – Average connectedness across quantiles

	RUWESsent	FSI	GPR	Wheat	URALS_Oil	N_GAS	Russ_Coin	MOEX	RUB	FROM
Panel A: Lower quantile (τ = 0.05)										
RUWESsent	22.88	7.94	12.29	11.84	10.35	9.56	10.40	7.22	7.51	77.12
FSI	10.50	31.13	9.62	8.59	8.13	7.93	8.46	7.71	7.94	68.87
GPR	11.32	7.88	20.08	11.71	11.63	9.17	11.09	8.95	8.17	79.92
Wheat	10.68	6.57	11.48	22.29	10.43	9.80	11.08	9.22	8.45	77.71
URALS_Oil	9.58	6.66	11.29	10.05	21.57	10.25	11.42	10.54	8.63	78.43
N_GAS	9.28	6.70	9.91	10.23	10.94	23.49	10.40	9.47	9.57	76.51
Russ_Coin	9.39	6.78	11.02	11.37	12.15	9.39	22.57	8.83	8.51	77.43
MOEX	9.26	7.87	10.46	10.29	10.75	8.75	9.65	23.55	9.43	76.45
RUB	8.12	7.18	8.43	9.22	8.06	8.35	8.65	8.68	33.31	66.69
TO	78.14	57.58	84.51	83.30	82.44	73.19	81.16	70.62	68.21	679.13
Inc.Own	101.01	88.71	104.59	105.60	104.01	96.68	103.73	94.16	101.52	**cTCI/TCI**
NET	1.01	-11.29	4.59	5.60	4.01	-3.32	3.73	-5.84	1.52	84.89/75.46
Panel B: Median quantile (τ = 0.5)										
RUWESsent	85.22	2.89	1.48	0.74	0.42	0.49	1.64	6.47	0.66	14.78
FSI	7.48	84.55	1.53	0.42	0.64	0.21	0.77	4.28	0.13	15.45
GPR	10.17	7.79	72.67	1.11	0.98	0.72	0.35	4.91	1.30	27.33
Wheat	1.37	0.74	0.56	93.21	1.12	0.37	1.22	0.60	0.81	6.79
URALS_Oil	0.44	0.66	0.98	1.67	89.96	0.48	2.66	1.05	2.11	10.04
N_GAS	0.32	0.45	0.38	0.60	0.46	95.82	0.70	0.58	0.69	4.18
Russ_Coin	0.68	1.19	0.35	0.32	2.47	0.59	91.95	1.23	1.21	8.05
MOEX	6.42	1.72	1.14	0.27	0.87	0.91	0.91	87.47	0.30	12.53
RUB	0.94	0.14	1.04	0.87	2.01	0.35	1.03	0.60	93.02	6.98
TO	27.82	15.58	7.44	6.00	8.97	4.12	9.27	19.73	7.21	106.14
Inc.Own	113.04	100.13	80.12	99.21	98.93	99.94	101.22	107.20	100.22	**cTCI/TCI**
NET	13.04	0.13	-19.88	-0.79	-1.07	-0.06	1.22	7.20	0.22	13.27/11.79
Panel C: Upper quantile (τ = 0.95)										
RUWESsent	31.70	5.46	11.13	10.63	9.32	6.75	9.27	7.42	8.32	68.30
FSI	12.58	36.04	11.50	8.08	6.80	5.30	7.77	5.73	6.19	63.96
GPR	18.50	6.79	19.25	10.87	10.66	7.47	9.76	8.25	8.45	80.75
Wheat	10.41	6.61	12.15	21.22	10.47	9.55	10.59	10.03	8.98	78.78
URALS_Oil	9.48	5.69	12.79	10.44	22.19	9.23	12.06	10.39	7.73	77.81
N_GAS	9.32	5.81	10.72	10.74	10.27	25.58	9.73	9.01	8.82	74.42
Russ_Coin	10.61	6.22	11.16	10.85	11.88	8.60	21.59	10.19	8.90	78.41
MOEX	9.35	6.25	11.76	11.04	10.96	9.47	11.39	21.05	8.72	78.95
RUB	12.37	5.33	9.08	8.92	7.59	7.68	8.66	8.10	32.28	67.72
TO	92.61	48.16	90.29	81.56	77.95	64.05	79.23	69.12	66.11	669.09
Inc.Own	124.32	84.20	109.54	102.78	100.15	89.63	100.82	90.17	98.39	**cTCI/TCI**
NET	24.32	-15.80	9.54	2.78	0.15	-10.37	0.82	-9.83	-1.61	83.64/74.34

Notes: The analysis is conducted using a Quantile Vector Autoregression (QVAR) framework, applying a rolling window of 200 days and selecting a lag order of 1 based on the Akaike Information Criterion (AIC). A 10-step-ahead generalized forecast error variance decomposition (GFEVD) is employed to capture the dynamic spillover effects across quantiles.

Source: authors' elaboration

These studies show that geopolitical tensions, especially the Russia-Ukraine conflict, significantly intensify market anxiety and amplify volatility spillovers. Similarly, MOEX's influence reflects the centrality of Russia's stock market in transmitting shocks across sectors and borders, particularly during periods of elevated financial stress, a dynamic also supported by Yuan *et al.* (2022) and Smales (2020), who highlight the critical role of equity markets in crisis-driven financial contagion. The relatively muted impact from commodities like wheat and natural gas may be due to long-term supply agreements, partial price stabilization mechanisms, or their lower short-term responsiveness to domestic investor sentiment, which is consistent with the findings of Le and Luong (2022) and Fasanya *et al.* (2021), who show that commodity markets often exhibit delayed or dampened responses to localized geopolitical events.

In the "FROM" column, the highest spillovers are directed toward the Financial Stress Index (FSI) at 15.45% and the Geopolitical Risk Index (GPR) at 27.33%, indicating their heightened vulnerability to shocks originating from other components of the system. In contrast, Natural Gas (4.18%), Wheat (6.79%), and the Russian Ruble (6.98%) exhibit the lowest spillovers, suggesting they are relatively less sensitive to external shocks within this quantile. This outcome highlights the essential role of FSI and GPR in reflecting systemic instability, as these indices consolidate reactions from a wide range of market actors. These factors are often found to respond significantly to external shocks, particularly in stressful times, as demonstrated in recent studies (Umar *et al.*, 2021; Boungou and Yatié, 2024; Soltani and Boujelbène Abbes, 2025) reinforcing their function as core indicators of macro-financial uncertainty.

The net spillover analysis further reveals that RUWESsent, FSI, RussiaCoin, MOEX, and the Russian Ruble are net transmitters, indicating their influential roles in spreading shocks across the financial and commodity landscape. This finding is consistent with Abakah *et al.* (2023) and Li *et al.* (2024) who show that investor sentiment and local financial markets often serve as initial transmitters of volatility, especially during periods of high uncertainty such as geopolitical conflicts. Moreover, Wheat, Urals Oil, rather than being a net receivers of spillovers, become a net transmitters of spillovers across the lower and upper quantiles. In contrast, Natural Gas is identified as net recipients, suggesting these assets tend to absorb rather than transmit shocks, a pattern in line with the behavior of defensive or lagging markets (Anyikwa and Phiri, 2023; Jiang and Chen, 2024). These results underscore the asymmetrical nature of connectedness during geopolitical stress, where domestic financial sentiment acts as a catalyst for volatility, while commodities and global uncertainty indicators respond more passively, playing a stabilizing or reactive role within the broader system.

As a consequence, the analysis of connectedness across the lower, middle, and upper quantiles reveals substantial asymmetries that depend heavily on prevailing market conditions. RUWESsent consistently emerges as a dominant transmitter of spillovers in both the lower ($\tau = 0.05$) and upper ($\tau = 0.95$) quantiles, underscoring its critical role in driving systemic shocks during periods of heightened uncertainty and market stress. This highlights the centrality of investor sentiment related to the Russia-Ukraine conflict in influencing the behavior of financial and commodity markets. Furthermore, the Total Connectedness Index (TCI) demonstrates that market interdependencies peak during extreme market conditions, particularly at the tails of the return distribution. These findings not only deepen our understanding of quantile-dependent contagion dynamics, but also offer practical implications for portfolio risk management, especially during periods of extreme volatility and geopolitical turmoil.

5.2 Time-Varying connectedness under lower, medium, and upper quantiles

Figure no. 2 presents the dynamic spillover indices, enabling an assessment of the time-varying nature of return spillovers across different quantiles. Utilizing a fixed rolling window of 200 days and a 10-step-ahead forecast horizon, we estimate the Time-Varying Connectedness Index (TCI) at the median ($\tau = 0.50$), lower ($\tau = 0.05$), and upper ($\tau = 0.95$) quantiles to examine connectedness under normal and extreme market conditions.

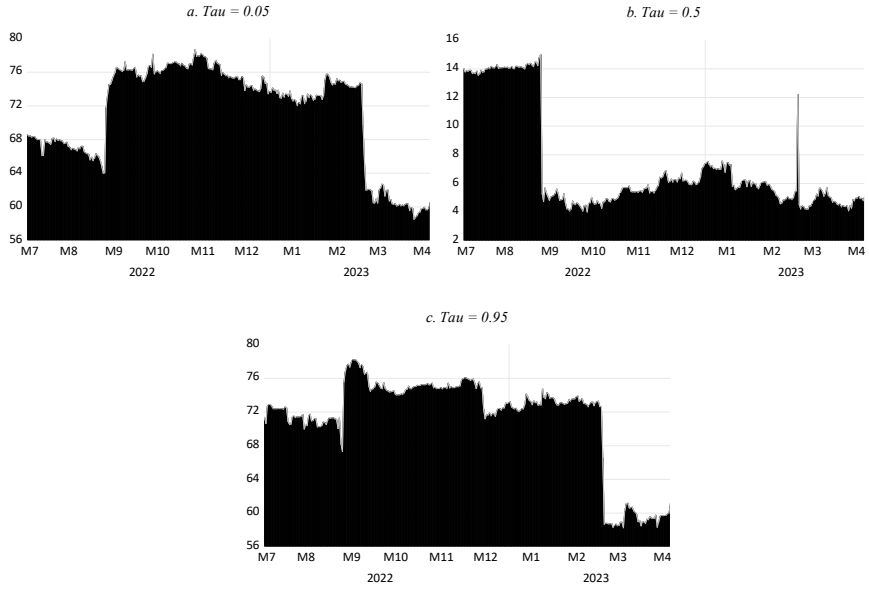


Figure no. 2 – Dynamic Total Connectedness Index (TCI) under quantiles

At the median quantile (Figure no. 2 - b), the TCI shows a variation, ranging between 4% and 15%. These fluctuations suggest that even under normal market conditions, cross-market interdependence remains active, allowing shocks in one market to transmit to others. This finding is consistent with previous studies (Alotaibi and Mishra, 2015; Liu *et al.*, 2024), which document that even during non-crisis periods, investors react to shared macroeconomic signals and market developments, contributing to moderate but persistent levels of interconnectedness. Notably, herding behavior, often triggered by uncertainty or market-wide fear, exacerbates spillovers as investors mimic the actions of others to avoid potential losses. In the lower quantile (Panel A), TCI values fluctuate within a very high range of 57% to 78%, while in the upper quantile (Panel C), they range from 58% to 79%. These elevated values confirm that during extremely bearish or bullish market conditions, markets become highly synchronized, exhibiting strong tail dependencies. This behavior underscores the vulnerability of financial systems to systemic shocks at both ends of the distribution. In Panel A, pronounced spikes in 2022 clearly align with the outbreak of the Russia–Ukraine conflict, emphasizing the event's role as a systemic shock. This geopolitical escalation significantly intensified downside risk across markets, resulting in elevated spillover effects, particularly at the 0.05 quantile. The TCI spike during this period illustrates how geopolitical uncertainty acts as a catalyst, amplifying the

vulnerability of global markets to localized events. More interestingly, Panel C (upper tail) shows fewer and less pronounced spikes, suggesting that positive shocks do not propagate as strongly as negative ones. This asymmetry implies that while market fragility is highly sensitive to downside risk, optimism or bullish trends have a weaker contagion effect. These results support the assertion by Belcaid *et al.* (2024), who emphasize that investors should remain vigilant in the face of negative events due to their potential to trigger adverse contagion effects. Furthermore, while the TCI surged in response to the conflict, particularly in the 0.05 quantile, the increase in the median quantile remained relatively subdued. This contrast highlights that under extreme stress, markets operate under collective alertness, leading to robust co-movements and limiting the marginal effect of additional shocks. In such cases, the overall correlation structure tightens, reducing the effectiveness of diversification and emphasizing the need for tail-risk-focused strategies in portfolio management.

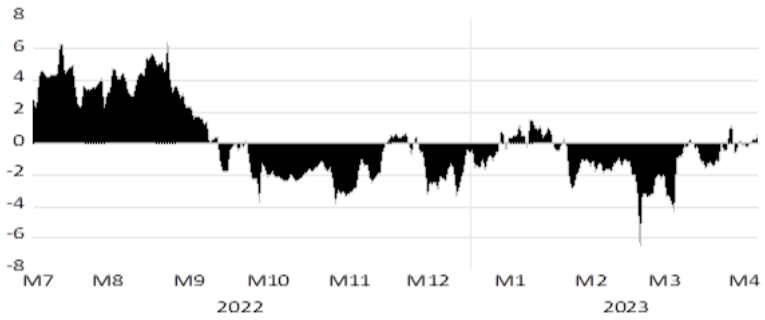


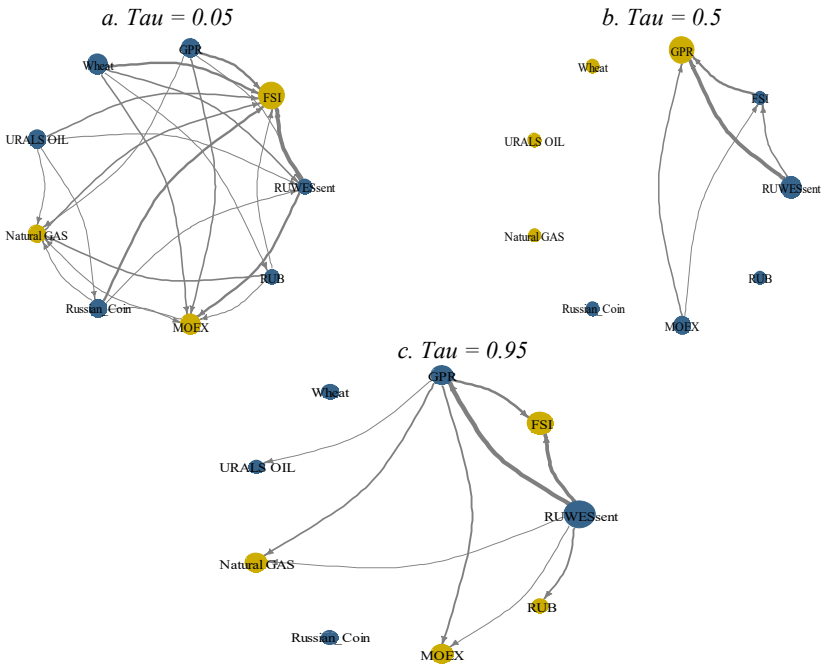
Figure no. 3 – Relative tail dependence ($TCI_{0.95} - TCI_{0.05}$)

Figure no. 3 presents the concept of Relative Tail Dependence (RTD), calculated as the difference between the Tail Connectedness Index (TCI) at the 95th quantile and the TCI at the 5th quantile, revealing a dynamic and time-sensitive pattern. A negative RTD value indicates a stronger dependence on the lower quantile, while a positive value signifies a robust connection to the upper quantile. The figure shows that the RTD is predominantly negative from mid-2020 until early 2023, suggesting a heightened dependence in lower quantile scenarios compared to upper quantile ones. This indicates a reduction in fragility during extremely bearish market conditions. Conversely, the spikes into positive territory during certain months suggest periods of increased interconnectedness among variables in extreme positive scenarios. Such fluctuations emphasize the importance of vigilance and proactive risk management strategies to navigate the complexities associated with significant market events.

5.3 Network connectedness under lower, medium, and upper quantiles

Furthermore, the network plots (Figure no. 4 - a, b, and c) illustrate the connections between RUWESsent and other financial assets across the lower, upper, and median quantiles, respectively. These plots are constructed based on the net pairwise spillover estimates reported in Table no. 2, providing a clear representation of directional connectedness under different market conditions. The arrows represent the direction of net spillover effects between each pair of variables, while the thickness of each line indicates the magnitude of the spillover. The size

and color of each vertex reflect the level and sign of the overall net spillovers between a specific variable and the other variables. Specifically, yellow-colored vertices indicate negative net spillovers, whereas blue-colored vertices represent positive net spillovers. In summary, at $\tau = 0.05$, the network is densely connected, reflecting heightened systemic risk and strong spillovers during stress periods, with RUWESsent, MOEX, and FSI serving as major transmitters of shocks. This corroborates the findings of Abakah *et al.* (2024), which suggest that Russia-Ukraine war and sanctions-related news sentiments (RUWESsent) serve as the net shock transmitter across extreme quantiles in global equity markets. Moreover, commodities and other variables are highly integrated, indicating a broad-based response to adverse conditions. At $\tau = 0.5$, the networks suggest moderate spillovers during normal market conditions. In addition, GPR emerges as the central driver, influencing MOEX, RUWESsent, and FSI (Balcilar *et al.*, 2018; Fang and Shao, 2022; Korsah and Mensah, 2024; NguyenHuu *et al.*, 2024; Nasouri, 2025), while commodities exhibit weaker connections. At $\tau = 0.95$, the network is characterized by fewer but more directional spillovers, highlighting concentrated influences during bullish periods. RUWESsent and MOEX dominate as pivotal transmitters, while GPR and FSI maintain targeted impacts. In addition, the Russian Ruble (RUB) appears as recipients of net shocks, (Luet *et al.*, 2023). Conversely, Natural Gas and Urals Oil, emerge as net recipients of shocks, reflecting their reduced integration during positive market scenarios, (Umar *et al.*, 2021; Huang *et al.*, 2024; Ullah *et al.*, 2024).



Notes: Yellow and blue nodes indicate the recipients and transmitters of shocks in the network, respectively. The size of the nodes represents the average net total spillover. The direction of spillover between assets is indicated by the arrows, and the weight of the arrows reveals the intensity of the spillover.

Figure no. 4 – Network plots at the 0.05, 0.5, and 0.95 quantile levels

5.4 Net directional connectedness under lower, medium, and upper quantiles

We further compute the dynamics of net quantile spillover effects for each variable in the system. This approach enables us to determine whether a variable acts as a net transmitter or recipient of information under varying magnitudes of shocks across different periods. Figure no. 5 presents the results at the median quantile (0.50) as well as the extreme lower (0.05) and upper (0.95) quantiles, illustrating the dynamic shifts in the role of each variable within the system. These shifts highlight how variables transition between being net contributors and net absorbers of shocks, depending on the intensity and direction of market stress. It is evident that the net spillovers of each variable vary over time, reflecting the dynamic nature of market interactions. Notably, the QVAR approach reveals that, consistent with the results presented in Table no. 2 and the network plots (Figure no. 4), RUWESsent is the major transmitter of shocks within the network across all three quantiles. This suggests that negative sentiment drives irrational investor behavior, amplifying noise trader loss aversion and herding tendencies. These findings are consistent with Abakah *et al.* (2024), who examine the impact of Russia-Ukraine war and sanctions-related news sentiment on global equity markets, demonstrating that RUWESsent acts as a net shock transmitter, particularly at extreme quantiles.

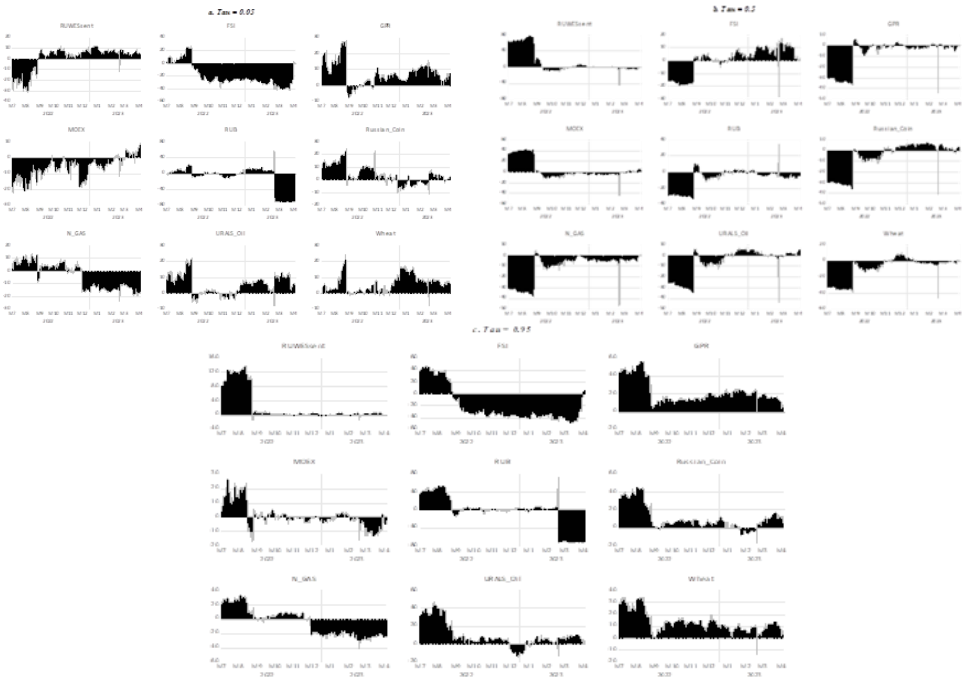


Figure no. 5– Net directional connectedness (NET) under quantiles

Overall, our findings demonstrate that the spillovers between RUWESsent, the Financial Stress Index (FSI), the Geopolitical Risk Index (GPR), and various financial assets remain

consistently strong throughout most of the sample period, underscoring a significant level of interconnectedness between uncertainty factors and asset dynamics. At the 0.05 quantile, during periods of financial stress, RUWESsent, FSI, and GPR exhibit strong positive connectedness to MOEX, underscoring their critical role in driving market sentiment and volatility, with commodities like Natural Gas and Urals Oil showing sensitivity to geopolitical and economic tensions (Gong and Xu, 2022; Ullah *et al.*, 2023). At the median quantile (0.50), the connectedness patterns reflect typical market conditions, with a more stable influence of RUWESsent, FSI, and GPR on MOEX and predictable behavior among commodities, aligning with studies on energy prices and economic stability Yousaf *et al.* (2022). At the upper quantile (0.95), extreme market conditions amplify the positive connectedness of RUWESsent, FSI, and GPR to MOEX, highlighting heightened volatility and interdependence, particularly for energy markets and RUB-linked assets, as supported by research on geopolitical risks and market dynamics (Wang *et al.*, 2022).

More interestingly, these spillovers are time-varying and exhibit substantial variation across different quantiles, with pronounced intensities observed in both the lower and upper tails compared to the mean. This asymmetry highlights the critical role of extreme market conditions, whether during periods of elevated stress or exuberance, in amplifying the transmission of shocks, thereby emphasizing the importance of considering tail dynamics in understanding market interdependencies. This observation is consistent with the findings of Balcilar *et al.* (2018), Fang and Shao (2022), Soltani *et al.* (2025) and Soltani and Boujelbène Abbes (2025).

6. CONCLUSION

This research investigates the impact of the Russia-Ukraine War Economic Sanctions News Sentiment Index (RUWESsent) on the dynamic connectedness across various assets in the context of the Russia-Ukraine conflict. Specifically, it explores how news sentiment surrounding economic sanctions influences inter-market relationships, and how financial stress and geopolitical risk further modulate these connections under varying market conditions. Utilizing a Quantile Vector Autoregression (QVAR) model, the analysis captures the risk transmission and connectedness among the Moscow Exchange Index (MOEX), major commodities (Natural Gas, Urals Oil, and Wheat), fiat currency exchange rates (RUB), the cryptocurrency RussianCoin (RC), as well as RUWESsent, the Financial Stress Index (FSI), and the Geopolitical Risk Index (GPR).

Our empirical analysis reveals robust and economically significant patterns in the relationship between RUWESsent, the Financial Stress Index (FSI), the Geopolitical Risk Index (GPR), and various markets. The Total Connectedness Index (TCI) exhibits substantial variation across the three quantiles, peaking at 74.34% during extreme high quantile levels and 75.46% during downturns, compared to just 11.79% at the median quantile. More precisely, spillovers increased at both the lower and upper quantiles during 2022, coinciding with the geopolitical tensions triggered by the invasion of Ukraine. This pattern demonstrates that inter-market connectedness intensifies during periods of extreme market conditions, both bullish and bearish, while remaining relatively stable under normal market circumstances. Such asymmetric behavior highlights the nonlinear nature of risk transmission, suggesting that geopolitical tensions and financial stress have more pronounced effect on market connectedness during turbulent periods. Furthermore, the high TCI during downturns underscores the potential for contagion effects, where negative shocks in one market rapidly

spread to others, amplifying systemic risk. In fact, we corroborate that the RUWESsent is the net shock transmitter within the network across all three quantiles, and risk sharing increased after the invasion and the sanctions against Russia. Furthermore, the net directional connectedness emphasizes that the spillovers between RUWESsent, the Financial Stress Index (FSI), the Geopolitical Risk Index (GPR), and various financial assets remain consistently strong throughout most of the sample period, underscoring a significant level of interconnectedness between uncertainty factors and asset dynamics.

Our findings offer valuable implications for both investors and policymakers. Investors are encouraged to adopt diversified, risk-aware strategies to better navigate sentiment-driven volatility, while policymakers should focus on evaluating and mitigating the interconnectedness between investor sentiment and asset classes during periods of severe shocks. Additionally, portfolio managers can improve decision-making by incorporating sentiment analysis and preparing for the time-varying nature of influences in extreme market conditions. This study is limited by its focus on Russia-centric assets, which may constrain the generalizability of the findings to broader or global financial markets. To address this limitation, future research should explore the impact of economic sanctions news sentiment on emerging markets and alternative financial segments, such as green and sustainable assets, to enhance the relevance and applicability of these insights.

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Notes

[1] This innovative index is constructed using a comprehensive dataset comprising 1,207,730 Tweets, Google Trends data, five carefully selected keywords, activity on two relevant Wikipedia pages, and 188,649 newspaper news. In this framework, Twitter data represent public opinion and sentiment on the conflict and sanctions, Google Trends and Wikipedia page reflect collective anxiety, and news articles reflect media intensity around these issues. The RUWESsent index ranges from 1 to 100, with values from 1 to 49 indicating negative (pessimistic) sentiment, and values from 50 to 100 reflecting positive sentiment.

[2] Ural oil: is one of the four types of Russian oil. It is a blend derived primarily from oil fields in Western Siberia, the Ural Mountains, and the Volga region. Ural oil serves as a key benchmark for determining the export price of Russian crude. It is also actively traded on the Russian stock exchange.

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Economic Insecurity, Inflation and Labour Market Dynamics: A Panel Analysis for EU countries

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Abstract: In the context of the global economic and financial downturns and social and political instability, the concept of economic insecurity has become a major concern for both researchers and policy-makers. Generally defined as the perceived or actual risk of financial instability and the awareness of the inability to address it, the economic insecurity has a great impact on both individual well-being and macroeconomic prosperity. Therefore, the purpose of the present paper is to analyse the impact of inflation and labour market dynamics on the economic insecurity within the European Union (EU) countries. To measure the economic insecurity, we used an index that was previously developed and which takes into account six variables: Inability to afford paying for one-week annual holiday away from home, Inability to face unexpected financial expenses, Children aged 0-17 living in jobless households, Arrears, Housing cost overburden rate and Inability to make ends meet. The analysis was conducted by using three different types of regression: OLS, Fixed Effects and Random Effects, and then it was validated by three types of robustness tests: the first one is regional decomposition, the second one is based on economic insecurity levels and in the third one we added institutional variables. The final results show robustness for six variables: Inflation rate, Household final consumption expenditure, Unemployment for 15-24 and 55-74 and Part-time and Vulnerable employment.

Keywords: economic insecurity; inflation; unemployment; labour market dynamics; European Union.

JEL classification: E24; I30; R20.

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1. INTRODUCTION

The 2007-2008 global economic and financial crisis and the COVID-19 pandemic, which increased the inequality and poverty, brought into light the significance of the economic insecurity, as a crucial aspect of the well-being. Insecurity was generally seen as the anxiety generated by the anticipation of future economic losses and the awareness of one's inability to address them (Rohde and Tang, 2018). The economic dynamics that contribute to this insecurity are complex, but two variables play a particular role: inflation and labour market conditions. Apart from eroding the purchasing power, particularly for low- and middle-income households who often experience the brunt of price increases in essential goods (Blanchard, 2017), inflation increases the economic uncertainty, making it difficult for households to plan their finances and, thus, leading to greater anxiety about their economic futures. In addition, the labour market's response to the external economic shocks, such as the 2007-2008 global crisis and the COVID-19 pandemic, has raised the employment instability and deepened the disparities in wages. All these labour markets' shortcomings, together with the inflationary pressures, create a feedback loop, where the increased economic insecurity exacerbates the labour market volatility (Vasile *et al.*, 2023).

Among the EU states, the structure of the labour markets varies widely, with disparities in job quality, employment stability and wage growth (Kalleberg, 2009). While some countries have relatively robust welfare systems and labour protections, others face higher rates of precarious work, including part-time and temporary employment, which contribute to rising economic insecurity. Furthermore, the external economic shocks, as it was the case of the global financial crisis and of the COVID-19 pandemic, have exacerbated these disparities, affecting labour market stability across the region (Eurofound, 2020).

Despite the significant socio-economic implications of the interaction between economic insecurity, inflation and labour market outcomes, this relationship is underexplored in the context of the European Union (EU) countries. The present paper intends to fill this gap by investigating the impact of inflation and labour market dynamics on the economic insecurity within the EU states. Our analysis includes 26 of the 27 countries of the European Union (Luxembourg was excluded due to the lack of data) and focuses on the period 2014-2022, thus including the years when the 2009 sovereign debt crisis started to affect the European countries (in particular the PIIGS countries) and also the pandemic period. In this study, we will measure the economic insecurity of EU households with the help of an index that was previously developed, which is composed of two main dimensions: Lack of savings and leisure time and Households' predisposition to risk (Pricop and Diaconu (Maxim), 2025).

As independent variables, we considered the following: the compounded and disaggregated unemployment rate (disaggregated into the three age groups of the working population: 15-24, 25-54, and 55-74), the annual inflation rate, the share of part-time jobs in the total share of jobs, job vulnerability and household final consumption expenditure. In order to validate the various statistical models resulting from the interaction of these variables with the composite index of economic insecurity, we use different robustness tests.

The first tests will cover the regional breakdown as presented by Eurovoc (Northern Europe comprising six countries, Western Europe comprising six countries, Central and Eastern Europe comprising eight countries and Southern Europe comprising six countries). The next tests will focus on the division between countries with low and very low levels of economic insecurity (eighteen countries) and those with medium, high or very high levels of

economic insecurity (eight countries). Finally, on the same premises as in the study carried out by Zouita and Mohamed Salah (2021), the baseline model will be tested by adding various institutional variables provided by the World Bank to observe their impact on the model.

The novelty of our study derives precisely from the use of this new index of economic insecurity that was previously developed (Pricop and Diaconu (Maxim), 2025) in relation with the variables reflecting inflation and labour market conditions and, also, by validating the model using various robustness tests.

2. THEORETICAL BACKGROUND AND RESEARCH HYPOTHESES

All the economic, political and social downturns that occurred since the beginning of the 21st century have conducted numerous debates among researchers that tried to quantify and analyse the economic security. Many of these studies attempted to develop theories of economic security and, more than that, to suggest various economic measures that can lead to its enhancement. While some considered economic security to be synonymous with 'resilience' to various attacks that can disrupt the financial system (Zuleeg, 2023), others argued that it may also mean physical or national security (McCaffrey and Poitiers, 2024). All these studies have the roots in the classical economic theory according to which the individuals maximize their utility (well-being) based on income and consumption. Therefore, the economic insecurity reduces the disposable income or raises the uncertainty, decreasing, thus, the well-being. Taking into account all these aspects, in the present study we associate the economic security with all the issues encompassed by the well-being of a household (Hacker *et al.*, 2012; Pricop and Maxim, 2024). Consequently, the opposite of economic security, the economic insecurity, synonymous with poverty and perpetual indebtedness, reduces the life satisfaction (Diener *et al.*, 1999).

One of the causes the most often associated with poverty is inflation (Easterly and Fischer, 2001), some authors arguing that an increase in inflation increases the poverty (Blank and Blinder, 1986; Paul and Sharma, 2019), while others advocating the idea that, de facto, rising inflation corresponds to decreasing poverty rates (Cutler and Katz, 1991; Headey and Hirvonen, 2023). Another theory is that inflation would not affect those already below the poverty line (Cardoso, 1992).

All these arguments have to be taken into account in our analysis which we intend to conduct it for the European Union states during 2014-2022, period that can be divided into three interconnected phases: the mitigation of the effects of the economic crisis of 2008-2009, the economic recovery phase and the pandemic era. Thus, a key element of this period for many EU countries is austerity, often associated with a state of fear and insecurity (Autto *et al.*, 2021). Economic insecurity can be determined based on an index developed in a recent study (Pricop and Diaconu (Maxim), 2025) formulated by means of Principal Components Analysis (with the Kaiser selection criterion) and composed of two dimensions: the first one being “Lack of savings and leisure time” while the second one “Household's predisposition to risk”. The names of the two dimensions were derived from the results obtained by PCA, considering that the first dimension (Lack of savings and leisure time) was composed of the variables *Inability to afford paying for one-week annual holiday away from home* and *Inability to face unexpected financial expenses*, while the second (Household’s predisposition to risk) was composed *of Children aged 0-17 living in jobless households*, *Housing cost overburden rate*, *Arrears* and *Inability to make ends meet*. The complete formula of the index was:

Economic insecurity of European households = (0.400 × Inability to afford paying for one-week annual holiday away from home + 0. 405 × Inability to face unexpected financial expenses) × 0.4597 + (-0.410 × Children aged 0-17 living in jobless households + 0515 × Housing cost overburden rate + 0. 450 × Arrears + 0.424 × Inability to make ends meet) × 0.1941

It also can be simplified in:

Economic insecurity of European households = 0.4597 × Lack of savings and leisure time + 0.1941 × Household's predisposition to risk

We consider this index appropriate to describe the economic insecurity because it broadly covers much of what we mean by household "insecurity", namely the lack of savings to enable either survival against unforeseen situations or recreation, but also the structural composition of the household in which we live.

Inflation, on the other hand, fell from 2014 to 2016 due to the austerity policies, which have often been criticized for their impact on citizens' welfare (Dowell-Jones, 2015). However, since 2017, it started to increase again, showing how the shock of the UK's exit from the European Union has had inflationary effects not just for Britons (Breinlich *et al.*, 2017) but also for the European countries. Broadly speaking, however, we can say that the period 2014-2020 (until the pandemic) was one in which citizens gradually enjoyed economic security once again, while on the other hand the European governments had to 'live with' an almost constant but sustainable rise in inflation. Even after the COVID-19 pandemic it was noticed that households perceived the rising inflation as a sign of improving the macroeconomic conditions, which could improve their expectations about labour markets and reduce the perceived insecurity (Coibion et al., 2022). Based on these findings, our first research hypothesis is:

***H1**: In periods when inflation has small increases (such as post-crisis years), citizens' economic insecurity tends to reduce.*

Unemployment is also an important phenomenon. What can be noted is that the 'more sensitive' segments of society, such as the young (aged 15-24) or older (aged 55+), tend to be less resilient to unemployment (Eichhorst *et al.*, 2013), being more sensitive to changes in the economic conditions (O'Higgins, 1997; Johnson, 2009). Among the events that have played a key role in spreading youth unemployment we certainly include the 2008 economic and financial crisis, which had devastating effects for the Mediterranean countries (Eichhorst *et al.*, 2013). The 2008 crisis also had particularly important effects for the older population too. Willing to mitigate the disastrous economic effects, many countries resorted to raising the retirement age, directly correlated with the unemployment among the ageing population (Arranz and Garcia-Serrano, 2023). Apart from the 2008 crisis, we can also mention the consequences of the COVID-19 pandemic on the unemployment. According to the EU's *Employment and Social Developments in Europe (ESDE)* report released in 2022, young people were among the most severely impacted by employment losses during the COVID-19 pandemic (EU, 2022). By 2021, youth unemployment remained about 1 percentage point higher than pre-crisis levels. Young people also experienced volatile labour income since almost 46% of young workers were on temporary contracts (EU, 2022). Considering all these aspects, the second hypothesis is:

***H2**: Rising unemployment among the more 'sensitive' segments of society (young and elderly) tends to have a greater effect on overall economic insecurity (compared to the 25-54 segment).*

Another aspect that should not be neglected is that of part-time jobs, which often represent a real alternative to the classic "9-17" system for many individuals. Part-time jobs have started to become increasingly common in the Western economic set-up since the 1990s, with broadly positive economic effects and contributing to greater flexibility in the labour market (Buddelmeyer *et al.*, 2004), although it cannot be neglected that there are differences between countries in the dynamics and legislation of part-time jobs (Fagan and O'Reilly, 1998). Other studies argue that part-time jobs have emerged as a solution for married women or to fill a labour shortage niche, a practice that has been more successful in northern European countries than anywhere else on the continent (Smith *et al.*, 1998). Although initially this practice was popularized among females, over the years it has gained popularity among males as well (Buddelmeyer *et al.*, 2004), external constraints on choosing a part-time job playing a key role (Fagan *et al.*, 2014). It must be said that getting a part-time job is not always synonymous with avoiding poverty (Brülle *et al.*, 2019; Vaalavuo and Sirniö, 2022) but this is largely determined by the composition of the household, with part-time jobs being more prevalent in households with more than one employee (Horemans *et al.*, 2016). In recent years we have seen an increase in the number of people us ing two part-time jobs to avoid poverty, with flexibility being a key factor in choosing such a solution (Scott *et al.*, 2020). Although sometimes the psychological effects of a part-time job, especially a "non-desired" one, may not always be the most positive (Beck *et al.*, 2024), it was also spread the idea according to which a part-time job is still better than no job at all (Walwei, 1998). The increase in the rate of part-time jobs out of all jobs in the labour market does not necessarily mean that full-time jobs have decreased in number, but rather that new part-time jobs have emerged, providing opportunities for those employees who require more flexibility and who are voluntarily engage in such a contract. It is very important to make this distinction between the voluntary and involuntary part-time jobs, since the last ones may involve lower income, limited social protections and job instability, all these representing factors that exacerbate the economic insecurity. However, in a downturn period, the involuntary part-time jobs seem to prevail. As noticed by Hipp *et al.* (2015), an economic crisis increases the share of involuntary part-time and precarious jobs, especially in weaker labour protection regimes. Between 2008 and 2013, the share of involuntary part-time workers augmented across almost all EU member states, the highest increases being noticed in the Southern Europe (Eurofound, 2018). A study that investigated the poverty risk associated with part-time employment across Europe after 2008 crisis reveals that involuntary part-time workers (those working fewer than 30 hours a week, while seeking more) faced a poverty risk comparable to the unemployed persons (Horemans *et al.*, 2016). This risk proved to be statistically significantly higher than that faced by the full-timers or voluntary part-timers. Another research investigating the labour market instability in the period after COVID-19 shows that the job insecurity generated by the temporary contracts and the part-time jobs is associated with lower well-being and social exclusion, aspects that foster the economic insecurity (Eurofound, 2023). Considering all these aspects, our third hypothesis is:

***H3**: Increasing the share of part-time jobs as a share of total jobs in post-crisis periods can increase economic insecurity.*

One of the most debated topics in the area of household economic research is the choice that individuals make between consumption and savings (Krusell and Smith, 2003). Among the most interesting perspectives, we can find that of the economist John Maynard Keynes, according

to which income growth will lead to consumption growth 1936. In contrast, we find the Kuznets paradox stating that consumption growth falls when income increases (Palley, 2008). One explanation for Kuznets' paradox was formulated by Duesenberry (1949), who argued that as consumption increases in a society, households feel the social pressure to also increase their consumption in order to maintain their status. Thus, he stated that people don't just care about how much they consume in absolute terms, but rather how their consumption compares to others', especially to those in their social group or status level. Therefore, even though income rises, the motivation to consume more weakens when there is no relative gain in social status. Duesenberry (1949) also suggested that once a certain standard of living is achieved, people will be more tempted to save the additional income rather than spending it. However, we consider Milton Friedman's approach to be the most comprehensive, as he makes a valid distinction between permanent income (that which the household expects to have most of the time) and transitory income (Friedman, 1957). Parallel to permanent and transitory income, we have permanent and transitory consumption, and the conclusion he assumed is that both permanent and transitory consumption are independent of transitory income and that transitory consumption in any period is independent of permanent income (Parker, 2010). Meanwhile, according to Milton Friedman's permanent income theory (Friedman, 1957), households consume based on their expectations regarding the long-term income stability. A period of monetary expansion leads to transitory increases in income, especially for the early recipients. However, according to Cantillon effect (Cantillon, 1931), in this context many households may be pushed to increase their consumption without a simultaneous rise in permanent income. This disconnection can lead to greater economic insecurity, as families face rising costs and unstable financial planning.

Taking into account that the index used to determine economic insecurity has a "Lack of savings and leisure time" component, we will tend to consider that consumption growth in times of material deprivation, as it was the period that followed the 2009 crisis and the COVID-19 crisis, can be positively correlated to economic insecurity, thus formulating hypothesis 4:

***H4**: Households consumption growth in times of material deprivation increases economic insecurity.*

The economic crises that occurred in the beginning of the 21st century and the subsequent political reforms focused on employment flexibilization increased the use of non-standard employment (Bosmans *et al.*, 2023), which involves work arrangements that lack security, benefits, regular hours, or long-term stability. Therefore, they may be considered vulnerable employment which, due to poor quality, uncertain and low-return employment, usually fails to reduce the poverty (Yerrabati, 2022). Starting from the definition offered by World Bank to vulnerable employment (see Table 1), the ILO (2018) argues that citizens in vulnerable employment (own account workers and contributing family workers) are more prone to have informal work arrangements and less likely to have social security coverage and to benefit from social dialogue (ILO, 2018). A study conducted on households from Spain and Portugal found that employed adults lacking secure jobs faced a significantly higher risk of material deprivation (Pérez-Corral *et al.*, 2023). This effect increased in the period after 2008 crisis and in the aftermath of COVID-19. Based on these previous findings, we expect a positive correlation between job vulnerability and economic insecurity and, thus, the hypothesis 5 is:

***H5**: Job vulnerability increases economic insecurity.*

3. METHODOLOGY

Table no. 1 shows the variables used, their description and their function.

Table no. 1 – Variables description

Variable	Description	Source	Function
Economic Insecurity Index	Aggregate bi-dimensional index on the economic security of European Citizens	(Pricop and Diaconu (Maxim), 2025)	Dependent
Inflation Rate	It is based on annual fluctuations in HICP (Harmonised indices of consumer prices)	Eurostat (2025a)	Independent
Unemployment	Unemployment rates represent unemployed persons as a percentage of the labour force. It can be divided in three age categories: 15-24, 25-54 and 55-74.	Eurostat (2025b)	Independent
HFCE (Household final consumption expenditure)	Is the market value of all goods and services, including durable products (such as cars, washing machines, and home computers), purchased by households. It excludes purchases of dwellings but includes imputed rent for owner-occupied dwellings.	WB (2025a)	Independent
Part time employment (% total employment)	Part time employment refers to regular employment in which working time is substantially less than normal. Definitions of part time employment differ by country.	WB (2025b)	Independent
Vulnerable employment (% total employment)	Vulnerable employment is contributing family workers and own-account workers as a percentage of total employment.	WB (2025b)	Independent
Control of corruption	Control of corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.	WB (2025c)	Independent (for robustness only)
Government effectiveness	Government effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.	WB (2025c)	Independent (for robustness only)
Regulatory quality	Regulatory quality captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.	WB (2025c)	Independent (for robustness only)
Rule of Law	Rule of law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.	WB (2025c)	Independent (for robustness only)

Variable	Description	Source	Function
Voice and accountability	Voice and accountability captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media.	WB (2025c)	Independent (for robustness only)

Source: own elaboration

Based on the data and variations in economic insecurity, we can divide the statistical models into at least four variants. In the first variant we could use the 15-24 age group exclusively.

$$Eiit = \alpha + \beta 1HFCEit + \beta 2INFit + \beta 3PTEit + \beta 4VEit + \beta 5UNMP15\text{-}24it + u \quad (1)$$

For the second variant we exclude, among the independent variables, Unemployment 15-24 and replace it with Unemployment 25-54.

$$Eiit = \alpha + \beta 1HFCEit + \beta 2INFit + \beta 3PTEit + \beta 4VEit + \beta 5UNMP25\text{-}54it + u \quad (2)$$

For the third variant we will use the last age category available to us in the Eurostat: 55-74.

$$Eiit = \alpha + \beta 1HFCEit + \beta 2INFit + \beta 3PTEit + \beta 4VEit + \beta 5UNMP55\text{-}74it + u \quad (3)$$

In the latter model, however, we no longer differentiate by age but simply use the unemployment rate for the whole working population.

$$Eiit = \alpha + \beta 1HFCEit + \beta 2INFit + \beta 3PTEit + \beta 4VEit + \beta 5UNMPit + u \quad (4)$$

The models presented above will be tested in Table no. 4 using OLS, Random Effects and Fixed Effects regression equations. Until then, we need to statistically describe the variables (Table no. 2) and also to present the correlation matrix (Table no. 3).

Table no. 2 – Descriptive statistics

Variable	Mean	Median	Min	Max	SD
EC. INS.	14.71	13.96	5.85	30.89	6.21
HFCE	53.80	54.08	23.62	69.53	8.37
INF	2.21	1.20	-1.60	19.40	3.51
PT JOBS	32.31	30.31	9.47	60.52	10.91
VU EMP	11.56	10.94	4.77	30.93	4.97
UN 15-24	19.05	17.10	5.60	53.20	9.77
UN 25-54	7.09	6.00	1.80	26.10	4.12
UN 55-74	5.97	5.10	1.30	19.40	3.42
UN	7.87	6.80	2.00	26.60	4.25

Source: own elaboration

Table no. 3 – Correlation matrix

	EC INS	HFCE	INF	PT JOBS	VU EMP	UN 15-24	UN 25-54	UN 55-74	UN
EC INS	1.00								
HFCE	0.624	1.00							
INF	-0.204	-0.052	1.00						
PT JOBS	-0.696	-0.545	-0.047	1.00					
VU EMP	0.513	0.414	-0.078	-0.283	1.00				
UN 15-24	0.605	0.529	-0.271	-0.211	0.496	1.00			
UN 25-54	0.610	0.519	-0.314	-0.181	0.428	0.919	1.00		
UN 55-74	0.542	0.475	-0.306	-0.145	0.309	0.814	0.930	1.00	
UN	0.588	0.492	-0.326	-0.141	0.415	0.932	0.994	0.943	1.00

Source: own elaboration

4. RESULTS AND DISCUSSIONS

As mentioned in the previous paragraph, we proceed with testing various models (with different unemployment variables), by using OLS, REM and FEM regressions. Finally, we will select the model that we consider the most appropriate to explain the economic insecurity variable.

Table no. 4 – Regression equations with OLS, RE and FE

Variable	OLS Model	REM Model	FEM Model
HFCE	0.057 (0.035)	0.302 (0.050) ***	0.407 (0.060) ***
Inflation	-0.214 (0.062) ***	-0.162 (0.033) ***	-0.153 (0.034) ***
Part time employment	-0.311 (0.023) ***	-0.148 (0.036) ***	-0.102 (0.046) **
Vulnerable employment	0.182 (0.050) ***	0.208 (0.099) **	0.264 (0.149) *
Unemployment 15-24	0.218 (0.028) ***	0.245 (0.029) ***	0.246 (0.034) ***
Constant	15.884 (2.227) ***	-3.509 (3.160)	-11.321 (3.646) ***
Adj R	0.730	0.621	0.931
Observations	234	234	234
Hausman test		19.88 (0.0013)	

Variable	OLS Model	REM Model	FEM Model
HFCE	0.033 (0.034)	0.264 (0.049) ***	0.354 (0.060) ***
Inflation	-0.166 (0.061) ***	-0.123 (0.034) ***	-0.118 (0.034) ***
Part time employment	-0.319 (0.022) ***	-0.146 (0.035) ***	-0.074 (0.045)
Vulnerable employment	0.202 (0.046) ***	0.187 (0.095) *	0.141 (0.153)
Unemployment 25-54	0.582 (0.064) ***	0.632 (0.069) ***	0.662 (0.084) ***
Constant	17.099 (2.153) ***	-1.136 (3.112)	-8.024 (3.665) **
Adj R	0.752	0.639	0.934
Observations	234	234	234
Hausman test		19.46 (0.0016)	

Variable	OLS Model	REM Model	FEM Model
HFCE	0.052 (0.034)	0.263 (0.050) ***	0.344 (0.061) ***
Inflation	-0.193 (0.063) ***	-0.135 (0.033) ***	-0.131 (0.034) ***
Part time employment	-0.315 (0.023) ***	-0.145 (0.035) ***	-0.086 (0.045) *
Vulnerable employment	0.270 (0.046) ***	0.325 (0.091) ***	0.378 (0.136) ***
Unemployment 55-74	0.594 (0.074) ***	0.636 (0.070) ***	0.631 (0.080) ***
Constant	15.847 (2.201) ***	-2.047 (3.123)	-8.857 (3.634) **
Adj R	0.735	0.638	0.934
Observations	234	234	234
Hausman test		18.24 (0.0027)	

Variable	OLS Model	REM Model	FEM Model
HFCE	0.035 (0.033)	0.265 (0.049) ***	0.345 (0.059) ***
Inflation	-0.158 (0.061) **	-0.121 (0.033) ***	-0.177 (0.033) ***
Part time employment	-0.326 (0.022) ***	-0.145 (0.034) ***	-0.066 (0.045)
Vulnerable employment	0.203 (0.046) ***	0.182 (0.094) *	0.111 (0.150)
Unemployment total	0.564 (0.061) ***	0.598 (0.062) ***	0.634 (0.075) ***
Constant	16.907 (2.137) ***	-1.392 (3.071)	-7.722 (3.602) **
Adj R	0.754	0.648	0.936
Observations	234	234	234
Hausman test		19.64 (0.0015)	

Notes: Significance levels are *** for 1%, ** for 5% and * for 10%

Source: own elaboration using EViews 12 SV

The results of the various regression equations show that, based on the fixed-effects models, youth unemployment (15-24) and elderly unemployment (55-74) are better fitted to the general model than general unemployment or middle-aged unemployment (25-54), since we want a model in which all variables are significant (in the 25-54 unemployment model, the variables related to part-time and vulnerable jobs lose statistical significance, a case that is replicated for general unemployment). For this reason, in order to obtain a final model in which all variables are statistically significant, we formulate a joint model for ages 15-24 and 55-74, in the following form:

$$EIit = \alpha + \beta 1HFCEit + \beta 2INFit + \beta 3PTEit + \beta 4VEit + \beta 5UNMP15\text{-}24it + \\ + \beta 6UNMP55\text{-}74it + u \quad (5)$$

The final variant of the model that we propose is the fixed effects model (so urges the Hausman test) that can be seen in Table no. 5, thus merging the two extremes of the age groups in terms of unemployment into the model.

Table no. 5– Final selected models

Variable	OLS Model	REM Model	FEM Model
HFCE	0.037 (0.034)	0.267 (0.050) ***	0.350 (0.060) ***
Inflation	-0.180 (0.062) ***	-0.131 (0.033) ***	-0.127 (0.033) ***
Part time employment	-0.317 (0.022) ***	-0.141 (0.035) ***	-0.081 (0.044) *
Vulnerable employment	0.217 (0.050) ***	0.238 (0.098) **	0.240 (0.145) *
Unemployment 15-24	0.113 (0.041) ***	0.110 (0.043) **	0.119 (0.046) **
Unemployment 55-74	0.375 (0.108) ***	0.439 (0.103) ***	0.429 (0.111) ***
Constant	16.466 (2.181) ***	-2.301 (3.110)	-8.852 (3.584) **
Adj R	0.742	0.646	0.935
Observations	234	234	234
Hausman test		18.05 (0.0061)	

Notes: Significance levels are *** for 1%, ** for 5% and * for 10%

Source: own elaboration using EViews 12 SV

Hypothesis 1 (In periods when inflation has small increases (such as post-crisis years), citizens' economic insecurity tends to reduce) is confirmed by the presented model, albeit to an extremely small extent since the effect is only -0.127. Inflation can sometimes be synonymous with poverty reduction (Cutler and Katz, 1991; Headey and Hirvonen, 2023),

but only if, we tend to argue, it is sustainable (such as the 2% rate that the European Central Bank is advocating). The same discourse cannot be applied to Hypothesis 3 (Increasing the share of part-time jobs as a share of total jobs in post- crisis periods can increase economic insecurity), considering that the hypothesis is not confirmed (having a low negative correlation of -0.081). Also, the variable part-time jobs have, in the final model, a very low significance (close to the 0.10 cutoff) compared to the other variables. Therefore, we may argue that part-time jobs can be a temporary solution to combat economic insecurity but this very much depends on the household structure (Horemans *et al.*, 2016) and on the voluntary or involuntary characteristic of the part-time job (Horemans *et al.*, 2016). Thus, we reiterate that only in some cases a part-time job can be a solution, when the other option would be the complete lack of the job (Walwei, 1998). Also, considering that the correlation is not a stronger one, we could also relate on the opposite idea, according to which part-time jobs may undermine income's stability, since they involve little or no wage progression, limited or no fringe benefits and little control over work activities or schedules, making them precarious and insecure (Kalleberg, 2011). Moreover, due to these aspects, the households become more vulnerable to external shocks (Kalleberg, 2009).

Hypotheses 2 and 5 are confirmed, taking into account the fact that, indeed, unemployment among the most vulnerable segments of society tends to play a major role in generating economic insecurity (with the mention that we consider the final regression model, in which all independent variables utilized are statistically significant). Both the young persons (due to inexperience) and the elderly ones (due to physical capabilities) tend to have a low resilience in such a case, being prone to longer periods of unemployment (Eichhorst *et al.*, 2013). On the other hand, we observe how more vulnerable jobs may imply a greater predisposition towards economic insecurity. Our results are in line the findings of previous studies that concluded that workers in vulnerable jobs face various challenges, from employment and financial instability to marginal status, which heighten the susceptibility to economic insecurity (Vanroelen *et al.*, 2024) and undermine their well-being (Irvine and Rose, 2022).

Regarding Hypothesis 4, we will reject the Kuznets paradox and consider the Duesenberry (1949) 's relative income theory to be more appropriate for our analysis, as we observe a positive correlation between consumption growth, probably because of the social pressure, and increased economic insecurity (as European citizens tend to diminish savings in this way). As people adjusted their lifestyles upward, they became locked into consumption patterns they could not easily reverse, further deepening the debt dependency. On the other hand, we admit that this analysis could also be explained by Milton Friedman's theory, given that the uncertainty-filled period of the study (2014-2022) was targeted by a negligible volatility of European household incomes.

Since the Hausman test shows that the fixed effects model is preferable to the random effects model, we propose, subsequently, three robustness tests. The first test, presented in Table no. 6, concerns the regional decomposition on the Eurovoc model. The second test, visible in Table no. 7, aims at differentiating countries between those with a very low or low degree of economic insecurity from those with a medium, high or very high degree.

The last test, following the study of Zouita and Mohamed Salah (2021), aims to introduce institutional variables to observe whether there are major changes in the baseline model.

Table no. 6 – Robustness test excluding various EU regions

W/o Western Europe	**OLS Model**	**REM Model**	**FEM Model**
HFCE	0.215 (0.051) ***	0.312 (0.068) ***	0.365 (0.080) ***
Inflation	-0.225 (0.063) ***	-0.167 (0.037) ***	-0.161 (0.038) ***
Part time employment	-0.349 (0.030) ***	-0.233 (0.047) ***	-0.183 (0.060) ***
Vulnerable employment	0.045 (0.055)	0.141 (0.106)	0.205 (0.161)
Unemployment 15-24	0.210 (0.046) ***	0.133 (0.049) ***	0.125 (0.052) **
Unemployment 55-74	0.062 (0.115)	0.375 (0.119) ***	0.405 (0.127) ***
Number of countries	20	20	20
Adj. R-Squared	0.775	0.678	0.930
Hausman Test		7.15 (0.3067)	
W/o Eastern and Central Europe	**OLS Model**	**REM Model**	**FEM Model**
HFCE	0.055 (0.029) *	0.353 (0.040) ***	0.466 (0.048) ***
Inflation	-0.143 (0.062) **	-0.065 (0.029) **	-0.060 (0.030) **
Part time employment	-0.296 (0.025) ***	-0.054 (0.031) *	-0.005 (0.036)
Vulnerable employment	0.551 (0.058) ***	0.303 (0.108) ***	0.121 (0.169)
Unemployment 15-24	-0.036 (0.037)	0.026 (0.037)	0.053 (0.040)
Unemployment 55-74	0.394 (0.101) ***	0.393 (0.084) ***	0.360 (0.090) ***
Number of countries	18	18	18
Adj. R-Squared	0.819	0.695	0.964
Hausman Test		37.06 (0.0000)	
W/o Northern Europe	**OLS Model**	**REM Model**	**FEM Model**
HFCE	0.035 (0.039)	0.249 (0.057) ***	0.307 (0.068) ***
Inflation	-0.200 (0.085) **	-0.138 (0.044) ***	-0.131 (0.044) ***
Part time employment	-0.297 (0.027) ***	-0.091 (0.041) **	-0.034 (0.049)
Vulnerable employment	0.170 (0.058) ***	0.192 (0.114) *	0.169 (0.154)
Unemployment 15-24	0.134 (0.051) **	0.146 (0.050) ***	0.159 (0.053) ***
Unemployment 55-74	0.349 (0.130) ***	0.400 (0.115) ***	0.369 (0.122) ***
Number of countries	20	20	20
Adj. R-Squared	0.709	0.657	0.933
Hausman Test		12.51 (0.0514)	
W/o Southern Europe	**OLS Model**	**REM Model**	**FEM Model**
HFCE	-0.073 (0.038) *	0.203 (0.059) ***	0.293 (0.073) ***
Inflation	-0.134 (0.065) **	-0.111 (0.037) ***	-0.110 (0.037) ***
Part time employment	-0.357 (0.023) ***	-0.169 (0.039) ***	-0.116 (0.054) **
Vulnerable employment	0.146 (0.057) **	0.370 (0.113) ***	0.511 (0.171) ***
Unemployment 15-24	0.153 (0.050) ***	0.099 (0.056) *	0.076 (0.061)
Unemployment 55-74	0.550 (0.164) ***	0.725 (0.154) ***	0.735 (0.166) ***
Number of countries	20	20	20
Adj. R-Squared	0.738	0.630	0.923
Hausman Test		17.39 (0.0079)	

Notes: Significance levels are *** for 1%, ** for 5% and * for 10%

Source: own elaboration using EViews 12 SV

Following the robustness test carried out on regional premises, we can note several interesting aspects. First of all, the effect of the independent variables remains unchanged regardless of the excluded region, which confirms the robustness of the model. Secondly, we observe how excluding from Central and Eastern Europe countries the share of part-time jobs

becomes almost insignificant (only -0.005), showing how relevant such jobs are in this part of Europe. It can even be argued that, in order to increase the economic security, they have now become more relevant in Central and Eastern Europe than in Northern Europe, as they were originally (Smith *et al.*, 1998), although the exclusion of Northern European countries also has a significant impact on the role of part-time jobs. Moreover, inflation seems to be quasi-irrelevant, if we exclude Central and Eastern Europe, since, in the short run, it led to an increase in consumption and, thus, in the economic growth. However, the short-term positive effects of inflation in these contexts may hide deeper distributional dynamics, especially if we consider the Cantillon (1931) effect, according to which inflation disproportionately advantages the early recipients of new money. Moreover, limiting our analysis to consumer price indices overlooks parallel trends in asset price inflation, debt accumulation and relative income pressures, all of which contribute to increased economic insecurity, despite the illusion of prosperity. We can also note how unemployment among the 55-74 age group obtains a relatively higher correlation if the Southern European countries are excluded, emphasizing how, for the other age groups, it plays a greater role in the link between unemployment and economic security (perhaps even the 15-24 category, given that excluding Southern Europe it remains with a correlation of only 0.076). Also, excluding the Mediterranean area, Vulnerable employment reaches 0.511, demonstrating that job vulnerability does not play a major role in economic insecurity in that region.

On the other hand, excluding Western Europe, the results remain almost unchanged, showing how these countries follow, more or less, the same trend. Next, in Table no. 7, we proceed with the differentiation based on the economic insecurity.

Table no. 7 – Robustness test based on economic insecurity levels

W/o Low E.I. countries	**OLS Model**	**REM Model**	**FEM Model**
HFCE	0.239 (0.111) **	0.240 (0.181)	0.256 (0.196)
Inflation	-0.391 (0.116) ***	-0.232 (0.081) ***	-0.222 (0.082) ***
Part time employment	-0.179 (0.061) ***	-0.240 (0.109) **	-0.216 (0.125) *
Vulnerable employment	0.124 (0.101)	0.115 (0.199)	0.109 (0.256)
Unemployment 15-24	0.201 (0.108) *	0.136 (0.108)	0.133 (0.111)
Unemployment 55-74	-0.294 (0.247)	0.317 (0.268)	0.357 (0.277)
Number of countries	8	8	8
Adj. R-Squared	0.514	0.602	0.799
Hausman Test		2.06 (0.9134)	
W/o Medium-High E.I. countries	**OLS Model**	**REM Model**	**FEM Model**
HFCE	-0.032 (0.026)	0.218 (0.040) ***	0.350 (0.052) ***
Inflation	-0.110 (0.053) **	-0.089 (0.031) ***	-0.084 (0.031) ***
Part time employment	-0.232 (0.020) ***	-0.076 (0.030) **	-0.052 (0.039)
Vulnerable employment	0.248 (0.056) ***	0.424 (0.117) ***	0.575 (0.202) ***
Unemployment 15-24	0.073 (0.032) **	0.086 (0.038) **	0.097 (0.044) **
Unemployment 55-74	0.653 (0.111) ***	0.574 (0.097) ***	0.487 (0.105) ***
Number of countries	18	18	18
Adj. R-Squared	0.690	0.650	0.908
Hausman Test		33.88 (0.0000)	

Notes: Significance levels are *** for 1%, ** for 5% and * for 10%

Source: own elaboration using EViews 12 SV

Differentiation by economic insecurity scores (Pricop and Diaconu (Maxim), 2025) also yields interesting results. Excluding countries with a medium or high degree of economic insecurity (Latvia, Bulgaria, Croatia, Croatia, Hungary, Cyprus, Spain, Romania and Greece), we observe how part-time jobs and inflation lose importance, showing how they are a good antidote to increasing economic insecurity for countries in distress (we reiterate that we are talking about sustainable inflation, synonymous with a period of economic growth). Vulnerable employment and unemployment 55-74 also increase if countries with a higher degree of economic insecurity are removed from the model, demonstrating how such variables have a greater impact in countries where households enjoy more security.

Table no. 8 – Robustness test with institutional variables

Variable	OLS Model	REM Model	FEM Model
HFCE	0.033 (0.033)	0.288 (0.048) ***	0.409 (0.062) ***
Inflation	-0.200 (0.058) ***	-0.126 (0.032) ***	-0.122 (0.032) ***
Part time employment	-0.161 (0.037) ***	-0.110 (0.038) ***	-0.067 (0.043)
Vulnerable employment	0.203 (0.054) ***	0.224 (0.099) **	0.440 (0.148) ***
Unemployment 15-24	0.047 (0.045)	0.113 (0.041) ***	0.114 (0.045) **
Unemployment 55-74	0.521 (0.114) ***	0.471 (0.100) ***	0.417 (0.106) ***
Control of corruption	1.620 (0.970) *	-1.333 (0.938)	-1.639 (1.028)
Government effectiveness	0.495 (1.504)	-0.648 (1.040)	-1.089 (1.115)
Regulatory quality	0.478 (1.175)	1.219 (0.996)	0.871 (1.050)
Rule of Law	-3.396 (1.444) **	-3.342 (1.227) ***	-4.417 (1.392) ***
Voice and accountability	-5.352 (1.847) ***	6.261 (1.673) ***	10.558 (1.888) ***
Constant	18.875 (2.404) ***	-7.158 (3.267) **	-19.617 (3.837) ***
Adj R	0.777	0.665	0.944
Observations	234	234	234
Hausman test		43.38 (0.0000)	

Notes: Significance levels are *** for 1%, ** for 5% and * for 10%

Source: own elaboration using EViews 12 SV

We consider the introduction of institutional variables necessary to test the robustness of the basic model and, moreover, to capture the relationship between the quality of institutions and the economic sector, which are often closely correlated. Broadly speaking, the model remains stable, but we can also note two new significant correlations: a negative one with Rule of Law, which shows us exactly how poverty can be fought by transparent and functional legal frameworks (Dessie, 2014; Chirwa *et al.*, 2020), and another one with extremely positive with Voice and Accountability, which leads us to believe that citizens tend to be much more vocal in times of economic insecurity, through protests and such other manifestations (Kriesi *et al.*, 2020).

Previous robustness tests confirm the main model, with small variations in the impact that some variables have.

5. CONCLUSIONS

The analysis carried out in this research was focused on, two major dimensions of the economic insecurity: *Lack of savings and leisure time* and *Household's predisposition to risk*. These two dimensions were chosen because they capture both the material and psychological aspects of insecurity: chronic time and financial constraints together with a deeper structural

pressures rather than personal choice. Therefore, these tow variables reveal not only the immediate vulnerabilities, but also the long-term exposure to instability, making them relevant for understanding how households experience and adapt to economic uncertainty.

We considered the index to be both comprehensive and relevant and, thus, we proceeded with the testing of various independent variables, including Inflation, Household final consumption expenditure, Part time employment, Vulnerable employment and Unemployment divided into various age categories (15-24, 25-54 and 55-74). The result of the statistical analysis, which involved OLS, Random Effects and Fixed Effects regressions and had a total of 234 observations (26 countries and 9 years), proposed a model with six variables. The statistical results allowed us to confirm three of the five hypotheses developed based on the literature review (the other two being only partially confirmed).

First of all, we observed how a slight increase in inflation (which, sometimes, as it was in our case, can be synonymous with periods of post-crisis economic growth) can lead to a decrease in economic insecurity (recall that among the index's variables we also find a negative correlation with children in jobless households, which could also imply financial contributions from the state). The hypothesis that is not confirmed is the third one (regarding part-time jobs), as the correlation is showing the opposite (even not being a strong one). On the other hand, the variables with a stronger correlation are Household final consumption expenditure (since we have argued that the consumption-saving dichotomy is still a relevant one) or Vulnerable employment, since it is self-evident that job vulnerability restricts the horizons of economic security. Hypothesis 2 is confirmed, underlying that the more vulnerable segments of the society (the young and the elderly persons), once unemployed, would have lower resilience, which would force them to remain in this state, thus causing an increase in the economic insecurity.

Subsequently, we undertook a regional and then economic decomposition to test the robustness of the model. In both cases, the model proved to be robust, with small differences. As for the differentiation between low/high economic insecurity countries, we can say that the model retains its significance especially among the low economic insecurity countries, and vulnerable employment increases its correlation in this case. On the other hand, the addition of the institutional variables does not lead to a change in the correlations of the model, but adds two new correlations, a negative one with the rule of law and a positive one with voice and accountability.

In conclusion, we can state that the presented model, validated by the robustness tests, comprehensively explains the phenomenon of the economic insecurity, showing how inflation, household consumption and various labour market dynamics play an essential role in shaping it. We also state how both the used index and the regression models can be improved.

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The Interplay of Entrepreneurship, Investment, Credit, and Market Capitalization in Shaping Sustainable Economic Growth: An ARDL Approach for the United States

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Abstract: This study explores the interplay between entrepreneurship, foreign direct investment (FDI), domestic credit, and market capitalization in driving sustainable economic growth in the United States from 2001 to 2023. It aims to provide valuable insights for policymakers to understand how these factors collectively influence economic performance. The study employs an Autoregressive Distributed Lag (ARDL) model to analyze the long- and short-term relationships between the variables. An error correction model (ECM) is also used to investigate the speed of adjustment towards long-run equilibrium. Data for the analysis covering key economic indicators such as GDP, early-stage entrepreneurial activity, FDI, credit, and market capitalization. The results indicate that entrepreneurship (TEA) has a consistently positive impact on economic growth across all lags. FDI shows a positive effect in the current period, though its lagged effects are weaker. Domestic credit to the private sector, while significant, has a negative short-term effect on GDP growth, suggesting that credit allocation inefficiencies may hinder growth. Market capitalization exhibits a strong positive effect, underlining the importance of well-developed financial markets for economic expansion. The error correction model suggests that adjustments towards long-term equilibrium are slow, highlighting areas for policy intervention. This paper contributes to the understanding of how key economic factors interact to influence sustainable growth, particularly by emphasizing the role of entrepreneurship and market capitalization. The findings are relevant for policymakers seeking to foster long-term economic growth in the U.S., as well as for future research on economic development dynamics.

Keywords: entrepreneurship; foreign direct investment; domestic credit; market capitalization; economic growth; U.S. economy; ARDL model; error correction model.

JEL classification: O16; O11; G20; F21; E44.

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1. INTRODUCTION

Sustainable economic growth is a primary objective for policymakers worldwide, particularly in developed economies like the United States, where economic stability is foundational for long-term prosperity. The search for the determinants of economic growth has led researchers to focus on a variety of factors, including entrepreneurship, foreign direct investment, domestic credit, and market capitalization. While these factors have been extensively studied in isolation, their combined and dynamic interactions on economic growth, especially over both short and long horizons, have received limited empirical attention, particularly within the U.S. context. This study addresses this research gap by integrating these four dimensions into a unified econometric framework, providing a more comprehensive perspective on their roles in shaping sustainable economic growth.

Entrepreneurship is widely recognized as a vital driver of economic dynamism. Schumpeter's (2021) theory of "creative destruction" underlines the transformative role of entrepreneurship in fostering innovation, technological advancements, and competition, which in turn stimulate economic growth. In recent years, the focus has expanded to encompass the importance of early-stage entrepreneurial activity (TEA) as an indicator of an economy's ability to innovate and adapt (Bosma *et al.*, 2023). Research has shown that entrepreneurship is not only a catalyst for new product markets but also contributes to job creation, wealth accumulation, and the development of a resilient economy (Audretsch and Thurik, 2003). However, the precise relationship between entrepreneurial activity and growth is nuanced, as it depends on factors such as access to finance, market conditions, and regulatory environments (Urbano *et al.*, 2019). Understanding how TEA influences sustainable growth, especially in the context of the U.S. economy, is crucial for fostering a vibrant entrepreneurial ecosystem.

Foreign Direct Investment is another significant contributor to economic growth. FDI facilitates the flow of capital, technology, and expertise across borders, and has been found to positively influence productivity and economic growth (Borensztein *et al.*, 1998; Alfaro *et al.*, 2004). The relationship between FDI and growth, however, is conditional on the host country's absorptive capacity, which includes factors such as human capital, institutional quality, and financial market development (UNCTAD, 2023). In the United States, FDI plays a crucial role in enhancing global competitiveness by integrating the U.S. economy into international supply chains and driving technological advancements. Nevertheless, the impact of FDI on long-term economic growth remains an area of debate, as some studies suggest diminishing returns over time or highlight the importance of strategic policy frameworks to ensure that FDI translates into sustainable growth (OECD, 2023). Comparative studies have shown that the effectiveness of FDI in stimulating economic growth depends on complementary macroeconomic policies and structural factors (Abid, 2025a).

Domestic credit to the private sector and market capitalization are essential pillars of a robust financial system, which plays a key role in economic development. Credit availability supports investment in productive sectors, fosters innovation, and enhances consumption capacity, all of which contribute to economic growth (Beck *et al.*, 2000). However, an excessive accumulation of credit can lead to financial instability and misallocation of resources, as observed during financial crises (Cecchetti and Kharroubi, 2012). Therefore, understanding the balance between credit expansion and economic stability is crucial for fostering sustainable growth. In this regard, recent empirical work underscores the dual nature of credit's impact,

showing short-run negative effects due to inefficiencies and long-run benefits through enhanced capital formation (Abid, 2025b). Similarly, market capitalization, as a measure of financial market development, provides an important signal of economic health and resilience. Well-functioning financial markets facilitate the efficient allocation of capital, support entrepreneurial ventures, and enhance investor confidence (Pagano, 1993; Levine and Zervos, 1998). The deepening of U.S. capital markets has been linked to higher levels of economic growth and a more diversified financial ecosystem, making it a vital factor in the broader economic landscape. Studies in similar economic contexts have highlighted the importance of capital market deepening for sustainable growth outcomes (Chaabouni and Abid, 2025).

This paper aims to investigate the interplay between entrepreneurship, FDI, domestic credit, and market capitalization in shaping sustainable economic growth in the United States between 2001 and 2023. This study is unique in its integrated approach, assessing both individual and joint effects of these variables through a unified model. By employing an autoregressive distributed lag (ARDL) model and an error correction model (ECM), this study examines the short- and long-term effects of these variables on GDP. The ARDL model is particularly suitable for this analysis because it accommodates variables with mixed levels of integration (I(0) and I(1)), allows for a small sample size, and provides robust estimates of both long-run equilibrium and short-run dynamics (Pesaran *et al.*, 2001). The analysis provides a comprehensive view of these factors over the past two decades. In doing so, it contributes to the existing literature by addressing the multidimensional nature of economic growth drivers and demonstrating the relevance of a combined macro-financial and entrepreneurial framework in understanding growth trajectories in the U.S.

The remainder of this paper is structured as follows: Section 2 reviews existing literature on entrepreneurship, foreign direct investment, domestic credit, and market capitalization, emphasizing their individual and combined roles in sustainable economic growth. Section 3 outlines the methodology, describing the data, model specifications. Section 4 presents the results of the empirical analysis. Section 5 discusses the findings in the context of U.S. economic growth. Finally, Section 6 concludes the paper, summarizing key findings and offering policy recommendations for fostering sustainable growth.

2. LITERATURE REVIEW

The interplay of entrepreneurship, foreign direct investment (FDI), domestic credit, and market capitalization in driving sustainable economic growth has been extensively examined in the economic literature. This section synthesizes relevant studies to provide a robust theoretical foundation.

2.1 Entrepreneurship and Economic Growth

Entrepreneurship is widely recognized as a critical driver of economic growth through its role in fostering innovation, employment creation, and economic diversification. Schumpeter's (2021) theory of "creative destruction" remains a cornerstone, emphasizing that entrepreneurial ventures disrupt inefficient systems, driving productivity improvements and technological advancements.

Following Schumpeter, numerous scholars in the mid-to-late 20th century expanded the theoretical foundations of entrepreneurship and its macroeconomic relevance. Kirzner (1973)

introduced the concept of the "alert entrepreneur," emphasizing the role of opportunity recognition and arbitrage in market processes. Baumol (1990) later distinguished between productive and unproductive entrepreneurship, arguing that the institutional environment determines whether entrepreneurial activity contributes to or detracts from economic growth. These theoretical advancements underscored the importance of regulatory and institutional quality in channeling entrepreneurship toward productive outcomes.

In the 1990s and early 2000s, empirical studies began to validate these theories using cross-country data. Wennekers and Thurik (1999) highlighted the dual role of entrepreneurship in promoting innovation and employment while noting its dependence on broader economic structures. Carree and Thurik (2003) provided econometric evidence that shifts in entrepreneurial activity correlate strongly with GDP growth in both developed and developing economies, especially during periods of structural change.

Recent empirical studies have built upon this framework. For instance, Acs *et al.* (2013) demonstrate that entrepreneurial ecosystems significantly contribute to GDP growth by fostering innovation and addressing market failures. Similarly, Bosma *et al.* (2023) highlight the crucial role of Total Early-stage Entrepreneurial Activity (TEA) in enhancing long-term economic performance, particularly in high-income economies like the United States. Audretsch and Thurik (2003) expand on these findings, showing that entrepreneurship is a key determinant of knowledge-based growth, where small and medium-sized enterprises (SMEs) play a pivotal role in accelerating technological innovation. Furthermore, Urbano *et al.* (2019) argue that entrepreneurship positively impacts social and economic resilience, enabling economies to adapt to structural changes. Recent regional studies employing the ARDL framework confirm the significance of entrepreneurial activity in promoting sustained economic expansion (Abid, 2025c).

2.2 Foreign Direct Investment

FDI is a major channel for technology transfer, capital inflows, and market integration. Its impact on growth, however, is contingent on the host country's absorptive capacity. Borensztein *et al.* (1998) argue that FDI significantly boosts growth only when accompanied by adequate human capital and robust institutions. Alfaro *et al.* (2004) expand on this, highlighting that the presence of well-functioning financial markets is critical for translating FDI into productivity gains.

In addition, UNCTAD (2023) emphasizes the importance of targeted policies to maximize FDI spillovers, such as workforce development programs and infrastructure investments. OECD (2023) notes that countries with effective FDI strategies experience greater integration into global value chains, enhancing competitiveness. In the United States, the immediate positive effects of FDI on GDP growth align with these findings, though diminishing long-term impacts suggest potential inefficiencies in leveraging FDI for sustained economic benefits.

2.3 Domestic Credit and Financial Development

The role of domestic credit in economic growth is complex. While financial intermediation enables investment and innovation, excessive credit growth can lead to inefficiencies and financial instability. Beck *et al.* (2000) find that while credit supports

medium-term growth, its short-term effects are often negative due to over-leveraging or misallocation of resources. Cecchetti and Kharroubi (2019) similarly caution that financial sector overexpansion can hinder growth by diverting resources from productive sectors.

Rajan and Zingales (2001) underscore the importance of effective financial regulation to ensure that credit is allocated economically productive activities. In developed economies like the United States, the dual impact of domestic credit, supporting economic expansion while fostering financial vulnerabilities, reflects the need for balanced financial policies to mitigate risks.

2.4 Market Capitalization and Financial Markets

Market capitalization, a key indicator of financial market development, plays a pivotal role in economic growth by enabling efficient capital allocation, risk management, and investor confidence. Levine and Zervos (1998) provide evidence that well-functioning stock markets significantly enhance GDP growth by improving liquidity and facilitating long-term investments. Pagano (1993) similarly highlights that deep and liquid financial markets channel resources into high-growth industries, fostering innovation.

In the U.S. context, market capitalization's strong positive relationship with GDP growth aligns with the findings of Demirgüç-Kunt and Levine (2001), who emphasize that developed financial markets enhance resilience and innovation capacity. Further, Bencivenga and Smith (1991) argue that market development mitigates financing constraints for entrepreneurial ventures, supporting sustainable economic performance.

While individual contributions of entrepreneurship, FDI, credit, and financial markets to economic growth are well-documented, their combined effects remain underexplored, particularly in developed economies like the United States. Furthermore, the role of structural factors, such as regulatory frameworks and innovation systems, in mediating these relationships requires further investigation. The present study addresses these gaps by integrating these variables into a unified empirical framework, offering new insights into their dynamic relationships.

2.5 Hypotheses Development

Based on the preceding review of literature and theoretical underpinnings, we propose the following hypotheses to guide the empirical analysis:

H1*: Entrepreneurship, as measured by Total Early-stage Entrepreneurial Activity (TEA), has a positive and significant impact on sustainable economic growth in the United States.*

H2*: Foreign Direct Investment (FDI) positively influences sustainable economic growth, although its effect may vary depending on the absorptive capacity of the U.S. economy.*

H3*: Domestic credit to the private sector has a non-linear effect on economic growth, positively contributing to the long term but potentially showing negative short-term effects due to resource misallocation or financial instability.*

H4*: Market capitalization, as an indicator of financial market development, has a positive and significant relationship with sustainable economic growth.*

3. METHODOLOGY

The use of autoregressive distributed lag (ARDL) and error correction models (ECM) in economic analysis provides insights into short- and long-term relationships between variables. Pesaran *et al.* (2001) advocate for ARDL models due to their ability to handle variables with different integration orders, making them particularly useful for macroeconomic studies. Bahmani-Oskooee and Brooks (1999) emphasize the importance of ECM terms in understanding the speed of adjustment toward long-term equilibrium, a key metric for assessing policy effectiveness. Studies applying these methods, such as Asteriou and Hall (2016), highlight their utility in exploring complex relationships among financial and economic variables.

The current study contributes to these growing empirical studies by applying these models to understand the interplay between entrepreneurship, foreign direct investment, domestic credit, market capitalization, and sustainable economic growth in the United States over the period 2001–2023.

The analysis uses two main econometric approaches: the Autoregressive Distributed Lag (ARDL) model and the Error Correction Model (ECM). These methods are chosen for their suitability in capturing both short- and long-term dynamics between variables, particularly in the presence of potential non-stationary time series data.

The methodology follows a structured approach, combining descriptive data exploration, econometric modelling, and robustness checks.

3.1 Data Sources and Variables

This study explores the interconnections between entrepreneurship, foreign direct investment, domestic credit, and market capitalization in driving sustainable economic growth in the United States from 2001 to 2023. The data for the analysis are sourced from the Global Entrepreneurship Monitor (GEM) Adult Population Survey and the World Bank Database. Key variables include:

- DP (constant 2015 US$): Used to measure economic growth (denoted as GDPC).
- Total Early-stage Entrepreneurial Activity (TEA): A measure of entrepreneurial activity within the economy.
- Foreign Direct Investment (FDI): Measured as the net inflows of FDI as a percentage of GDP.
- Domestic Credit to Private Sector (CRE): Measured as domestic credit extended to the private sector as a percentage of GDP.
- Market Capitalization (CAP): Measured as the market capitalization of listed domestic companies as a percentage of GDP.

Table no. 1 below presents the key variables; their descriptions and sources of data covered in the analysis.

Table no. 1 – Summary of Variables, Descriptions, Sources, and Coverage

Variable	Description	Source
GDPC	GDP per capita (constant 2015 US$)	World Bank
TEA	Total Early-stage Entrepreneurial Activity	GEM APS
FDI	Foreign Direct Investment (% of GDP)	World Bank
CRE	Domestic Credit to Private Sector (% of GDP)	World Bank
CAP	Market Capitalization (% of GDP)	World Bank

The descriptive statistics for the selected variables are presented in Table no. 2. This table summarizes key statistical measures such as the mean, standard deviation, minimum, maximum. These statistics offer valuable insights into the characteristics of the dataset before performing more advanced econometric analyses.

Table no. 2 – Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
GDPC	22	30.4705	0.1193	30.2619	30.6721
TEA	23	2.5162	0.2294	2.0268	2.9544
FDI	23	0.4424	0.3554	-0.4419	1.0280
CRE	23	5.2350	0.0715	5.0901	5.3987
CAP	22	4.8976	0.2204	4.3627	5.3267

The descriptive statistics for the variables GDPC, TEA, FDI, CRE, and CAP reveal various patterns. GDPC (GDP in constant 2015 US$) has minimal variation, and a very small standard deviation, indicating a stable GDP over the period. TEA (Total early-stage Entrepreneurial Activity) shows moderate variation, with a mean of 2.5162. FDI (Foreign Direct Investment as a percentage of GDP) exhibits significant fluctuation, with a mean of 0.4424. CRE (Domestic credit to the private sector as a percentage of GDP) is quite stable, with a low standard deviation. CAP (Market capitalization of listed domestic companies as a percentage of GDP) shows some variation. Overall, the data suggests that GDPC and CRE are relatively stable, while FDI and TEA show more variation, indicating greater economic fluctuation in those areas.

3.2 Autoregressive Distributed Lag (ARDL) Model

The ARDL model for the dependent variable (GDPC) and independent variables (TEA, FDI, CRE, and CAP is specified as:

$$\Delta GDPC_t = \alpha_0 + \sum_{i=1}^{p} \beta_i \, \Delta GDPC_{t-i} + \sum_{j=0}^{q} \gamma_j \, \Delta TEA_{t-j} + \sum_{k=0}^{r} \delta_k \, \Delta FDI_{t-k} + \sum_{l=0}^{s} \theta_l \, \Delta CRE_{t-l} + \sum_{m=0}^{t} \varphi_m \, \Delta CAP_{t-m} + \epsilon_t \quad (1)$$

where Δ denotes the first difference of the variables, and ϵt is the error term. The number of lags (p, q, r, s, t) is determined by the Akaike Information Criterion (AIC) or Bayesian Information Criterion (BIC) (Akaike, 1974; Schwarz, 1978). This method is preferred because it can effectively handle both short- and long-run dynamics in a single framework (Pesaran *et al.*, 2001).

3.3 Error Correction Model (ECM)

To examine the speed of adjustment towards long-run equilibrium, an Error Correction Model (ECM) is estimated. The ECM is derived from the ARDL model and is used to capture short-run dynamics and the speed at which the system returns to equilibrium after a shock. The ECM equation is given by:

$$\Delta GDPC_t = \alpha_0 + \sum_{i=1}^{p} \beta_i \, \Delta GDPC_{t-i} + \sum_{j=0}^{q} \gamma_j \, \Delta TEA_{t-j} + \sum_{k=0}^{r} \delta_k \, \Delta FDI_{t-k} + \sum_{l=0}^{s} \theta_l \, \Delta CRE_{t-l} + \sum_{m=0}^{t} \varphi_m \, \Delta CAP_{t-m} + \lambda EC_{t-1} + \epsilon_t \quad (1)$$

where EC_{t-1} is the error correction term derived from the long-run equilibrium relationship. The coefficient λ represents the speed of adjustment toward equilibrium. A negative and statistically significant λ indicates that the system corrects back to the long-run equilibrium (Engle and Granger, 1987; Johansen, 1988).

3.4 Model Diagnostics and Testing

To ensure the robustness and reliability of the analysis, several diagnostic tests are conducted. Unit root tests, such as the Augmented Dickey-Fuller (ADF) test, are employed to examine the stationarity of variables, as the ARDL approach accommodates variables integrated of order zero (I(0)) or one (I(1)), but not of order two (I(2)) (Dickey and Fuller, 1979).

The presence of a long-run relationship among the variables is assessed through the bounds testing procedure within the ARDL framework, which confirms cointegration if the calculated F-statistic exceeds critical values (Pesaran *et al.*, 2001).

The application of diagnostic tests such as the Breusch-Pagan and White tests is essential in validating regression results by detecting potential heteroskedasticity, which represents a violation of the assumption of constant error variance (Breusch and Pagan, 1979; White, 1980). Addressing heteroskedasticity ensures more reliable and efficient parameter estimates. Similarly, the Durbin-Watson test is employed to detect autocorrelation in the residuals, thus verifying the independence of error terms, a crucial assumption in linear regression (Durbin and Watson, 1950). These tests collectively enhance the robustness and reliability of the model's estimates by addressing violations of key econometric assumptions. Additionally, the Shapiro-Wilk test is applied to assess the normality of the residuals. This test determines whether the residuals deviate significantly from a normal distribution. A p-value greater than 0.05 suggests that the residuals follow a normal distribution, meeting one of the fundamental assumptions required for valid statistical inference in regression analysis (Shapiro and Wilk, 1965). Together, these diagnostic tests reinforce the robustness of the regression model and the reliability of its conclusions. Lastly, model stability is evaluated using the CUSUM and CUSUMSQ tests, which detect parameter constancy over time, ensuring the reliability of the estimated relationships (Brown *et al.*, 1975).

The ARDL and ECM models are estimated with optimal lag lengths chosen based on the AIC and BIC criteria.

This methodology allows for a comprehensive examination of the impact of entrepreneurship, FDI, credit, and market capitalization on economic growth, both in the short

and long run. By using ARDL and ECM models, the study addresses the complexities of dynamic interactions and provides insights into policy interventions aimed at fostering sustainable economic growth.

4. RESULTS

To examine the relationships between the variables in this study, we present the correlation matrix for GDP (GDPC), Total Early-stage Entrepreneurial Activity (TEA), Foreign Direct Investment (FDI), Domestic Credit to the Private Sector (CRE), and Market Capitalization (CAP) in Table no. 3.

Table no. 3 – Correlation matrix

Variable	GDPC	TEA	FDI	CRE	CAP
GDPC	1.0000				
TEA	0.7201	1.0000			
FDI	0.1022	-0.1702	1.0000		
CRE	0.5993	0.3132	0.0522	1.0000	
CAP	0.6350	0.6283	-0.0897	0.6891	1.0000

The correlation analysis for the variables GDPC, TEA, FDI, CRE, and CAP reveals several relationships. GDPC exhibits a strong positive correlation with TEA and moderate positive correlations with CRE and CAP. This suggests that as GDP per capita increases, early-stage entrepreneurial activity, domestic credit to the private sector, and market capitalization of listed companies tend to rise as well. TEA is moderately positively correlated with CAP and shows a weaker relationship with CRE. FDI shows very weak correlations with all the other variables, indicating limited or no significant relationship with GDPC, TEA, CRE, and CAP. Finally, CRE is moderately correlated with CAP, suggesting that credit to the private sector is somewhat related to the market capitalization of domestic companies. Overall, GDPC, TEA, CRE, and CAP are positively correlated, while FDI shows weak associations with the other variables.

The results of the Dickey-Fuller unit root tests for the variables GDPC, TEA, FDI, CRE, and CAP are summarized in Table no. 4. This test allows to assess the stationarity of the data.

Table no. 4 – Dickey-Fuller test results

Variable	Test Statistic	Variable	Test Statistic
GDPC	-0.5190	DGDPC	-4.8720***
TEA	-1.6870	DTEA	-5.0120***
FDI	-4.1410***	DFDI	-7.6770***
CRE	-2.3480	DCRE	-4.7590***
CAP	-2.0670	DCAP	-5.4700***

Note: *** implies the significance at 1% level

The Dickey-Fuller tests reveal that FDI is stationary, while GDPC, TEA, CRE, and CAP are non-stationary with p-values greater than 0.05. Non-stationary series will require differencing or transformation to ensure stationarity for further analysis. The Dickey-Fuller test results for the first-differenced variables indicate that all series are now stationary.

When selecting the appropriate lag length for an Autoregressive Distributed Lag (ARDL) model, both AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion) are commonly used to evaluate model fit (Table no. 5).

Table no. 5 – Model selection

Model	Lag	AIC	BIC
Model 1	1	-120.7317	-110.7744
Model 2	2	-167.3856	-153.2190

Model 2 is the more appropriate choice due to its better fit, as indicated by the lower AIC and BIC values compared to Model 1. The inclusion of multiple lags in Model 2 allows for capturing more temporal dynamics, making it more suitable for analyzing the relationships between the variables.

The estimation results of the ARDL model are presented in Table no. 6. This table displays the coefficients and statistical significance of the various variables included in the model, as well as the lag structure of the variables.

Table no. 6 – ARDL regression model

Variable	Coefficient	Std. Err.	t-Statistic	p-value	95% Confidence Interval
DGDPC					
L1	-0.1045	0.1639	-0.6400	0.5590	[-0.5596, 0.3507]
L2	0.6735***	0.1286	5.2400	0.0060	[0.3166, 1.0304]
DTEA					
No Lag	0.0662***	0.0073	9.1000	0.0010	[0.0460, 0.0863]
L1	0.0478***	0.0076	6.3200	0.0030	[0.0268, 0.0688]
L2	0.0411***	0.0065	6.2900	0.0030	[0.0230, 0.0592]
FDI					
No Lag	0.0130***	0.0027	4.7500	0.0090	[0.0054, 0.0206]
L1	-0.0005	0.0040	-0.1100	0.9160	[-0.0115, 0.0106]
L2	0.0081*	0.0032	2.5600	0.0630	[-0.0007, 0.0169]
DCRE					
No Lag	-0.1882***	0.0257	-7.3100	0.0020	[-0.2596, -0.1167]
L1	-0.3767***	0.0702	-5.3700	0.0060	[-0.5715, -0.1819]
L2	-0.1294**	0.0413	-3.1400	0.0350	[-0.2439, -0.0148]
DCAP					
No Lag	0.0979***	0.0095	10.2500	0.0010	[0.0714, 0.1244]
L1	0.1421***	0.0280	5.0700	0.0070	[0.0643, 0.2198]
L2	0.0305	0.0144	2.1100	0.1030	[-0.0096, 0.0706]
Constant	11.8387***	1.1862	9.9800	0.0010	[8.5452, 15.1321]
R-squared		0.8998	Adjusted R-squared		0.8991
F-statistic		1458.3400	p-value		0.0000
Root MSE		0.0029			

Note: ***, **, and * imply the significance at 1%, 5%, and 10% level, respectively

The ARDL regression for the period 2001-2023 shows strong results, indicating that the model explains a significant portion of the variation in GDP. The F-statistic of 1458.34 with a p-value of 0.0000 suggests that the overall model is highly significant. The R-squared value of 0.8998 indicates that the model explains 99.98% of the variance in the dependent variable,

with an adjusted R-squared of 0.8991 indicating a good fit even after accounting for the number of predictors.

In terms of individual variables, the second lag of DGDPC (L2) is statistically significant, while the first lag (L1) is not. Total Early-stage Entrepreneurial Activity is highly significant, with all lags (no lag, L1, and L2) contributing positively to DGDPC. Foreign Direct Investment shows a positive effect for the current period, but the first lag is insignificant, and the second lag is marginally significant. Domestic Credit to the Private Sector is significant across all lags, suggesting that changes in credit have a strong influence on economic growth. Similarly, Market Capitalization shows significant effects for the current period and the first lag, though the second lag is marginally significant.

The constant term is highly significant, confirming a strong baseline effect. The model's low Root MSE of 0.0029 and the significant t-statistics across many variables suggest that the ARDL model provides a robust explanation of DGDPC.

The tests for autocorrelation and heteroskedasticity suggest that the model meets the necessary assumptions for reliable inference. The autocorrelation test, with a p-value of 0.1357, indicates that there is no significant evidence of autocorrelation in the residuals, meaning that the residuals are independent of each other. This satisfies the assumption of no serial correlation in the errors. Additionally, both tests for heteroskedasticity, White's test and the Breusch-Pagan test (Breusch, 1978), yield p-values of 0.3253 and 0.3199, respectively, which are greater than the common significance threshold of 0.05. This means that we fail to reject the null hypothesis of homoskedasticity, indicating that the variance of the residuals is constant across observations. Lastly, the Shapiro-Wilk test for normality of the residuals yields a p-value of 0.36327, which is also above the 0.05 threshold. This result suggests that there is no significant evidence to reject the null hypothesis that the residuals are normally distributed. Since normality is crucial for performing hypothesis tests and constructing confidence intervals, this result further supports the model's reliability.

In conclusion, the findings from these diagnostic tests suggest that the model satisfies the assumptions of no autocorrelation, no heteroskedasticity, and normality in the residuals. These results indicate that the model is well-specified and that the statistical inferences drawn from it are likely to be valid.

The ECM regression output provides insights into the short-run dynamics and the adjustment toward long-run equilibrium (Table no. 7).

Table no. 7 – Error Correction Model (ECM) Results

Variable	Coefficient	Std. Error	t-value	p-value	95% Confidence Interval
DTEA	0.0439	0.0978	0.4500	0.6600	[-0.1658, 0.2536]
FDI	0.0057	0.0436	0.1300	0.8990	[-0.0879, 0.0992]
DCRE	-0.9587***	0.2843	-3.3700	0.0050	[-1.5684, -0.3490]
DCAP	0.4145***	0.0734	5.6500	0.0000	[0.2572, 0.5719]
ecm	0.8315	1.7155	0.4800	0.6350	[-2.8479, 4.5110]
Constant	28.4572***	0.3611	78.8200	0.0000	[27.6828, 29.2316]
R-squared		0.7276	Adjusted R-squared		0.6304
F-statistic		7.4800	p-value		0.0013
Root MSE		0.0640			

Note: *** implies the significance at 1% level

The results of the error correction model (ECM) provide valuable insights into the short-run dynamics and the adjustment process toward long-run equilibrium for GDP. The model explains 72.76% of the variation in DGDPC in the short run (R-squared = 0.7276), with an adjusted R-squared of 63.04%, indicating a good fit. The overall model is statistically significant, as demonstrated by the F-statistic (7.48, p = 0.0013).

In terms of short-run impacts, the coefficients for domestic credit and market capitalization are statistically significant, with contrasting effects. Domestic credit negatively influences GDP, suggesting that higher credit availability may not immediately translate into economic growth. Conversely, market capitalization has a strong positive effect, indicating its pivotal role in boosting GDP. However, the short-run impacts of Total Early-stage Entrepreneurial Activity and Foreign Direct Investment are statistically insignificant, suggesting limited immediate effects on GDP.

The error correction term reflects the speed of adjustment toward long-run equilibrium. With a coefficient of 0.8315 and an insignificant p-value, the term fails to confirm a statistically significant adjustment toward equilibrium. This may indicate a weak adjustment dynamic in the model.

We apply the diagnostic tests for autocorrelation and heteroscedasticity to the residuals of the regression. The results in Table no. 8 provide insight into the validity of the regression model by identifying potential issues with these assumptions and confirming the robustness of the model's estimates.

Table no. 8 – Validity of the model

Test	Chi-squared	p-value
Durbin's test for autocorrelation	2.3780	0.1231
Breusch-Pagan / Cook-Weisberg test	0.5100	0.4734

The results from the Durbin's test for autocorrelation and the Breusch-Pagan / Cook-Weisberg test for heteroskedasticity both indicate no significant issues with the model's residuals. For Durbin's test, the chi-squared statistic is 2.378 with a p-value of 0.1231, which is greater than the typical significance level of 0.05. This suggests that there is no significant autocorrelation in the residuals, and the assumption of no serial correlation holds. Similarly, the Breusch-Pagan / Cook-Weisberg test gives a chi-squared statistic of 0.51 with a p-value of 0.4734. Since this p-value is also above 0.05, we fail to reject the null hypothesis of constant variance, meaning there is no evidence of heteroskedasticity in the residuals. Both tests support the validity of the model's assumptions regarding residuals.

Figure no. 1 displays a CUSUM squared plot, which is typically used to test the stability of a regression model's coefficients over time. The plot includes a cumulative sum of squared residuals (CUSUM squared) with bounds of significance.

The CUSUM squared test results indicate that the model is stable over time, as the CUSUM squared line remains within the confidence bands (dashed lines). This suggests that the parameters of the model do not undergo significant structural changes, confirming the stability of the long-run relationship. Stability tests, like the CUSUM squared, ensure the reliability and robustness of the model's estimates by demonstrating that the model's coefficients remain consistent throughout the sample period.

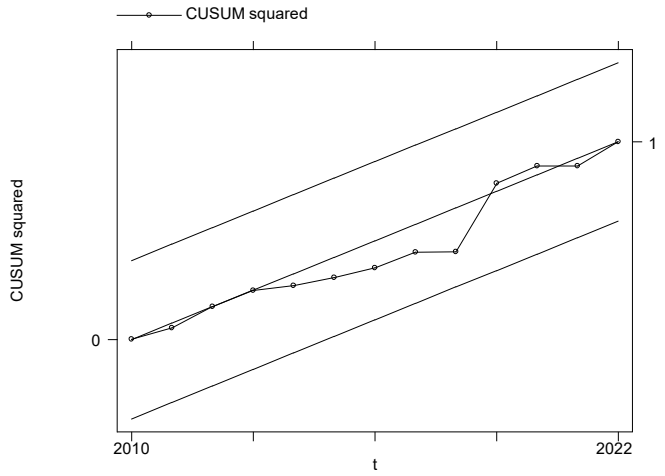

Figure no. 1 – CUSUM of Squares Test for Parameter Stability

5. DISCUSSION

This study examines the relationships among entrepreneurship, foreign direct investment (FDI), domestic credit, and market capitalization in shaping sustainable economic growth in the United States from 2001 to 2023. Using ARDL and ECM approaches, the analysis provides insights into short- and long-run dynamics, offering valuable policy implications. The empirical findings support several of the hypotheses proposed in this study.

H1: Entrepreneurship positively affects sustainable economic growth in both the short and long run. This hypothesis is supported. Entrepreneurship significantly impacts GDP growth in both the short and long run, as evidenced by the positive and significant coefficients across all lags. Total Early-stage Entrepreneurial Activity (TEA) fosters innovation, job creation, and economic diversification, which align with findings from Acs *et al.* (2013), who emphasize the systemic importance of entrepreneurial ecosystems. Similarly, Bosma *et al.* (2023) highlight the crucial role of entrepreneurship in driving sustainable economic growth by addressing gaps in traditional markets and fostering resilience. This conclusion also echoes evidence from East Asia, where technological entrepreneurship and innovation were key to sustaining economic performance across dynamic sectors (Abid, 2025d).

H2: FDI has a positive short-term effect on economic growth but a diminishing impact in the long run. This hypothesis is partially supported. Foreign Direct Investment exhibits immediate positive effects on GDP but shows diminishing significance in the long term. This aligns with Alfaro *et al.* (2004), who argue that the growth impact of FDI is contingent on the maturity of local financial markets. FDI's effectiveness also depends on policies that ensure technology spillovers and integration with local economies, as noted by UNCTAD (2023). Empirical analysis from Saudi Arabia further suggests that FDI-related growth effects are significantly enhanced when accompanied by economic diversification and environmental policy coordination (Abid and Gafsi, 2025).

H3: Domestic credit has a mixed impact, with short-term inefficiencies but potential long-term benefits. This hypothesis is supported. Domestic credit consistently influences

GDP growth, though its short-run negative impact suggests inefficiencies in credit allocation. Excessive credit availability may lead to non-productive investments or financial instability, as supported by Beck *et al.* (2000). Additionally, Cecchetti and Kharroubi (2019) emphasize that financial sector overexpansion can hinder sustainable growth if not aligned with productive economic activities. This is consistent with findings from energy-intensive Gulf economies, where poor credit alignment with productive sectors exacerbated inefficiencies and hindered green transition goals (Abid *et al.*, 2024).

H4: Market capitalization has a positive effect on sustainable economic growth in both the short and long term. This hypothesis is strongly supported. Market capitalization has a strong positive impact on GDP in both the short and long run, reflecting its role in fostering capital formation and investment. This finding is consistent with Levine and Zervos (1998), who highlight the role of stock markets in efficient resource allocation and innovation funding. Moreover, Pagano (1993) stresses the importance of liquidity and investor confidence for long-term economic stability. In addition, cross-country findings emphasize that financial market depth, coupled with technological integration, is essential for supporting resilient and sustainable growth models (Abid, 2025e).

The findings from this study provide several actionable insights for policymakers to foster sustainable economic growth. First, expanding support for entrepreneurship is essential, as it can amplify the long-term benefits of innovation and job creation. Policies should focus on nurturing start-ups and innovation hubs, which can drive new business ventures and stimulate economic dynamism (Audretsch and Thurik, 2003). Additionally, enhancing the spillover effects of foreign direct investment (FDI) requires targeted policies such as workforce development and supply chain integration, ensuring that local businesses and labor markets can fully absorb and benefit from FDI inflows (OECD, 2023). Optimizing credit allocation is another key area; financial oversight reforms are needed to ensure that credit flows to productive sectors, reducing the risks associated with misallocation and financial instability, thus supporting long-term growth (Rajan and Zingales, 2001). Finally, strengthening financial markets is critical to sustaining economic growth. By developing deeper and more liquid markets, the U.S. can improve the resilience of its economy, ensuring that businesses, particularly small and medium-sized enterprises (SMEs), have access to necessary capital while fostering broader economic stability (Bencivenga and Smith, 1991). Together, these recommendations offer a comprehensive framework for enhancing the economic growth trajectory of the U.S. in the years to come.

This study highlights the multidimensional interplay among entrepreneurship, FDI, credit, and market capitalization in driving sustainable economic growth. While entrepreneurship and financial markets emerge as strong drivers, inefficiencies in credit utilization and weak long-term adjustments point to areas for policy intervention. The confirmation of most hypotheses enhances the robustness of the empirical framework used.

6. CONCLUSIONS

This paper has explored the interplay between entrepreneurship, foreign direct investment (FDI), domestic credit, and market capitalization in shaping sustainable economic growth in the United States from 2001 to 2023. The empirical analysis, using an autoregressive distributed lag (ARDL) model and an error correction model (ECM), provides valuable insights into both short- and long-term dynamics.

The results demonstrate that while entrepreneurship, as measured by total early-stage entrepreneurial activity (TEA), has a consistently positive impact on economic growth, its effects are more pronounced in the long run. FDI also plays a positive role, especially in the short term, by facilitating capital inflows, technology transfer, and market expansion. Domestic credit to the private sector shows mixed effects, with its short-term influence being negative, suggesting that excessive credit expansion may not immediately translate into growth. In contrast, market capitalization has a strong positive impact on GDP in both the short and long term, highlighting the importance of robust financial markets in supporting economic growth.

Despite the overall positive influence of these variables, the study suggests that the U.S. economy faces challenges in achieving a balanced growth model that includes sustainable levels of credit and fosters deeper market capitalization. The findings underscore the need for a comprehensive policy approach that supports entrepreneurial activity, attracts FDI, ensures financial stability, and deepens capital markets.

However, several limitations must be acknowledged. First, the study focuses solely on the United States, which may limit the generalizability of the findings to other economic contexts. Second, while the ARDL and ECM methodologies capture important short- and long-run dynamics, they are inherently linear models and may not fully account for nonlinear or structural shifts in the economy. Third, data availability, particularly regarding entrepreneurial activity (TEA), imposes constraints on the temporal coverage and granularity of the analysis. Lastly, external shocks – such as the COVID-19 pandemic and global financial crises – may introduce volatility that is difficult to fully isolate within the model's framework.

In conclusion, for the U.S. to maintain and enhance its sustainable economic growth trajectory, it is essential to create an environment that encourages entrepreneurship, optimizes the benefits of FDI, manages credit expansion carefully, and further develops its financial markets. Future research should address these limitations by incorporating nonlinear modeling approaches, panel data across countries, and additional structural variables such as digital transformation, environmental sustainability, and institutional quality to provide a more holistic understanding of the drivers of sustainable growth.

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Efficiency of Higher Education Systems in the European Union Member States: A DEA Approach

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Abstract: The system of higher education is formed as one of the main pillars in the modern economic development of each country. The consequences of educational activities can be both positive by creating opportunities for achieving greater added value, and negative, expressed in various market deficits and vulnerabilities in financial management and the implementation of government policy. Therefore, the analysis of higher education is important for the national economy, the labour market, the participants in the educational process (teachers, students, PhD students, researchers, administrators, etc.), as well as for all taxpayers who indirectly finance the state education system. This has resulted in a significant number of scientific publications evaluating various aspects of higher education institutions. The present study aims to evaluate, by means of a non-parametric model such as Data envelopment analysis, the technical efficiency of higher education systems in the European Union in three main aspects: teaching activity, research activity and management of education expenditure. The analysis covers the period from 2013 to 2021, and this period is divided into two sub-periods to track changes in the efficient management of education systems.

Keywords: higher education; efficiency; DEA; students.

JEL classification: H52; H44; I22; I23.

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1. INTRODUCTION

In the context of economic theory, education represents a mixed good. Moreover, education is a good that is often classified as a merit good, or as Brussarski (2007) points out, it is a good that brings much greater benefits to society and to specific consumers than they actually appreciate. Shaw and Allison (1999) classify these types of benefits as tangible and intangible (or qualitative), indicating that they are obtained in the course of information transmission during teaching/learning. The authors also relate education to modern models of economic development based on knowledge and skills.

Higher education, including doctoral study constitutes the highest form of the education system. The significance of the higher education system for the development of the national economy is extremely important. Oketch *et al.* (2014) present a conceptual framework for the impact of higher education on economic growth and development and highlight three main pillars: teaching, developing research and innovative approaches, and providing educational benefits. The process of training current and future students (investment in human capital) plays a significant role in shaping the profile of potential participants in the labour market, including the opportunities for improving their economic well-being. On the other hand, the structure of the higher education system, teaching models and their modernization can contribute to meeting the requirements and expectations of employers on the labour market, and can also create additional forms of market deficits of a certain type of specialists, respectively surplus of others (Angelov, 2019). The system of higher education, through the research activity of academic staff members, as well as other types of independent researchers, also contributes to the development of models and approaches, the generation of new knowledge and technological processes. These research findings, in turn, can be applied in practice in search of greater added value in production processes, or as Halaskova *et al.* (2020) point out, to achieve "*stable and sustainable social growth*". Therefore, the education system should be subject to continuous monitoring, as well as an assessment of its efficiency in terms of processes, management and financing. Precisely for this reason, the object of this paper is the higher education systems. The subject of the research is specifically the processes and activities in higher education in the 27 European Union (EU) member states. The purpose of the article is to develop models and assess the technical efficiency of higher education within the European Union. The present study seeks to examine and assess the technical efficiency of higher education systems in the EU-27 from multiple dimension and perspectives by analyzing three essential aspects – teaching activity, scientific (research activity) and financial management.

The paper consists of five sections. Section 2 provides an extensive review of the existing literature related to the evaluation of the efficiency of higher education and the applicable tools for analysis. Section 3 outlines a methodological framework for applying Data envelopment analysis (DEA) under certain constraints and develop three evaluation models. Section 4 contains a descriptive statistics of the input and output variables selected for the purpose of the analysis. Section 5 presents the results of the applied models. Section 6 includes the conclusions and future research opportunities.

2. LITERATURE REVIEW

In research practice, various approaches are used to calculate the efficiency of individual units, including in performance evaluation for units operating in both the public and private

sectors. One of these approaches is the so-called DEA analysis. DEA is a non-parametric approach with extremely wide application in the evaluation of economic processes. Mihaylova-Borisova and Nenkova (2021) point out that one of the significant advantages of DEA is that it is not necessary to define the type of production function in advance, which is necessary in alternative approaches, and this in turn contributes to minimizing the possible errors. The method is based on mathematical linear programming. This approach makes it possible to assess both the overall technical efficiency of selected units, as well as pure technical efficiency, scale efficiency, cost efficiency, etc. In general, the DEA model aims to achieve comparability in the degree of efficiency between the individual researched units (called "decision-making unit" or DMU), i.e. the evaluation in practice results in the so-called comparative efficiency. Efficiency evaluation through DEA is carried out on the basis of matching multiple outputs (results) and multiple inputs (resources).

The Data envelopment analysis is an extremely popular technique for evaluating the efficiency of units operating in the education system. This approach is used for assessment, both in primary and secondary education, and in the assessment of universities, colleges and the higher education system as a whole. In the theoretical and empirical literature, there is quite a large number of studies whose object is the evaluation of the efficiency of educational institutions and in which DEA is used as the main tool. Conducting such researches in the higher education system can be divided into several groups.

The first group of studies estimates the efficiency of the institutions operating in the system of higher education in a specific country, i.e. assessment of universities, colleges and other institutions according to the national classification (Abbott and Doucouliagos, 2003; Johnes, 2006; Worthington and Lee, 2008; Katharaki and Katharakis, 2010; Cunha and Rocha, 2012; Tochkov *et al.*, 2012; Nazarko and Šaparauskas, 2014; Srairi, 2014; Mikušová, 2015; Selim and Bursalıoğlu, 2015; Yuangyai, 2017; Figurek *et al.*, 2019; Hammes Junior *et al.*, 2020; Perović and Kosor, 2020; Cossani *et al.*, 2022; Sun *et al.*, 2023; Temoso *et al.*, 2023; Tran *et al.*, 2023).

The second group of studies makes a comparative assessment of the efficiency of higher education systems in different countries. Within these studies, performance is assessed not at the level of an individual educational institution, but at the level of individual countries and their higher education systems (Agasisti, 2011; Obadić and Aristovnik, 2011; Agasisti and Pohl, 2012; Wolszczak-Derlacz, 2017; Yotova and Stefanova, 2017; Ahec Sonje *et al.*, 2018; Nadoveza Jelić and Gardijan Kedžo, 2018; Din and Coculescu, 2019; Blecich, 2020; Stefanova and Velichkov, 2020).

The third group of studies focuses on the performance evaluation at the level of individual university/college structures, such as faculties, departments, research centers (Halkos *et al.*, 2012; Abd Aziz *et al.*, 2013; Laaraf and Bouguera, 2020; Ramírez-Valdivia *et al.*, 2022; Wildani *et al.*, 2023).

The last group of researches evaluates the efficiency of the entire system of education and its individual subdivisions, including the system of higher education (Tyagi *et al.*, 2009; Aristovnik, 2011; Brzezicki *et al.*, 2022).

Studies related to the evaluation of the efficiency of higher education systems through DEA can also be distinguished according to the specific model used. The differences can be outlined in several aspects:

- the evaluation approach can focus on either the input side or the output side of the process,

- the estimation approach can be established under the assumption of constant returns to scale (CRS) or variable returns to scale (VRS),
- the assessment approach can also differ to a great extent in terms of the selected variables that are used as input and output.

Based on the first distinguishing criterion (the focus of analysis), the DEA approach can be input-oriented. Such an approach aims to minimize the input resources, assuming that there is no change in the outputs, in order to achieve efficiency from the actions of the unit under analysis. The DEA approach can also be output-oriented, in cases where the purpose is to maximize the results of the individual unit through more efficient utilization of the available input resource. The choice of a specific model in the application of DEA depends mostly on the degree of influence of the analysed DMUs on the input and output. If it is assumed that the analysed DMUs in the higher education system have a greater influence on the selected input resources, then the input-oriented DEA approach can be applied (Abbott and Doucouliagos, 2003; Katharaki and Katharakis, 2010; Mikušová, 2015; Yotova and Stefanova, 2017; Ahec Sonje *et al.*, 2018; Stefanova and Velichkov, 2020). Incidentally, this is a widely accepted approach to assessment, especially when the focus is on evaluating units in the public sector. The reason is that this strategy permits searching different options for optimizing the use of scarce resources. This approach also has some disadvantages such as the dominant emphasis on resource use and focus shifts away from possibilities for improvement current results, even when this is achievable. A negative aspect also occurs within the regulatory and institutionally established minimum levels of resources used, as well as in the case of significant differences between the assessed units. If the degree of influence on the selected output variables is greater, it is recommended to use output-oriented DEA (Aristovnik, 2011; Obadić and Aristovnik, 2011; Tochkov *et al.*, 2012; Nazarko and Šaparauskas, 2014; Selim and Bursalıoğlu, 2015; Wolszczak-Derlacz, 2017; Nadoveza Jelić and Gardijan Kedžo, 2018; Din and Coculescu, 2019; Hammes Junior *et al.*, 2020; Laaraf and Bouguera, 2020; Cossani *et al.*, 2022). It is possible to use this approach also in the evaluation of educational policies when the goal is to achieve better results by using available resources (without requiring any adjustments). A disadvantage of output-oriented DEA is that it places too much emphasis on results and underestimates the efficient use of scarce resources. In the pursuit of a potentially higher result, this may occur at the expense of excessive use of budgetary resource. It is usually more preferred in analyses and assessments of activities in the private sector, but in fact, it also finds application in the public sector.

When choosing a DEA approach based on returns to scale, expectations regarding the relationship between changes in the selected outputs and changes in the inputs are relevant. If changes in higher education outputs are expected to be proportional to changes in inputs, then DEA with constant returns to scale can be applied. In the absence of such proportionality, a DEA approach based on variable returns to scale including both increasing and decreasing returns to scale, should be used. In the existing scientific literature, there are also studies that establish rather the presence of some form of proportionality and the possibility of applying the constant returns to scale approach (Katharaki and Katharakis, 2010; Cunha and Rocha, 2012; Nazarko and Šaparauskas, 2014; Laaraf and Bouguera, 2020; Sun *et al.*, 2023). Most researchers emphasize the existence of various forms of externalities, which support the view that an approach based on variable returns to scale would be more appropriate (Abbott and Doucouliagos, 2003; Aristovnik, 2011; Obadić and Aristovnik, 2011; Tochkov *et al.*, 2012; Mikušová, 2015; Selim and Bursalıoğlu, 2015; Wolszczak-Derlacz, 2017; Yotova and

Stefanova, 2017; Ahec Sonje *et al.*, 2018; Nadoveza Jelić and Gardijan Kedžo, 2018; Din and Coculescu, 2019; Hammes Junior *et al.*, 2020; Stefanova and Velichkov, 2020; Çetin and Maral, 2022). It is further supported by the fact that higher education institutions can change their scale over time in pursuit of certain goals.

The choice of specific input and output variables of the DEA model is extremely difficult, and this actually creates the most significant differences in the existing studies on the topic when the object of evaluation is the efficiency of higher education. It should be noted that DEA is also quite sensitive to the selected input and output variables. In such cases, even a subsequent analysis of statistical robustness and sensitivity of the obtained results is recommended, and for this purpose the so-called bootstrap DEA, the Monte Carlo approach, etc. can be applied. Nevertheless, with smaller samples, or when studying entire populations, as is the present case with the 27 EU member states, such additional analyses and assessments are not always conceptually justified. Tests and analyses of this kind can lead to high variability and difficult interpretation of the results, including unstable and unreliable estimates, especially confidence intervals that represents the simulation procedure more than the true variability. Although the criticism of the classic DEA model is that it does not evaluate the statistical error or also known as noise due to the influence of external factors, it is necessary to take into account that additional simulations, such as those in the Monte Carlo method, can „cause noise", associated with relatively stable indicators for which frequent fluctuations are not typical. Under such circumstances, the classical DEA model can be considered to provide an estimate that is robust to a certain extent, maintaining logical interpretability, especially in studies aimed at comparing well-established and specific educational systems operating within recognized institutional and economic structures.

The difficulty in choosing input and output variables of the model is due to several reasons:

(1) personal subjective preferences of researchers, based on their views on the importance and priority of various factors related to the higher education system,

(2) subjective preferences of researchers consistent with their selected DEA approach (under the circumstances mention above), as well as,

(3) objective circumstances related to the available data used for estimation and the scope of the study.

Despite the availability of substantial databases containing educational information, analysing performance at the cross-country level is hindered by obstacles in gathering enough data on the preselected indicators and time periods. The choice of variables in the evaluation of the efficiency of the higher education system also depends on the scope of the activities analysed: teaching and learning activities, administrative responsibilities, research endeavours, financial management (including sources of revenue or expenditure), international cooperation and mobility, other types of activities or the general functioning of educational institutions.

Most researchers who focus on the efficiency of higher education primarily use the following variables as inputs to their DEA models (see Table no. 1):

The indicators mentioned above are among the most commonly used input variables in research practice, but certainly others can be specified. It should be noted that in the analysis of higher education performance, including public expenditure on higher education as an input variable is not always the most appropriate approach. The reason for such a conclusion is that in quite a few countries higher education is offered as a service by the private sector, and in other countries it can even be said that private higher education dominates in terms of relative market share (Latvia, Cyprus and Belgium). In addition, even in public institutions in the field

of higher education there are payments made by private entities, such as payment of tuition fees by students. It is typical for some EU countries that the share of private payments significantly exceeds public funds for higher education (France, Spain, Austria, Bulgaria, Italy and Slovakia). In some studies, the budget of a higher education institution, and more specifically the focus on the *revenue* part, is considered as an input variable (Wolszczak-Derlacz and Parteka, 2011; Agasisti and Berbegal-Mirabent, 2021), especially when the studies are devoted to a particular educational institution.

Table no. 1 – Input variables

Input variables	Summary of relevant empirical studies
Number of academic staff	(Abbott and Doucouliagos, 2003; Johnes, 2006; Worthington and Lee, 2008; Katharaki and Katharakis, 2010; Tochkov *et al.*, 2012; Bonaccorsi *et al.*, 2013; Mikušová, 2015; Selim and Bursalıoğlu, 2015; Quiroga-Martínez *et al.*, 2018; Blecich, 2020; Brzezicki *et al.*, 2022; Cossani *et al.*, 2022; Temoso *et al.*, 2023; Tran *et al.*, 2023)
Number of non-academic staff	(Abbott and Doucouliagos, 2003; Katharaki and Katharakis, 2010; Bonaccorsi *et al.*, 2013; Srairi, 2014; Wolszczak-Derlacz, 2017; Tran *et al.*, 2023)
Operating costs	(Ramírez-Correa *et al.*, 2012; Tochkov *et al.*, 2012; Mikušová, 2015; Yuangyai, 2017; Blecich, 2020; Cossani *et al.*, 2022)
Number of entrants or enrolled students in various forms of higher education - bachelor's, master's, phd	(Johnes, 2006; Agasisti and Pohl, 2012; Sav, 2013; Figurek *et al.*, 2019; Perović and Kosor, 2020)
Ratio between the number of academic staff and the number of students or reciprocal to it	(Cunha and Rocha, 2012; Yuangyai, 2017; Nadoveza Jelić and Gardijan Kedžo, 2018; Perović and Kosor, 2020)
Total expenditure on higher education	(Hammes Junior *et al.*, 2020; Sun *et al.*, 2023; Temoso *et al.*, 2023)
Expenditure on higher education as percentage of GDP	(Agasisti, 2011; Nadoveza Jelić and Gardijan Kedžo, 2018; Din and Coculescu, 2019; Perović and Kosor, 2020)
Expenditure per student as a percentage of GDP per capita	(Obadić and Aristovnik, 2011; Yotova and Stefanova, 2017; Ahec Sonje *et al.*, 2018; Stefanova and Velichkov, 2020)
Research expenditure	(Johnes and Yu, 2008; Tran *et al.*, 2023)
Capacity (or size) of edu–cational and research area	(Tochkov *et al.*, 2012; Dogan *et al.*, 2016)

The process of selecting appropriate input and output variables is a complex task. Every researcher should search for the most accurate output variables possible so that they provide an adequate response to the research goal, on the one hand, and its relationship with the input variables, on the other hand. In terms of choosing indicators for the result related to teaching and learning activity, the focus is usually placed *on the number or share of enrolled or graduated students in different forms of higher education* (Avkiran, 2001; Aubyn *et al.*, 2009; Aristovnik, 2011; Cunha and Rocha, 2012; Nazarko and Šaparauskas, 2014; Hammes Junior *et al.*, 2020; Laaraf and Bouguera, 2020). Tochkov *et al.* (2012) also pay attention to another segment of student learning as an aspect used for evaluation (result), namely *the share of*

foreign students in the total number of students studying. As the authors point out, such an indicator highlights the qualitative effects and results of education in higher education institutions. The higher the proportion of foreign students, the more it is assumed that local higher education institutions may offer higher standards and better training. Blecich (2020) points out that this is a clear expression of the recognition of a given higher education institution. In this context, Johnes and Yu (2008) include a *reputation index* as a result, although they take into account the effect of subjectivity in its modeling. Another group of authors targets certain *members of society* (segmented mainly by age within the groups: 20-34 years, 25-34 years, 30-34 years, 25-29 years, 25-64 years, etc.) *with acquired higher education*, using indicators (strategic goals) set at the pan-European level in their studies (Yotova and Stefanova, 2017; Din and Coculescu, 2019). In addition, to being directly related to the educational activity, some of the output indicators are reflected in research on the relationship between the higher education system and the labour market by tracking the subsequent *realization of students*, based on *employment* indicators (Abbott and Doucouliagos, 2003; Selim and Bursalıoğlu, 2015; Din and Coculescu, 2019; Mihaljevic Kosor *et al.*, 2019) and *unemployment* (Obadić and Aristovnik, 2011; Ahec Sonje *et al.*, 2018; Stefanova and Velichkov, 2020). Yuangyai (2017) adds another significant aspect of the labour market-higher education relationship, namely, the *degree of satisfaction of employers in hiring graduates of the given university*. Although the author points out that this is an indicator of a result related more to the teaching activity, it is certainly related to the abilities for career development.

Research activity and its results are also an important component of the higher education system. Therefore, many authors involve the *number of scientific publications* (including monographs, articles, reports presented at scientific conferences, books, patents, etc.) as an output variable in their analyses. In particular, attention is paid to *publications* in international journals or conference proceedings that are *indexed in* major world-renowned databases, such as Scopus (2024) *and Web of Science (2024)* (Tochkov *et al.*, 2012; Bonaccorsi *et al.*, 2013; Sagarra *et al.*, 2017; Wolszczak-Derlacz, 2017; Dolgikh, 2023). Some additional indicators are also used to evaluate the scientific publication, such as the *number of citations, or specific evaluation indices,* e.g. *Hirsch Index* (Dolgikh, 2023), *own calculated (weighted) indices* (Tyagi *et al.*, 2009), or by weighting the *number of publications per academic staff member (Yuangyai, 2017)*, etc. In the efficiency analysis of public universities and colleges, the *amount of research grant* is also used as an output related to scientific activity (Katharaki and Katharakis, 2010; Thanassoulis *et al.*, 2011; Srairi, 2014).

3. METHODOLOGY

The object of analysis in the present study is the higher education systems in the 27 EU member states. Although the United Kingdom is part of the European Union until 2020, this country is not included in the current analysis. Given that the assessment is at the national level (among EU member states), the higher education system takes on the role of DMUs. As a result, it is assumed that educational institutions would have greater opportunities to influence the input variables, considering that in most EU countries (predominantly in Northern and Western Europe) universities maintain a relatively high degree of academic, staffing and organizational autonomy. Circumstances change significantly with regard to the model's output variables, which depend on processes associated with socio-economic

development, labour market conditions, psychological and motivational attitudes of students, as well as on the government's approach to education and research policy. Therefore, the present study adopts input-oriented DEA. This is a logical consequence of the fact that, despite the dominant share of public higher education institutions, the analysis also includes private universities and colleges, which have greater decision-making autonomy. Also, the selection of input resources takes into account the possibility of encouraging institutions to have more freedom in decision-making. Of course, it is essential to consider that government policy sometimes places public educational institutions in a position where they do not have much authority to make independent decisions, but if the elements of input and output are compared, certainly the possibility of influencing the input is greater.

The present study supports the fact that the proportionality in input and output dynamics cannot be guaranteed. Therefore, the research uses the DEA approach under the assumption of variable returns to scale. This allows to evaluate the pure efficiency ($Technical\ efficiency_{VRS}$) and the scale efficiency of educational institutions. The use of variable returns to scale is a reliable tool, especially when in the evaluation of heterogeneous units, although it often shows lower discriminative ability, leading to an artificial increase in the number of units classified as efficient. For this reason, and in order to estimate the scale efficiency of educational institutions, it is necessary to calculate the technical efficiency, assuming a constant returns to scale ($Technical\ efficiency_{CRS}$), or the so-called overall technical efficiency.

$$\text{Scale efficiency} = \frac{Technical\ efficiency_{CRS}}{Technical\ efficiency_{VRS}} \tag{1}$$

As a result of the above-mentioned determination of the model approach (oriented toward input) and the assumption made about changes in the scale of the studied units (with variable returns to scale), the DEA model can take the following envelopment form:

$$\text{Min } \theta_f \tag{2}$$

Subject to Constraints:

$$Y_{rf} - \sum_{d=1}^{n} \lambda_d Y_{rd} \leq 0, \qquad where\ r = 1,2,3,\ldots..,w$$

$$\theta_f X_{if} - \sum_{d=1}^{n} \lambda_d X_{id} \geq 0, \qquad \text{where } i = 1,2,3,..,v$$

$$\sum_{d=1}^{n} \lambda_d = 1$$

$$\lambda_d \geq 0, \quad \forall d = 1,2,3,\ldots..,n$$

where: Y_{rf} is the quantity of r[th] output produced by DMU *f*, X_{if} is the quantity of i[th] input used by DMU *f*, *n* is the number of DMU to be evaluated (in the present study these are the 27 national systems of higher education), *w* is the number of outputs, *v* is the number of inputs, θ_f is the relative efficiency score for DMU *f,* λ is the vector with weights Ix1, X_{id} is the quantity of i[th] input used by DMU *d* and Y_{rd} is the quantity of r[th] output produced by DMU *d*.

For each DMU that is located on the efficient frontier, θ will be equal to 1, while for the remaining DMUs that are located below the efficiency frontier, the value of θ will be lower than 1. The first DMUs with efficiency equal to 1 can function as conditional benchmarks, whereas the second ones appear to be as inefficient.

The selection of specific input and output variables in this study mainly relies on the components of the higher education system that are subject to estimation and on the basis of the literature review conducted on the researched topic. Due to the fact that the research aims to answer the question of the efficiency of the higher education systems in the EU in terms of teaching activity, financial management and research activity, the analysis involves specifying three different evaluation models.

The teaching activity assessment model consists of one input variable (ratio of the number of academic staff members to enrolled students, % (RAsENRst)) and four output variables ([1] share of graduated bachelors to enrolled bachelor's students, % (RGEund), [2] share of graduated master's and PhD students to enrolled master's and PhD students, % (RGEpost), [3] share of foreign students to enrolled students, % (RFSENR) and [4] employment of the population aged 25-64 with higher education, % ($EMTE_{25\text{-}64}$)). Despite the intention to include the number of non-academic members of higher education institutions as an input variable, which has a direct impact on the modern educational process, the lack of sufficient data to cover all the higher education systems encompassed in the analysis and referring to entire period studied, means that it is necessary to exclude this indicator from the input variables.

The model for evaluating the expenditure efficiency (financial management) consists of one input variable (ratio of expenditure per student to GDP per capita, % (RTEpsGDPpc)) and three output variables ([1] share of graduates to enrolled students, % (RGradTOErn), [2] share of the population aged 25-64 with higher education to the total population in the same age group, % ($PopTE_{25\text{-}64}$) and [3] ratio of unemployment among the population aged 25-64 with higher education to unemployment among the population aged 25-64 with all levels of education, % ($invRUNE_{25\text{-}64}$)). It is worth mentioning that the unemployment is an output with a negative effect, and DEA aims to estimate the positive effects of the input resource. In this regard, the unemployment result is transformed as shown in equation 3 below:

$$invRUNE_{25-64} = 1 - \left(\frac{UNETE_{25-64}}{UNEAllISCED_{25-64}}\right) \text{x } 100 \quad (1)$$

where: $invRUNE_{25-64}$ is the unemployment output that is included in the model, $UNETE_{25-64}$ is the unemployment among university graduates, $UNEAllISCED_{25-64}$ is the unemployment among those who have completed some degree of education.

The presented frameworks of the two models above include indicators related to the labour market with the age group 25-64 years selected because the analysis assumes that most graduates start their professional activity around the middle of their twenties. On the other hand, in most countries the set retirement age is around 65 (or anticipated to be so in the future).

The research performance evaluation model consists of two input resources ([1] number of academic staff members (As) and [2] number of enrolled PhD students (PhDenr)) and three output variables ([1] number of publications indexed in the Scopus (2024) database (ScopusPub), [2] number of publications indexed in the Web of Science (2024) database (WoSPub) and [3] Hirsch index (H-index) based on information from the Scopus database).

4. DATA AND DESCRIPTIVE STATISTICS

Over the last ten years, there has been a gradual trend within the EU towards an increase in the number of people enrolled in higher education institution. While in 2013, slightly more than 17 million students were studying within the European Union, the latest Eurostat (2024) data (as of the end of 2021) indicate that the number of students has risen to 18.5 million. Most students study in Germany (about 3.35 million, which represents about 18.1%), France (2.8 million, or 15.2%), Spain (2.26 million, or 12.2%), Italy (2.1 million or 11.3%), Poland (1.34 million or 7.27%) and the Netherlands (0.98 million or 5.33%). Between 1.2 and 1.45 million members of the academic staff of higher education institutions (incl. professors, associate professors, assistant professors, lecturers, researchers, etc.) are involved in the training of these students. On average, each academic staff member in the European Union is responsible for between 12 and 13 students, but it is necessary to highlight that serious differences are observed, both between individual countries and also with regard to different scientific fields. While in Greece a member of the academic staff teaches about 40-41 students, in Ireland - between 26 and 27, in Luxembourg the number of students taught is significantly smaller (5), in Austria - 7, and in Poland, Croatia and Lithuania – 9. In the present study, the reciprocal of this value is used, namely the number of academic teachers per student (%). As can be seen from Table no. 2 below, for the period 2013-2016, academic staff members formed between 2.39% and 13.88% of the enrolled students, while during the period 2017-2022 this percentage varied in the range between 2.38% and 17.98%. The data shows that there is an increase in differentiation between the lowest and highest value. Table no. 2 contains descriptive statistics for the selected input variables, with two sub-periods defined. The purpose is to compare the results of the input management and the obtained output for these two sub-periods. Main sources of data are the Eurostat educational statistics database, as well as the Scopus (2024), including Scimago Journal & Country Rank (2024) and Web of Science (2024) databases.

Table no. 2 – Descriptive statistics of input variables

Indicator and period		Min	Max	Mean	SD
Number of academic staff members (As)					
Period	2013-2016	777	388,144	47,842	78,326
	2017-2021	1,309	441,858	51,411	88,291
Number of enrolled PhD students (PhDenr)					
Period	2013-2016	104	205,275	23,309	39,607
	2017-2021	256	195,110	24,426	39,544
Ratio of the number of academic staff members to enrolled students, % (RAsENRst)					
Period	2013-2016	2.39	13.88	7.72	2.79
	2017-2021	2.38	17.98	8.36	3.43
Ratio of expenditure per student to GDP per capita, % (RTEpsGDPpc)					
Period	2012-2015	15.07	54.04	35.46	7.54
	2016-2020	12.66	46.61	34.13	7.01

Source: authors' calculations based on data from Eurostat (2024), Scimago Journal & Country Rank (2024), Web of Science (2024)

From the previously mentioned 18.5 million students, nearly 80% of them study in public universities, and based on data from Eurostat (2024) for 2021, this share in Greece and

Luxembourg is 100%, in Denmark 99.6%, Ireland 96.57%, Estonia 93.41%, Croatia 90.97%, Czech Republic 89.73%, Lithuania 88.49%, Sweden 88.38%, Slovakia 88.10%, Romania 87.77% and Bulgaria 87.67%. As already indicated above in the literature review, there are European Union member states in which the majority of students study at organizations whose control is not government, but predominantly private. These are Latvia (92.51% of students study at private universities), Cyprus (73.41%) and Belgium (58.35%). In Finland, the ratio approximates one to one (48.18% in private universities). The relative share is high in Poland (31.55% of students), Hungary (27.95%) and Spain (25.50%). This, in fact, predetermines the decision to include the total expenditure of education in the model for evaluating the expenditure efficiency of higher education. This expenditure includes transfers made by governments for the state education policy, but also expenditure incurred by students (in the form of paid fees), by corporate/non-governmental (non-educational) organizations (in support of funding of student training, scholarships) and by international organizations.

The conducted research presents the expenditure of higher education in the form of a ratio, which, on the one hand, includes the number of enrolled students, and on the other hand, compares these cost per student to the dynamics of the main macroeconomic indicator, which is the GDP per capita. Through this approach, the aim is to establish the extent to which the expenditure of higher education changes in response to the changes occurring in the economy. The descriptive statistics of the input data in Table no. 2 show downward trend for the period 2016-2020 compared to the first sub-period 2012-2015. Furthermore, in the analysis of expenditure efficiency, the input resource is purposefully included with a time lag of t-1 relative to the main variables in the model (assuming that the years 2013 and 2016 represent the t period for the two sub-periods). The reason is to trace how the expenditure incurred (and their dynamics at the macro level) influence subsequent activities and processes within the higher education system. In this regard, the output variables in the specified model for assessment the expenditure efficiency also differ in terms of time periods (see Table no. 3). For example, the ratio of graduates to enrolled students (RGradTOErn) is calculated for the sub-periods 2013-2016 and 2017-2021, which provides an opportunity to check the result on main educational activities within a year. It is indicative of the data in Table no. 3 that for the second sub-period the average values of the ratio increase by about 0.22 pp, noting that this increase in Hungary averaged between sub-periods to 8.94 pp, in Ireland 4.86 pp, Denmark 2.43 pp and Estonia 2.05 pp. A decline is observed in half of the EU countries (Slovenia -4.2 pp, Slovakia -3.86 pp, Romania -2.03 pp, Latvia -1.81 pp, Czech Republic -1.78 pp, Netherlands -1.29 pp, Malta and Bulgaria -0.81 pp, Greece -0.62 pp, Croatia -0.61 pp, Lithuania - 0.59 pp, France -0.57 pp and Cyprus -0.51 pp). The other two indicators in this model (the share of the population aged 25-64 with a university degree and the output variable for unemployment) are included with data from sub-periods 2013-2017 and 2018-2022. The purpose is to assess the lag effect of previously incurred expenditure. In research practice, an even larger lag is sometimes taken, consistent with the years of study in higher education.

Table no. 3 – Descriptive statistics of output variables

Indicator and period		Min	Max	Mean	SD
Number of publications indexed in the Scopus database (ScopusPub)					
Period	2013-2017	762	180,402	33,958	44,400
	2018-2022	1,189	198,700	39,499	49,687
Number of publications indexed in the Web of Science database (WoSPub)					
Period	2013-2017	803	207,427	38,591	49,982
	2018-2022	1,293	231,184	45,633	57,299
Hirsch index (H-index)					
Period	2013-2017	169	1,584	682	406
	2018-2022	169	1,584	682	406
Share of foreign students to enrolled students, % (RFSENR)					
Period	2013-2016	0.77	45.06	8.17	8.32
	2017-2021	3.01	48.16	10.69	8.82
Employment of the population aged 25-64 with higher education, % ($EMTE_{25-64}$)					
Period	2013-2017	69.70	90.14	84.12	4.24
	2018-2022	76.20	91.08	86.64	3.25
Share of graduated bachelors to enrolled bachelor's students, % (RGEund)					
Period	2013-2016	8.73	31,37	20.63	4.84
	2017-2021	7.42	31.64	21.41	5.66
Share of graduated master's and PhD students to enrolled master's and PhD students, % (RGEpost)					
Period	2013-2016	17.02	48.50	20.63	7.75
	2017-2021	18.78	60.34	27.71	8.48
Ratio of graduates to enrolled students (RGradTOErn)					
Period	2013-2016	9.77	33,41	22.96	5.27
	2017-2021	9.16	36.96	23.18	5.59
Share of the population aged 25-64 with higher education to the total population in the same age group, % ($PopTE_{25-64}$)					
Period	2013-2017	16.74	44.40	30.90	8,12
	2018-2022	18.68	50.06	35.49	8.67
Ratio of unemployment among the population aged 25-64 with higher education to unemployment among the population aged 25-64 with all levels of education, % ($invRUNE_{25-64}$)					
Period	2013-2017	16.47	62.09	38.53	12.47
	2018-2022	5.69	57.70	34.09	13.60

Source: authors' calculations based on data from
Eurostat (2024), Scimago Journal & Country Rank (2024), Web of Science (2024)

In all 27 member states, the share of the population aged 25-64 with higher education has increased in the sub-period 2018-2022 compared to 2013-2017. The average growth rate for the EU is around 4.59 pp, with the highest growth rates recorded in Malta (8.28 pp), the Netherlands (6.46 pp) and Slovenia (6.44 pp), and the lowest growth rate in Bulgaria (1.86 pp), Romania (1.94 pp), Finland (2.24 pp) and Italy (2.4 pp). In addition, Romania and Italy are the countries with the lowest relative share of university graduates (aged 25-64) in the entire EU according to the latest Eurostat (2024) data for 2022. For Romania, this share is only 19.7% in 2022 (or almost twice less than the EU average level), and in Italy 20.3%. Bulgaria also has a rather low value of the considered indicator (29.8%), while the data show that Finland reports above the EU average levels. It should be noted, however, that in Bulgaria the employment rate of higher education graduates (aged 25-64) is one of the highest compared to the employment rate of the rest of the population with acquired education as a whole. This can be deduced from the ratio of unemployment among people with higher education (ISCED levels 5-8) and unemployment among persons included in all ISCED

levels. The relative share for Bulgaria is about 0.4 (as much as it is in Hungary and Slovakia), while in Denmark is 0.97 for 2022. As a result, it is not surprising that in the second sub-period 2018-2022 the lowest value of the indicator $invRUNE_{25-64}$ (5.69%) is calculated for Denmark. In 2022, in Romania the unemployment among people with higher education aged 25-64 is 1.3%, while the unemployment for all ISCED levels is 4.5%. Therefore, the ratio is 0.29 (while for 2012 it is 0.71), respectively $invRUNE_{25-64}$ for Romania is 71% for 2022 and for the entire second sub-period 2018-2022 is 57.7%. The average value of $invRUNE_{25-64}$ for EU countries in 2018-2022 shows a decrease compared to 2013-2017, which should be perceived as a negative effect. At the same time, the standard deviation grows, which means that the variation between countries is increasing.

Table no. 3 provides an opportunity to analyse the indicators of the publication activity of the academic staff of higher education institutions in the EU countries. Undoubtedly, when comparing the two sub-periods, it can be concluded that not only the members of the academic staff are increasing (see Table no. 2 above), but also the number of publications indexed in Scopus (2024) (an average increase of about 5 541 publications) and Web of Science (2024)(an average increase of about 7 042 publications). A significant relative rate of growth between the sub-periods considered in the data for publications indexed in Scopus (2024) is observed in Cyprus (69%), Malta (56%), Bulgaria (53%), Latvia (41%) and Lithuania (39%). According to Web of Science (2024) Database, the relative growth rate is highest in Luxembourg (91%), Cyprus (69%), Malta (61%), Lithuania (34%), Bulgaria and Croatia (32%). It is necessary to note that some of these countries have a relatively lower base and a more tangible change leads to the data indicated above. The countries with the highest number of publications indexed in Scopus (2024) are Germany (198,700 publications average for the period 2018-2022), Italy (142,756), France (126,055) and Spain (112,189), but this is also due to the significantly greater number of higher education institutions and academic staff members in these countries. The reference also shows similar data on Web of Science (2024). In relation to the inclusion of an index of publication relevance and productivity, such as the H-index, it should be emphasized that, apart from the leading countries (in terms of a greater number of researchers), the Netherlands, Belgium, Denmark and Sweden also report extremely high value of this index.

5. RESULTS AND DISCUSSION

As already mentioned above, the analysis of the efficiency of higher education systems within the European Union is carried out over the period 2013-2021, which is divided into two sub-periods to ensure comparability of results. Although it is indicated that some of the variables are included with their lagged values (t+1 and t+2) or for period t-1, sub-periods can be conceptually distinguished as: first sub-period (2013-2016) and second sub-period (2017-2021). The study incorporates three evaluation models in the methodological framework section. The study applies the Data Envelopment Analysis Program (DEAP) software, version 2.1 for analysis. The results below summarize the findings by type of activity subject to performance evaluation, more specifically: teaching activity, scientific (research) activity and financial management (expenditure efficiency).

Teaching activity

Table no. 4 below presents the results from model application for evaluating the efficiency of teaching activity within the education systems of EU member states. The data show that the member states have an average value of the overall efficiency of their teaching activity of 0.628 (CRSTE), respectively assuming that variable returns to scale is the more appropriate approach, the average efficiency is 0.751 (VRSTE) in the first sub-period and 0.729 in the second sub-period. Consequently, the inefficiency levels under the variable returns to scale model vary on average from about 25% in the first sub-period to around 27% in the second sub-period across the EU. The inefficiency levels are actually calculated by subtracting from 100% (*equivalent to an efficiency ratio of 1, or θ=1*) the calculated value of the efficiency ratio for the given period for the respective Member State.

Table no.4 – Summarized data from the evaluation of the efficiency of the teaching activity in the EU member states

	2013-2016			2017-2021		
	CRSTE	**VRSTE**	**SCALE**	**CRSTE**	**VRSTE**	**SCALE**
Number of DMUs	27	27	27	27	27	27
Number of efficient DMUs	5	11	5	3	8	3
Number of inefficient DMUs	22	16	22	24	19	24
Mean	0.628	0.751	0.842	0.578	0.729	0.802
Max	1.000	1.000	1.000	1.000	1.000	1.000
Min	0.283	0.375	0.392	0.302	0.368	0.385
SD	0.233	0.237	0.186	0.223	0.234	0.163

Source: authors' calculations with DEAP, version 2.1

Figure no. 1 and Table no. A1 of the Annexes provide detailed information by country. The data show that during the first period under consideration Czech Republic, Greece, Luxembourg, Ireland, France, Poland, Romania and Netherlands demonstrate pure technical efficiency *(θ=1)*, whereas the remaining sixteen countries are inefficient *(θ<1)*. In the second sub-period, the number of efficient higher education systems decreased to eight (Greece, Cyprus, Ireland, Luxembourg, Romania, Poland, Hungary and Malta), leading to an increase in the number of inefficient DMUs (from 16 to 19). At the same time, the period 2013-2016 shows a difference in the number of efficient DMUs under VRS and CRS.

The results show that only five out of eleven efficient higher education systems in terms of their management of teaching activities reach their optimal scale (Czech Republic, Greece, Luxembourg, Ireland and France). In the remaining countries, there is inefficiency arising from the scope of the education systems (see Table no. A1 of the Annexes). A similar result appears in the second sub-period, where three of the efficient systems have reached their optimal scale (Greece, Cyprus and Ireland).

The Hungarian higher education system demonstrates a notable change in the pure technical efficiency during the second sub-period, but not in terms of its optimal scale. For the period 2017-2021, the data show a slight increase in inefficiencies of scale among EU Member States in respect of their education outputs compared to 2013-2016. This may be partly due to the emerging COVID-19 pandemic in the EU and globally in early 2020.

The analysis of the data in Table no. 4 and Table no. A1 of the Annexes indicates that the efficiency of the teaching activity is the lowest in both periods in Croatia (0.375 in 2013-2016 and 0.368 in 2017-2021). The Austrian system of higher education, as well as that of

Spain, also does not show particularly favourable results related to the teaching activity compared to other EU countries. Most higher education systems in the EU member states operate under decreasing returns to scale (drs). Given the value of returns to scale (scale <1), it is good for these countries to adapt to their optimal scale and this contributes to reducing the input resource, or in this case, the number of academic staff. Similar conclusions are valid for-Germany, Portugal and Slovenia. While in the period 2013-2016 six countries (Poland, Romania, Netherlands, Sweden, Lithuania and Malta) operate under conditions of increasing returns to scale (irs), in 2017-2021 the situation in Luxembourg, Romania, Poland Hungary and Malta remains analogous. Sweden, as well as Denmark, the Netherlands and Finland, despite possessing systems that demonstrate a high degree of organizational autonomy (Pruvot *et al.*, 2023), are unable to manage their human resources in the most efficient manner.

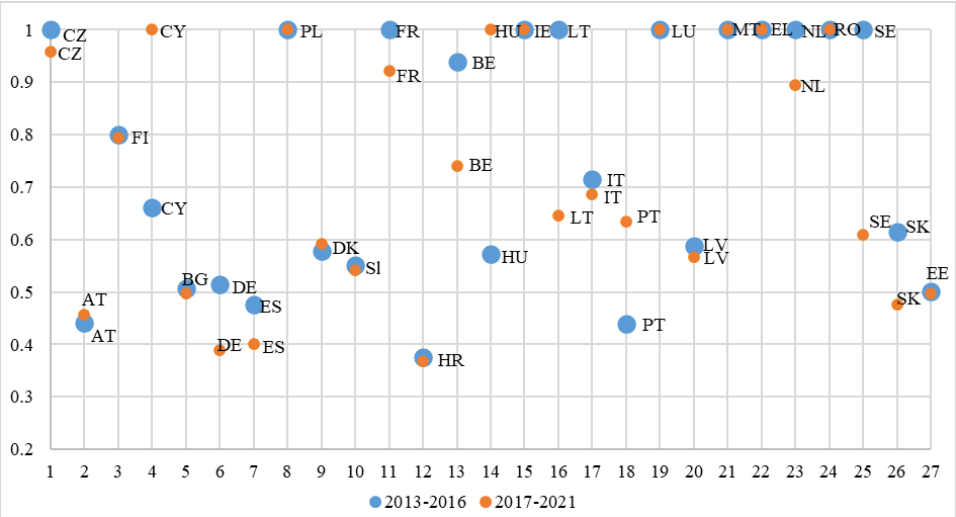

Figure no. 1 – Pure technical efficiency of educational activity in the EU member states for the periods 2013-2016 and 2017-2021

Source: authors' calculations with DEAP, version 2.1

Scientific (research) activity

Another important segment of the activity of higher education institutions in the EU is the research activity of members of the academic staff, as well as PhD students. Table no. 5 presents the results of the applied model. In both sub-periods eleven out of the 27 member countries achieve efficient systems for managing research activity. However, during the period 2017-2021, the average value of pure technical inefficiency increased to 25.9% compared to 24.4% observed in 2013-2016.

Another key aspect to consider when analyzing teaching activity, is that over 85% of countries with efficient management of their research activity simultaneously show some inefficiency in the optimal input used to achieve their output (scale<1). This is especially relevant to Germany, France, Sweden and Finland, where the inefficiency of scale is greatest, which implies optimizing the input, in particular of the academic staff and the number of PhD students (see Table no. A2 of the Annexes).

Table no. 5 – Summary data from the assessment of the efficiency of research activity in the EU member states

	2013-2016			2017-2021		
	CRSTE	VRSTE	SCALE	CRSTE	VRSTE	SCALE
Number of DMUs	27	27	27	27	27	27
Number of efficient DMUs	3	11	3	4	11	4
Number of inefficient DMUs	24	16	24	23	16	23
Mean	0.511	0.756	0.687	0.593	0.741	0.818
Max	1.000	1.000	1.000	1.000	1.000	1.000
Min	0.173	0.238	0.244	0.245	0.277	0.261
SD	0.247	0.278	0.186	0.248	0.265	0.177

Source: Authors' calculations with DEAP, version 2.1

The data in Figure no. 2 and Table no. A2 of the Annexes show that the Netherlands, Malta and Luxembourg are EU countries that, in addition to effectively managing their research activities in educational institutions, also reach their optimal scale. University researchers in Malta have managed to increase the number of their publications indexed in the Scopus (2024) and Web of Science (2024) databases by between 50 and 60%. Similar trends also emerge in Luxembourg, where during the period 2018-2022, the publications indexed in Scopus (2024) increased by over 30%, and those indexed in Web of Science (2024) grew by over 90%. A possible key factor contributing to this rise could be the increased number of academic staff members, but also the growing interest in enrolling in doctoral programs. Furthermore, Italy in 2013-2016 does not achieve optimal scale and has a relatively low level of overall technical inefficiency, which changes sharply in 2017-2021. In the first analyzed period, seventeen out of 27 EU member states show pure technical efficiency that is higher than the EU average, while in the second period the number of countries with higher than the average efficiency decreases to fifteen.

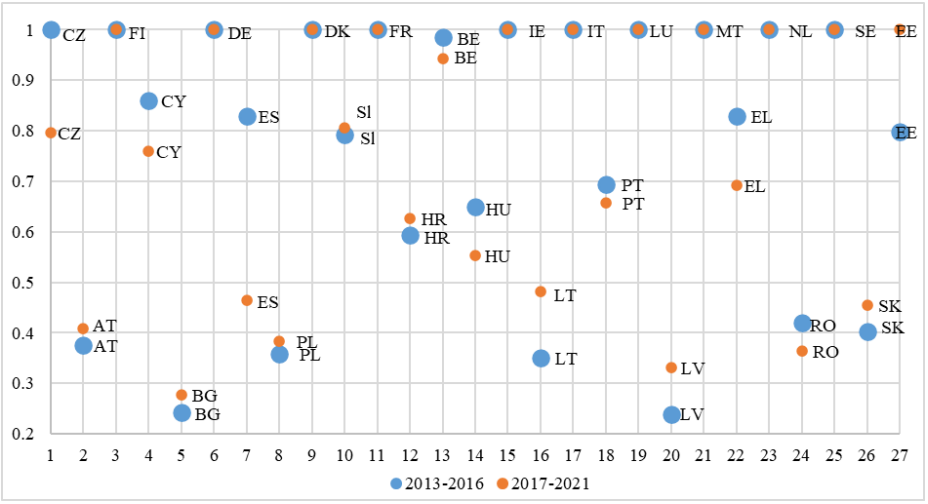

Figure no. 2 – Pure technical efficiency of research activity in the EU member states for the periods 2013-2016 and 2017-2021

Source: authors' calculations with DEAP, version 2.1

The average returns to scale for the both sub-periods improve significantly, respectively the inefficiency of scale decreases by nearly 13 pp. Latvia is the only country whose higher education system in the scientific part operates with increasing returns to scale. However, Latvia and Bulgaria are characterized by the lowest efficiency in the implementation of their research activity, although these countries reduce the degree of overall and pure technical inefficiency in 2017-2021 compared to 2013-2016 relative to the benchmark countries. Complex factors can explain the reasons for this. A possible explanation is that these are countries in the EU with one of the lowest ratios of students enrolled in doctoral programs to number of academic staff, and although this initially reflects on a reduction in the input, it cannot but impact the expected results (output). Latvia even shows a decrease in the number of enrolled doctoral students since 2016. On the other hand, with an average of 0.76 Scopus-indexed publications per author for the EU-27, in Bulgaria this value amounts to 0.32, and in Latvia it is 0.4. The trend is similar for indexed publications in Web of Science (2024), where the EU-27 average is 0.88 publications per author, compared to 0.31 in Bulgaria and 0.44 in Latvia. Consequently, the research activity in countries such as Bulgaria and Latvia is indicative of a modest contribution of these countries in an international context, both in terms of the volume of scientific publications and the degree of their visibility, citation and integration into global scientific communication. These outcomes, of course, may also arise from certain systematic and institutional challenges, expressed in insufficient funding of scientific activity in the countries, as well as in the absence of appropriate policies aimed at stimulating publication activity.

Spain is one of the countries that has experienced a significant decline in pure technical efficiency during the second sub-period. This is due to the substantial growth in enrolled doctoral students (their number increased by more than 157 % in the period 2017-2021 compared to 2013-2016). At the same time, the results of research activity in the form of indexed/refereed publications in Scopus (2024)and Web of Science (2024) have registered growth of approximately 21 to 22%. Additional financial capacity is needed to support publication activity, a pursuit of higher publication quality and most notably, emphasis on publishing in international journals. Changes in the educational workload of academic staff are also necessary, as many universities in Spain observe a substantial number of teaching hours during which lecturers are engaged in classrooms which reduces the time for carrying out scientific activities.

Expenditure efficiency

Expenditure management of the higher education system and its participants is one of the most important aspects of the activity. This is of particular importance in the case of a public resource generated by national taxpayers. In the present study, the efficiency analysis is carried out in relation to the aggregate resource used for higher education, not only public but also private. Table no. 6 below presents the results. The average value of the pure technical efficiency in the period 2017-2021 (0.658) compared to the first period (0.798) has decreased by nearly 14 pp. More generally, this can also be inferred from a reduction in the number of operationally efficient DMUs from 7 (Greece, Hungary, Ireland, Lithuania, Poland, Slovakia and Malta) to 5 (Greece, Ireland, Romania, Lithuania and Hungary) in the two sub-periods (see Table no. 6 and Table no. A3 of the Annexes). Obviously, some of the countries in Eastern Europe and the Balkans perform better in managing the expenditure of higher education. In most countries in this region, higher education costs have remained relatively stable over time, without any sudden

increases. On the contrary, in some countries, expenditures in certain years during the period 2016-2020 even show a noticeable decline (Estonia, Greece, Croatia, Latvia and Lithuania). Nevertheless, the RTEpsGDPpc indicator in Estonia remains the highest value over the 2016-2020 period, which is indicative of the country's positioning at the bottom of the ranking, as no similar trend is observed in terms of output.

Romania improves its pure technical efficiency and thus its position among the other EU member states. This stems from relatively stable costs over time, which results in a consistent value of the input variable. Simultaneously, in terms of the output, Romania succeeds in raising the value of the invRUNEMP25-64TE&ALLISCED indicator by approximately 60%. The reason for this is the sharp decrease in the share of unemployed persons with higher education aged 25-64 in the total unemployment rate for this age range. During the period 2017-2021, Romania records the highest value of the invRUNEMP25-64TE&ALLISCED indicator (57.7), followed by Hungary (56.4) and Bulgaria (55.1). Romania also shows progress in the share of people aged 25-64 who have acquired higher education, although the country holds the lowest position on this indicator among EU member states.

Table no. 6 – Summarized data from the expenditure efficiency assessment in the EU member states

	2013-2016			2017-2021		
	CRSTE	**VRSTE**	**SCALE**	**CRSTE**	**VRSTE**	**SCALE**
Number of DMUs	27	27	27	27	27	27
Number of efficient DMUs	4	7	4	3	5	3
Number of inefficient DMUs	23	20	23	24	22	24
Mean	0.751	0.798	0.945	0.622	0.658	0.949
Max	1.000	1.000	1.000	1.000	1.000	1.000
Min	0.467	0.523	0.651	0.378	0.396	0.831
SD	0.159	0.163	0.087	0.185	0.196	0.054

Source: authors' calculations with DEAP, version 2.1

For the period 2013-2016, fourteen of the member states countries reached pure technical efficiency greater than the average for all 27 countries, while in 2017-2021 the number of countries with higher than the average efficiency decreases to eleven. In addition, during the period 2017-2021, 22 out of 27 member states manage their higher education expenditure inefficiently. This should be of paramount importance in managing higher education expenditure in the short-term, while achieving optimal scale is a very difficult task and may be realized in the medium or long-term.

The calculations presented in Figure no. 3 and Table no. A3 of the Annexes show that Estonia experiences low operational (pure technical) efficiency in higher education expenditure management in both sub-periods. Denmark's position in this activity relative to other countries has significantly deteriorated (pure technical inefficiency increased from 2.4% to 56.3%). Two principal reasons can explain this and they can be classified into two main categories: (1) a sharp rise in higher education spending in Denmark for the period from 2016 to 2020 compared to the preceding years, leading to an increase in the input by over 60 % and (2) a significant decline in the invRUNEMP25-64TE&ALLISCED indicator, which is a result of the decreasing total unemployment in Denmark for persons aged 25-64, but at the same time many of those still unemployed possess higher education qualifications. The increase in higher education spending in Denmark during the second sub-period is to some extent also

related to a reform in the financing of the higher education system, which entered into force in 2019 and contributed to a rise in the share of block grants for public universities (up to 25%) at the expense of activity-based subsidies (OECD, 2021). Portugal and the Netherlands are also among the countries with high technical inefficiency score. As distinguished from the results of the previous two models, here it is noticeable that especially during the period 2013-2016, most countries operate with increasing returns to scale.

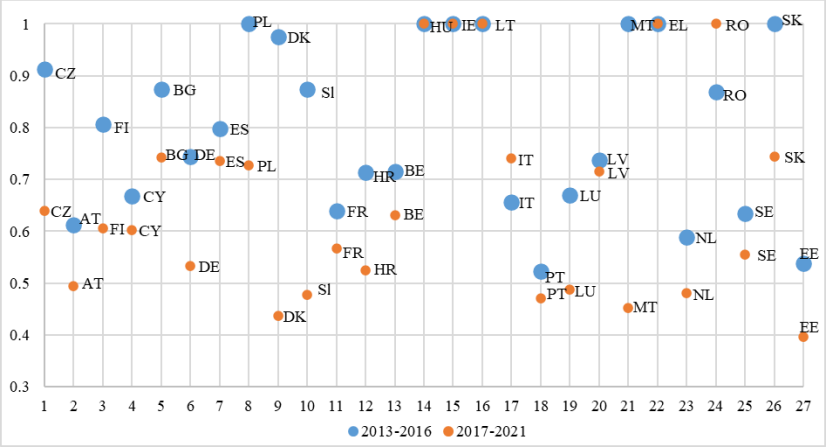

Figure no. 3 – Pure technical efficiency in higher education expenditure management in the EU member states for the periods 2013-2016 and 2017-2021.

Source: authors' calculations with DEAP, version 2.1

Besides the higher education system in Romania, the Italian one is the other that also manages to increase its pure efficiency of expenditure management during the second sub-period. The main reason for this is the observed decline in the RTEpsGDPpc variable by about 16 %. On the other hand, within the EU, Italy ranks second in terms of the rise in the invRUNEMP25-64TE&ALLISCED indicator. However, during the period under review, it is noteworthy that Italy is among the EU countries with one of the highest youth unemployment rates. Significant challenges facing the labour market in Italy include the lack of practical applicability of higher education (a low share of graduates finding jobs related to their specialty), the difficult and postponed job search, as well as the weak involvement of employers in the educational process (including participation in syllabus development), poorly implemented dual programs and the lack of sufficient internships and practical training during university studies. It is important to point out that similar education-related processes and labour market linkage are also present in Greece, which is among the countries with the highest efficiency. In contrast to Italy, the share of higher education expenditure per capita in GDP is nearly 2.3 times lower (and also tends to decrease within the period under study) in Greece. It should be mentioned that the problems with the labour market and its relationship with the higher education system are characteristic of most countries in Southern Europe – this applies to both the already discussed Italy and Greece, as well as Spain and Portugal, and this, not surprisingly, also affects their results. As is the case with Italy and Greece, the input parameter also declines in Spain and

Portugal, but this is insufficient to lead to an improvement in the pure technical efficiency of expenditure management in the second sub-period.

The decrease in the technical efficiency of expenditure management in the second sub-period in some of the Central and Eastern European countries, such as Bulgaria, the Czech Republic, Slovenia, Poland and Estonia, may stem from the more substantial increase in the input parameter associated with higher education expenditure per capita to GDP per capita. This may be due to a combination of complex factors – from the pursuit of convergence with the levels that are characteristic of Western and Northern European countries (as well as the EU average rates) and reforms aimed at increasing university administrative and management expenditures, to slower economic growth during the analysed period compared to the growth of expenditures themselves. This parameter changes noticeably in the context of the shifts occurring in some of the aforementioned countries in the model's output variables. Although countries, predominantly from Eastern and Southeastern Europe, allocate a comparatively lower budget for higher education, which to some extent explains their higher efficiency, the budget, considered in light of their degree of economic development, does not always imply a low relative share. A substantial challenge for Central and Eastern European countries, especially with respect to public financing of higher education, is the lack of well-established funding mechanism based on attained results. Despite attempts to introduce similar approaches in countries such as Bulgaria, Croatia, Romania, Slovakia, the Czech Republic, etc., the leading criterion remains either the number of admitted (enrolled) students or the volume of activity. In certain cases, there is even a lack of budgetary flexibility, using historically based models that maintain higher levels of spending, notably in conditions of declining student enrolment, and this is actually a reason for lower efficiency of expended funds. The applicable approaches in most Western and Northern European countries (Finland, Denmark) are entirely different, but the indicators that underlie the assessment of results are also essential, including their periodic evaluation and improvement of the models.

The analysis of the three components of the higher education systems within the EU member states shows that perhaps the best performing system focused on the preparation of students, the conduct of scientific research and in terms of financial management, is that of Ireland. In both analysed sub-periods, the efficiency assessment based on the assumption of variable returns to scale shows that the governance of higher education in Ireland is efficient. This country ranks first. The reasons for the good performance of Ireland's higher education system can be illustrated in a variety of aspects, including:

(1) This country has the highest share of people aged 25-64 with higher education (compared to the EU-27 average of 36.7% in 2020, Ireland registers a share exceeding 52%), which is due to its adaptive learning models and short-duration training.

(2) Ireland demonstrates one of the highest values of indicators, measuring the proportion of bachelor's/ master's graduates compared to admitted (enrolled) students, which is significantly influenced by well-established university mentoring services, provision of academic assistance and career advising, which encourage student persistence and successful completion of their studies.

(3) The country also shows one of the lowest values for the indicator measuring the ratio of higher education spending to GDP per capita, despite providing substantial financial support for students.

Ireland is among the EU countries that are distinguished by a very high degree of academic autonomy (Pruvot *et al.*, 2023), which ensures the ability of universities to manage

their resources in the most appropriate way. The results of the applied models on Ireland's performance are consistent with the findings of Perović and Kosor (2020), despite the differences in the selected input and output variables. The only problematic element for Ireland appears to be the inefficiencies of scale in terms of research activity, which can be solved by gradually reducing inputs.

Malta's education system in the period 2013-2016 also achieves a high degree of pure technical efficiency. In parallel, the country is characterized by a rather high degree of overall technical inefficiency in teaching and in the management of higher education expenditure, caused by inefficiencies of scale. This is perhaps one of the reasons that in the second sub-period (2017-2021) the country loses positions compared to other EU member states and reports inefficiency in terms of higher education expenditure management. The Lithuanian higher education system can also be considered among those that report a higher degree of pure technical efficiency. This applies to the management of teaching activities (2013-2016) and higher education expenditure, but not to the implementation of research activities, where the country has a high degree of technical inefficiency, pure technical inefficiency and inefficiency of scale. The results for the higher education in Greece are similar, with the difference that the Greek higher education system in terms of teaching activity and expenditure management is not only technically efficient, but also shows scale efficiency. The higher education system in Romania shows more efficient results compared to the rest of the countries in the second sub-period, with the exception of research activity. An improvement in positions is also present in Hungarian higher education, but again research activity is a serious challenge that generates pure technical inefficiency. Luxembourg, France, Sweden and the Netherlands show a high degree of pure technical efficiency in teaching and research activity, but not in expenditure management efficiency.

The results of the conducted research show quite a few weaknesses (inefficiency) in the higher education systems of countries such as Austria and Croatia (for all three components), Portugal (for all three components, although in the second sub-period there are some improvements in the positions) and Germany (in expenditure management and in teaching activity). Estonia is also among the countries reporting inefficiency, excluding the good positions in research activity in the second period. Latvia and Bulgaria report weak positions in teaching and research activity. At the same time, in the evaluation of the expenditure efficiency, Latvia and Bulgaria maintain more advanced positions, although an increase in inefficiency is noticeable in 2017-2021. Kolev and Tsoklinova (2023) compare the efficiency of higher education expenditure in Bulgaria in 2008-2020 and their findings show that the lowest efficiency is observed in 2020 (the beginning of the COVID-19 pandemic). This also explains the results of the present study and the reduced efficiency in Bulgaria compared to other EU countries. The management of the system of higher education in the Czech Republic in 2017-2021 compared to 2013-2016 shows a deterioration of the results in all three analysed components, which is evidenced by the increased pure technical inefficiency by 5 pp in the teaching activity, by 27.3 pp in expenditure management and by 20.3 pp in the management of research activity.

6. CONCLUSIONS

The topic of evaluating the efficiency of higher education always arouses significant interest, regardless of the level of analysis. Although various analysis techniques are used in research practice, the DEA approach remains perhaps one of the most widely applied options.

The implementation of this method in the present study allows to summarize some weaknesses leading to inefficiency of higher education systems within the EU member states. The analysis includes two sub-periods (2013-2016 and 2017-2021) in order to trace the change in the management of these systems and the subsequent effects. The obtained results show that, in a comparative aspect, there is a decrease in the efficiency of higher education within the EU. To the greatest extent, such a decline is evident in the assessment of expenditure efficiency, where the inefficiency of expenditure management increases by 14 pp. This is a serious challenge for most higher education systems in the EU, especially those that generate sustainable and increasing budgetary resource (mainly publicly funded) over time, which is weakly tied to the results achieved and in particular to socio-economic and demographic processes. It is essential to reform these systems, to introduce funding mechanisms that depend on the results obtained by universities, including a continuous pursuit of regular improvement of both established and recently adopted funding approaches. At any given moment, the funding system must respond to trends in social and economic development and market needs. It is inexpedient to waste financial resources in areas where the market is oversaturated, while at the same time there are staff shortages in other economic areas. The reforms should also focus on reducing the centralized approach to implementing processes, strengthening the relationship between the higher education system and the labour market, as well as introducing and financing new training models (dual training). In certain cases, particularly when expanding the scope of the higher education system, it is advisable to seek restructuring methods, including consolidation, merger of individual units, which may contribute to cutting specific types of expenditures. Such processes may also support efforts to tackle another major issue, specifically strengthening competitive positions, increasing global *visibility*, but also financial sustainability. Precisely for this reason, since 2010, similar processes have been observed within many EU member states, although it is difficult to define it as an established European practice.

The inefficiency of the management of teaching activity increases by approximately 2.2 pp, while in the management of research activity this growth is 1.5 pp. During the second sub-period, 75 % of EU countries report an increase in the ratio of the number of academic staff members to enrolled students. This actually reduces the number of students per teacher. Alongside this, in some EU countries there is a rather negative trend towards a steady rise in the age imbalance (with an emphasis on the increase in the average age of academic staff), as well as insufficient opportunities for the integration of younger staff. Typically, this trend reflects mostly on research results, which is actually the cause for the deterioration of efficiency in terms of research activity. The reason is that there is a stable capacity of human capital, the growth of which does not directly align with the outcomes of the activities. As a solution to this problem, it is appropriate to recommend the implementation of mechanisms that link employment contracts to the expected remuneration of employees. The dynamics in the number of academic staff is also related to the manner in which lecturers are hired. In approximately half of the EU countries, teaching staff on permanent contracts dominate, resulting in a trend towards stability and even an increase in the number of teachers. In some countries, universities prefer the use of temporary contracts, especially for initial (entry-level) positions, which may contribute to higher staff turnover but also to a less noticeable rise in the number of academic staff over time (although statistical data may be distorted, depending mainly on the reporting methodology).

A positive outcome of the applied models and the obtained results is the reduction of inefficiency of scale in the evaluation of expenditure and especially in the estimation of research activity. Therefore, higher education systems are thus approaching their optimal scale, but further efforts are still needed.

This study does not claim to cover all possible activities and functions of the higher education system, but rather aims to assess the most essential aspects of this system. On the other hand, the research can be a good starting point for subsequent analyses, including expanding the scope of this study with participation in other main or additional activities related to higher education. A suitable approach in future research would be to conduct a more comprehensive comparative analysis, that would highlight the main advantages and disadvantages not only of the European, but also of other educational systems in order to increase the overall efficiency.

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ANNEXES

Table no. A1 – Efficiency of the teaching activity of the higher education systems of the EU member states

2013 - 2016						2017 - 2021					
Country	**CRSTE**	**VRSTE**	**SCALE**	**RTS**	**RANK**	**Country**	**CRSTE**	**VRSTE**	**SCALE**	**RTS**	**RANK**
Czech Republic	1.000	1.000	1.000	-	1	Greece	1.000	1.000	1.000	-	1
Greece	1.000	1.000	1.000	-	1	Cyprus	1.000	1.000	1.000	-	1
Luxembourg	1.000	1.000	1.000	-	1	Ireland	1.000	1.000	1.000	-	1
Ireland	1.000	1.000	1.000	-	1	Luxembourg	0.757	1.000	0.757	irs	1
France	1.000	1.000	1.000	-	1	Romania	0.728	1.000	0.728	irs	1
Poland	0.832	1.000	0.832	irs	1	Poland	0.618	1.000	0.618	irs	1
Romania	0.822	1.000	0.822	irs	1	Hungary	0.522	1.000	0.522	irs	1
Netherlands	0.587	1.000	0.587	irs	1	Malta	0.385	1.000	0.385	irs	1
Sweden	0.454	1.000	0.454	irs	1	Czech Republic	0.851	0.958	0.888	drs	9
Lithuania	0.440	1.000	0.440	irs	1	France	0.911	0.922	0.988	drs	10
Malta	0.392	1.000	0.392	irs	1	Netherlands	0.592	0.895	0.661	drs	11
Belgium	0.826	0.939	0.880	drs	12	Finland	0.682	0.794	0.859	drs	12
Finland	0.702	0.801	0.876	drs	13	Belgium	0.669	0.740	0.904	drs	13
Italy	0.691	0.716	0.965	drs	14	Italy	0.672	0.687	0.978	drs	14
Cyprus	0.656	0.662	0.991	drs	15	Lithuania	0.359	0.645	0.556	drs	15
Slovakia	0.605	0.616	0.982	drs	16	Portugal	0.425	0.635	0.669	drs	16
Latvia	0.477	0.589	0.809	drs	17	Sweden	0.426	0.609	0.700	drs	17
Denmark	0.523	0.579	0.904	drs	18	Denmark	0.494	0.592	0.835	drs	18
Hungary	0.539	0.573	0.940	drs	19	Latvia	0.475	0.567	0.837	drs	19
Slovenia	0.479	0.552	0.869	drs	20	Slovenia	0.377	0.541	0.697	drs	20
Germany	0.283	0.515	0.549	drs	21	Bulgaria	0.377	0.497	0.759	drs	21
Bulgaria	0.437	0.507	0.863	drs	22	Estonia	0.454	0.496	0.914	drs	22
Estonia	0.428	0.500	0.855	drs	23	Slovakia	0.461	0.475	0.970	drs	23
Spain	0.462	0.476	0.970	drs	24	Austria	0.387	0.458	0.847	drs	24
Austria	0.393	0.441	0.891	drs	25	Spain	0.389	0.401	0.969	drs	25
Portugal	0.415	0.439	0.945	drs	26	Germany	0.302	0.389	0.775	drs	26
Croatia	0.348	0.375	0.926	drs	27	Croatia	0.306	0.368	0.831	drs	27

Source: authors' calculations with DEAP, version 2.1

Table no. A2 – Efficiency of the research activity of the higher education systems of the EU member states

2013 - 2016						2017 - 2021					
Country	**CRSTE**	**VRSTE**	**SCALE**	**RTS**	**RANK**	**Country**	**CRSTE**	**VRSTE**	**SCALE**	**RTS**	**RANK**
Luxembourg	1.000	1.000	1.000	-	1	Italy	1.000	1.000	1.000	-	1
Malta	1.000	1.000	1.000	-	1	Luxembourg	1.000	1.000	1.000	-	1
Netherlands	1.000	1.000	1.000	-	1	Malta	1.000	1.000	1.000	-	1
Italy	0.839	1.000	0.839	drs	1	Netherlands	1.000	1.000	1.000	-	1
Denmark	0.766	1.000	0.766	drs	1	Ireland	0.983	1.000	0.983	drs	1
Ireland	0.674	1.000	0.674	drs	1	Denmark	0.811	1.000	0.811	drs	1
Sweden	0.594	1.000	0.594	drs	1	Finland	0.748	1.000	0.748	drs	1
Czech Republic	0.540	1.000	0.540	drs	1	Sweden	0.688	1.000	0.688	drs	1
Finland	0.519	1.000	0.519	drs	1	France	0.556	1.000	0.556	drs	1
France	0.480	1.000	0.480	drs	1	Estonia	0.505	1.000	0.505	drs	1
Germany	0.244	1.000	0.244	drs	1	Germany	0.261	1.000	0.261	drs	1
Belgium	0.592	0.985	0.602	drs	12	Belgium	0.632	0.944	0.670	drs	12
Cyprus	0.565	0.861	0.656	drs	13	Slovenia	0.629	0.806	0.781	drs	13
Spain	0.627	0.830	0.756	drs	14	Czech Republic	0.703	0.797	0.883	drs	14
Greece	0.479	0.829	0.578	drs	15	Cyprus	0.713	0.760	0.939	drs	15

2013 - 2016						2017 - 2021					
Country	**CRSTE**	**VRSTE**	**SCALE**	**RTS**	**RANK**	**Country**	**CRSTE**	**VRSTE**	**SCALE**	**RTS**	**RANK**
Estonia	0.291	0.798	0.365	drs	16	Greece	0.629	0.692	0.910	drs	16
Slovenia	0.559	0.792	0.705	drs	17	Portugal	0.467	0.658	0.710	drs	17
Portugal	0.448	0.694	0.646	drs	18	Croatia	0.517	0.627	0.824	drs	18
Hungary	0.373	0.650	0.573	drs	19	Hungary	0.379	0.554	0.685	drs	19
Croatia	0.452	0.594	0.761	drs	20	Lithuania	0.409	0.481	0.849	drs	20
Romania	0.257	0.421	0.610	drs	21	Spain	0.353	0.464	0.761	drs	21
Slovakia	0.248	0.402	0.616	drs	22	Slovakia	0.409	0.455	0.898	drs	22
Austria	0.280	0.376	0.745	drs	23	Austria	0.345	0.409	0.844	drs	23
Poland	0.265	0.358	0.739	drs	24	Poland	0.366	0.384	0.954	drs	24
Lithuania	0.293	0.351	0.835	drs	25	Romania	0.340	0.365	0.933	drs	25
Bulgaria	0.173	0.242	0.715	drs	26	Latvia	0.331	0.332	0.996	irs	26
Latvia	0.237	0.238	0.994	irs	27	Bulgaria	0.245	0.277	0.885	drs	27

Source: authors' calculations with DEAP, version 2.1

Table no. A3 – Expenditure efficiency of the higher education systems of the EU member states

2013 - 2016						2017 - 2021					
Country	**CRSTE**	**VRSTE**	**SCALE**	**RTS**	**RANK**	**Country**	**CRSTE**	**VRSTE**	**SCALE**	**RTS**	**RANK**
Greece	1.000	1.000	1.000	-	1	Greece	1.000	1.000	1.000	-	1
Hungary	1.000	1.000	1.000	-	1	Ireland	1.000	1.000	1.000	-	1
Ireland	1.000	1.000	1.000	-	1	Romania	1.000	1.000	1.000	-	1
Lithuania	1.000	1.000	1.000	-	1	Lithuania	0.864	1.000	0.864	drs	1
Poland	0.929	1.000	0.929	drs	1	Hungary	0.855	1.000	0.855	drs	1
Slovakia	0.687	1.000	0.687	drs	1	Slovakia	0.673	0.744	0.904	drs	6
Malta	0.651	1.000	0.651	drs	1	Bulgaria	0.648	0.743	0.872	drs	7
Denmark	0.937	0.976	0.961	irs	8	Italy	0.735	0.740	0.994	irs	8
Czech Republic	0.910	0.913	0.997	irs	9	Spain	0.692	0.736	0.940	drs	9
Bulgaria	0.870	0.875	0.994	irs	10	Poland	0.705	0.728	0.968	drs	10
Slovenia	0.795	0.874	0.910	irs	11	Latvia	0.653	0.715	0.915	drs	11
Romania	0.851	0.869	0.980	irs	12	Czech Republic	0.639	0.640	0.999	-	12
Finland	0.711	0.806	0.883	drs	13	Belgium	0.577	0.631	0.913	drs	13
Spain	0.792	0.799	0.991	irs	14	Finland	0.533	0.606	0.880	drs	14
Germany	0.730	0.744	0.981	irs	15	Cyprus	0.592	0.603	0.980	drs	15
Latvia	0.731	0.738	0.991	irs	16	France	0.566	0.567	0.999	-	16
Belgium	0.715	0.716	0.998	irs	17	Sweden	0.461	0.555	0.831	drs	17
Croatia	0.690	0.714	0.967	irs	18	Germany	0.532	0.533	0.999	irs	18
Luxembourg	0.641	0.670	0.957	drs	19	Croatia	0.488	0.525	0.931	irs	19
Cyprus	0.626	0.668	0.937	drs	20	Austria	0.495	0.495	0.999	-	20
Italy	0.632	0.657	0.961	irs	21	Luxembourg	0.479	0.487	0.983	drs	21
France	0.637	0.640	0.994	irs	22	Netherlands	0.473	0.480	0.987	drs	22
Sweden	0.578	0.634	0.912	drs	23	Slovenia	0.474	0.477	0.994	irs	23
Austria	0.588	0.612	0.961	irs	24	Portugal	0.433	0.471	0.920	irs	24
Netherlands	0.589	0.589	0.999	-	25	Malta	0.451	0.452	0.996	irs	25
Estonia	0.524	0.538	0.974	drs	26	Denmark	0.410	0.437	0.937	irs	26
Portugal	0.467	0.523	0.892	irs	27	Estonia	0.378	0.396	0.956	drs	27

Source: authors' calculations with DEAP, version 2.1

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Corporate Governance and Accounting Conservatism: Evidence from French CAC 40 Listed Companies

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Abstract: This paper aims to study how board diversity impacts the accounting conservatism. It uses a sample of 34 companies listed on the CAC 40 during the 2012-2021period. Using Givoly and Hayn (2000) accrual-based measure of accounting conservatism, we found that directors' demographic characteristics (age, gender, nationality) positively affect the accounting conservatism. The findings may be of interest to regulators, corporate managers, and board of directors interested in enhancing disclosure quality. As the study links board demographic attributes to accounting conservatism, policies can be developed in order to improve the configuration of boards and thus the credibility of financial statements. This study claims originality insofar as it focuses on the effect of directors' demographic diversity on accounting conservatism practices. Unlike earlier studies that examined board of directors' structure from the corporate governance perspective, our study investigates how precisely demographic attributes of board directors affect the accounting conservatism.

Keywords: board gender diversity; board nationality diversity; board age diversity; accounting conservatism; demographic attributes.

JEL classification: G32; M41.

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1. INTRODUCTION

Accounting conservatism, as a financial reporting stance, is one of the most important characteristics of corporate accounting information quality (Shen and Ruan, 2022). It is a long-standing convention in financial reporting, and a multi-dimensional concept (Hansen *et al.*, 2018). In fact, a variety of accounting conservatism definitions have been developed (Boulhaga *et al.*, 2023). For instance, Givoly and Hayn (2000) define conservatism as « *a selection criterion between accounting principles that lead to the minimization of cumulative reported earnings by slower revenue recognition, faster expense recognition, lower asset valuation, and higher liability valuation* ». Basu (1997), on the other hand, defines conservatism as an asymmetry in reported earnings that respond more quickly and completely to bad news than to good news.

The relationship between internal corporate governance mechanisms and accounting conservatism is largely investigated in the literature (Yunos *et al.*, 2014; Hajawiyah *et al.*, 2020; Chatterjee and Rakshit, 2023). Prior studies assert that effective corporate governance mechanisms restrict the opportunistic behavior of the managers which may lead them to be more conservative in their financial reports (García Lara *et al.*, 2009; El-habashy, 2019a). Particularly, a huge body of empirical research has investigated the impact of board characteristics on the quality of financial reports (Aifuwa and Embele, 2019; Vitolla *et al.*, 2020; Aksoy *et al.*, 2021; Wang *et al.*, 2022; Almuzaiqer *et al.*, 2023; Islam *et al.*, 2023). They find evidence that the strength of board governance is positively associated with accounting conservatism (Boussaid *et al.*, 2015). The board of directors is assumed to be the most powerful governing body in companies (Iazzi *et al.*, 2023). It can mitigate information asymmetries among stakeholders, reduce conflicts with regulators, and ensure the fulfilment of legal responsibilities (Jensen and Meckling, 1976; Barros *et al.*, 2021; Dakhli, 2021). It has, in addition, the responsibility to guide and control the structures and strategies of the company. However, the effectiveness of this role is largely influenced by board of directors' structure (De Andres and Vallelado, 2008).

Several empirical studies have shown an increased interest in analyzing the relationship between board structure and accounting conservatism (Ruch and Taylor, 2015; Alves, 2021; Rustiarini *et al.*, 2021). In this vein, Usman *et al.* (2022) reported that the ratio of external directors has a negative effect on the earnings management proxy. Companies that have a higher rate of external directors are more likely to recognize losses in a timely manner than companies with a low rate of external directors (Sharma and Kaur, 2021; Hassaan and Salah, 2023). Previous empirical studies provided more support for small board size to be associated with effective governance (Malik *et al.*, 2014; Huang and Wang, 2015; Jamil *et al.*, 2021) and thus more accounting conservatism (Nasr and Ntim, 2018). Jensen and Meckling (1976) had argued that the problem of coordination for large board size can outweigh the advantages. However, Ahmed and Henry (2012) reported that large board size enhance the effectiveness of the monitoring process, which increases the scope of accounting conservatism due to expertise broad variety, especially the quality of financial reports. They claimed that women are more trustworthy than men, and are, thereby, less likely to manipulate corporate financial and other disclosures. Their conservative mindset and ethical leadership may contribute to a better internal control environment with a stronger emphasis on conservative and ethical financial reporting (Ho *et al.*, 2015).

Empirically, while numerous studies have investigated the impact of board structure on accounting conservatism (Muhammad *et al.*, 2025), they have limitations. First, there has been little evidence on how board demographic attributes (such as age, gender, and nationality) particularly affect the accounting conservatism (Plöckinger *et al.*, 2016; Gull *et al.*, 2018; Díaz-Fernández *et al.*, 2019). Previous studies in the area of accounting conservatism addressed the board of directors' structure from the corporate governance point of view by focusing on directors' independence, board size, leadership structure, and ownership. Nevertheless, there is a little attention to the effect of directors' demographic characteristics (Makhlouf *et al.*, 2018). Thus, our study aimed to portray a more reliable picture of the association between the diversity in top managers' demographic attributes and their effect on firms' accounting quality. Second, few studies have been conducted in Europe (Ben Fatma and Chouaibi, 2024), precisely in France which provides an interesting research context for exploring the drivers of accounting conservatism (Ahmadi and Bouri, 2024) for several reasons. According to Rahman *et al.* (2010) and Slimani *et al.* (2024), France has had a more conservative approach to regulate accounting activities. It is also a pioneer in promoting board gender diversity through laws (Muhammad *et al.*, 2025) by setting, in January 2011, the Copé-Zimmermann law stipulating that companies listed on the French stock market (CAC40) added to those having more than 500 employees and a turnover higher than 50 million euros, should increase female representation on their board to 20% by 2014 and 40% by 2017.

These limitations have undoubtedly hindered a full understanding of the board attributes-accounting conservatism association and, thus, deserve further investigation. Therefore, the current study seeks to fill the gap in the extant literature by examining what was relatively neglected by previous studies. It had to get, also, a more in-depth understanding of the board demographic attributes-accounting conservatism relationship. For this purpose, it incorporates gender diversity, nationality diversity, and age diversity into the study model to explore their impact on the accounting conservatism. While doing this our results will contribute to the exiting literature by providing evidence that board attributes may be meaningful drivers of reporting quality. The literature is certainly extensive (Malik *et al.*, 2014; Ho *et al.*, 2015; Huang and Wang, 2015; Nasr and Ntim, 2018; Jamil *et al.*, 2021; Sharma and Kaur, 2021; Usman *et al.*, 2022; Hassaan and Salah, 2023; Khoifin *et al.*, 2023), but it is limited to board attributes from a corporate governance perspective. To our knowledge, too few studies have examined the association between demographic attributes of directors and accounting conservatism (Makhlouf *et al.*, 2018; Ismail *et al.*, 2021). Hence, our study will offer incremental insights in this area.

This study claims originality insofar since its focus on the effect of directors' demographic diversity (age, gender and nationality) on accounting conservatism practices. Unlike earlier studies that examined board of directors' structure from the corporate governance perspective by analyzing the effects of board independence, board size, board meetings and CEO duality, our study went further to investigate how precisely demographic attributes of board directors affect the accounting conservatism. Thus, the findings will contribute to the literature by offering new evidence.

The remainder of the paper is structured as follows. Section 2 reviews relevant literature and develops the hypotheses. Section 3 describes the research methodology, followed by the results in Section 4. Section 5 presents the conclusion, limitations and suggestions for future research.

2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Based on prior studies, we develop, in this section, hypotheses on the impact of demographic diversity at board on accounting conservatism level. Directors' demographic characteristics such gender, nationality, and age are included.

2.1 Board gender diversity and accounting conservatism

The agency theory (Jensen and Meckling, 1976) postulates that the presence of women on the board of directors is more effective and resilient in monitoring decision making (Boussaidi and Hamed, 2015). It enables a firm to achieve a good governance structure (Orazalin, 2020). The presence of women on corporate boards can contain the selfish and opportunistic behaviors of managers (Dakhli, 2022). Proponents of agency theory argue that women are more trustworthy than men, and are thereby less likely to manipulate corporate financial and other disclosures. Accordingly, the conservative mindset and ethical leadership of women (Ho *et al.*, 2015; Faccio *et al.*, 2016) may contribute to a better internal control environment with a stronger emphasis on conservative and ethical financial reporting (Francis *et al.*, 2015; Chouaibi *et al.*, 2022; Garcia Lara *et al.*, 2022; Githaiga and Kosgei, 2023).

Based on agency theory, numerous prior studies showed a positive association between gender diversity in boards and accounting conservatism. For instance, Palvia *et al.* (2009) note that gender differences in board can influence the quality of financial reporting, given their personality traits such as conservatism, risk aversion and ethical behaviour. This result is later confirmed by Boussaid *et al.* (2015) who investigated the relationship between corporate board of directors' attributes and conditional accounting conservatism in the French context. Using a pooled regression model over the period 2009-2012, they found a positive association between gender diversity and accounting conservatism. They argued that female presence on the board builds and maintains ethical standards. Furthermore, it assists in more rigorous monitoring related to firms' strategic decisions. In the same vein, Makhlouf *et al.* (2018) confirm the monitoring role of board of directors, noting the positive influence of board diversity on accounting conservatism and its role in enhancing the credibility of financial reporting for firms listed on Amman Stock Exchange. More recently, Davis and Garcia-Cestona (2023) investigated the effects of board gender diversity on financial reporting quality proxied by restatements in listed US firms. They provide evidence that restatements are less likely when a higher proportion of women serve on the board of directors. Based on these findings, we assume a positive relationship between BGD and accounting conservatism.

H1*: Board gender diversity (BGD) is negatively associated with accounting conservatism.*

2.2 Board nationality diversity and accounting conservatism

Resource dependency theory as a management-based theory introduced by Pfeffer and Salancik (2015) focuses on a director's resource role covering some of a of board attributes (Khalifa *et al.*, 2020). This theory provides a theoretical basis that the nationality diversity of directors is a valuable resource for the company (Darmadi, 2011; Estélyi and Nisar, 2016) as it offers various perspectives, skills and values (Kaczmarek and Ruigrok, 2013) that may enhance the corporate reporting quality. From this theoretical perspective, Metwally (2021)

aimed to provide a better understanding of how the nationality diversity of directors may affect the accounting conservatism level. For this purpose, the researcher used large samples of UK firms over the period from 1999 to 2018 and provided robust evidence that nationality diversity on the board matters for financial reporting quality since it has positively impacted accounting conservatism. Similarly, Elleuch Lahyani (2022) analysed the association between carbon disclosure and board diversity by drawing on multiple theoretical frameworks that embody five dimensions including board nationality. Based on a sample of 120 French listed firms, findings show that board nationality plays a key role in enhancing carbon disclosure.

Another research stream also investigated the impact of directors' nationalities on accounting conservatism from a different theoretical perspective namely the upper echelon theory. In this line, Plöckinger *et al.* (2016) reviewed archival, experimental and survey research on the influence of individual executives demographic characteristics on corporate financial reporting drawing on upper echelons theory as an organizing framework. Their review of 60 studies shows that research consistently finds that top management executives exert significant influence on financial reporting decisions, particularly on disclosure quality. More precisely, Makhlouf *et al.* (2018) indicated that there is a positive and significant relationship between the existence of foreign members and accounting conservatism measured by accrual-based conservatism. The board of directors dominated by foreign members will require more quality information, so that they tend to use more conservative accounting procedures. Based on the arguments discussed above, we posit the following hypothesis:

H2*: Board nationality diversity (BND) is positively associated with accounting conservatism.*

2.3 Board age diversity and accounting conservatism

Board directors have varying background and demographic characteristics that may result in differences in cognitive orientation and, thus, strategic decision-making (Shen, 2021). Upper Echelon theory (Hambrick and Mason, 1984) assumes that board directors characteristics affect their information processing and decision making performance (Yu, 2021; Atwa *et al.*, 2023). Drawing on upper echelon theory, prior studies provide evidence showing that the directors' age affects corporate decision making (Dakhli and Mtiraoui, 2023), particularly the level of accounting conservatism (Makhlouf *et al.*, 2018; Martikainen *et al.*, 2023). According to Hambrick and Mason (1984), the young managers develop a strategy more conducive to risk-taking and innovation. However, older managers are more conservative and seek job stability (Matta and Beamish, 2008). They are more rigid in adopting new practices (Nguyen *et al.*, 2022). In this perspective, Huang *et al.* (2012) hypothesized that older top managers are associated with higher quality financial reporting. Using a sample of 3,413 firms for the period from 2005 to 2008, they extended the corporate governance and financial reporting quality literature by identifying managers' age as a determinant of financial reporting quality. They find a positive association between CEO age and financial reporting quality. More recently, Makhlouf *et al.* (2018) denied this finding by showing that age diversity does not matter to accounting conservatism, which implies that there is no notable distinction between the younger and older directors regarding it Focusing on Islamic banks particularly, Almutairi and Almutairi and Quttainah (2019) confirmed the existence of a positive association between directors' age and accounting conservatism behaviors. More specifically, they prove that older outside directors make better acquisition decisions, engage less in earnings management and support more conservative accounting practices. Although previous studies reveal somewhat mixed

results, we expect a positive relationship between accounting conservatism and directors' age. Therefore, we offer the following hypothesis:

H3*: The board age diversity is positively associated with accounting conservatism.*

3. RESEARCH DESIGN

3.1 Data and sample selection

We used an initial sample of 40 French companies listed on the CAC 40 during the period between 2012 and 2021. First, we exclude financial firms as they are subject to different regulations and market trading mechanisms. Since, not all the necessary financial data have been available for each firm over such period, we remove those with missing value. Our final sample includes 34 firms (340 firm-year observations). Table no. 1 summarizes the sample selection procedure. For our empirical analysis, we used the database DataStream to compute financial information. Data concerning board of directors' information is collected from the firms' annual report and website. We also hand-collected the director's attributes.

Table no. 1 – Sample selection

Initial sample	40
Financial firms	(5)
Firms with missing data	(1)
Final sample	34
Observation period 2012-2021	10 years
Number of observations	**340**

3.2 Variables measures

3.2.1 Dependent variable

The accounting conservatism is our dependent variable. A variety of measures of accounting conservatism have been developed (Hansen et al., 2018). This study adopts the accrual-based measure of conservatism (CON-ACC) used by Givoly and Hayn (2000) and Ahmed and Duellman (2007). These authors measure accruals as follows:

$$Accruals = \frac{EBEXT_{it} + DEP_{it} - OCF_{it}}{TA_{it}}$$

where: EBEXT is the income before tax and extraordinary items; DEP is the depreciation charge for the year; OCF is operating cash-flow, and TA is total assets.

These authors posit that accounting conservatism (CON-ACC), as based on accruals, results in negative accruals where more negative accruals indicate a higher level of conservative accounting in corporate financial reporting (El-Habashy, 2019b). Therefore, the accounting conservatism measure is: CON-ACC = Accruals × (-1).

Table no. 2 – Variables measures

Variable	Acronym	Definition
Dependent variable		
Accounting conservatism	CON-ACC	$CON - ACC = \left(\frac{EBEXT_{it}+DEP_{it}-OCF_{it}}{TA_{it}}\right) \times (-1)$ Where: EBEXT is the income before tax and extraordinary items; DEP is the depreciation charge for the year; OCF is operating cash-flow and TA is total assets.
Independent variables		
Board gender diversity	BGD	the percentage of female directors
Board nationality diversity	BND	the percentage of foreign directors in the board
Board age diversity	BAD	The average age of board directors
Control variables		
Firm size	SIZE	Natural log of total assets
Firm leverage	LEV	Total debt divided by total assets

3.2.2 Independent variables.

Based on the literature, we included four independent variables expected to influence accounting conservatism, namely:

- Board age diversity (BAD). Age diversity describes the age distribution of board members in the company's board structure (Anggraenia and Kurniantob, 2020; Biduri *et al.*, 2023). To assess this variable, we used the average age of board directors. This measure has been largely used by prior empirical studies (Sartawi *et al.*, 2014; Makhlouf *et al.*, 2018; Almutairi and Quttainah, 2019).
- Board nationality diversity (BND). In this study, board nationality diversity is measured by the percentage of foreign directors on the board. Numerous previous studies (Darmadi, 2011) Ibrahim and Hanefah, 2016) have used it as an independent variable which could influence the accounting conservatism (Metwally, 2021).
- Board gender diversity (BGD) is measured by calculating the percentage of female directors serving on a firm's board. We calculate the ratio of female board members to total board members of the sampled firms (Boussaid *et al.*, 2015; Dakhli, 2022).

3.2.3 Control variables

Based on the literature, we included three control variables that are expected to influence accounting conservatism, namely, firm size and firm leverage.

- Firm size as measured by taking the natural log of total assets is one of the most frequently used measures for firm size (Jarboui, 2013). Boussaid *et al.* (2015) and Yuliarti and Yanto (2017) argued that Firm size has a positive effect on accounting conservatism. The larger the firm size is, the greater the tax imposition for the company will be. Hence, to reduce taxes, large companies tend to apply a conservative accounting (Solichah and Fachrurrozie, 2019; Ismail *et al.*, 2021; Le *et al.*, 2023; Muslim and Setiawan, 2024).
- Firm leverage was assessed as total debt divided by total assets (Mohammed *et al.*, 2017). Dang and Tran (2020) show that financial leverage has a positive effect on accounting

conservatism proving the great impact of creditors on the firm's demand for accounting conservatism application (Salehi *et al.*, 2021; Khalifa *et al.*, 2022; Lonare, 2024).

3.3 Models specification

In this study, we aim at examining the effect of board demographic diversity on accounting conservatism. For this purpose, we estimate the following equation:

$$CON\text{-}ACC_{it} = \beta_0 + \beta_1 BGD_{it} + \beta_2 BND_{it} + \beta_3 BAD_{it} + \beta_4 SIZE_{it} + \beta_5 LEVit + \varepsilon_{it}$$

where: CON-ACC is accounting conservatism as measured with the model of Givoly and Hayn (2000); BGD is board gender diversity; BND is board nationality diversity; BAD is average age of directors; SIZE is firm size; LEV is firm leverage.

4. EMPIRICAL RESULTS

4.1 Descriptive statistics

Table no. 3 provides descriptive statistics for the regression variables. The panel presents descriptive statistics for the entire sample, including the mean, minimum, maximum and standard deviation. The dependent variable, accounting conservatism, has a mean value 0.007 and varies between -0.253 and 0.179. These values are similar to those reported by Slimani *et al.* (2024) for French firms listed on the SBF 120 index. This finding implies that the French firms have become both more conservative in their financial reporting and more compliant with the accounting standards.

For BGD, the mean value was 0.39 at a standard deviation of 0.129, notably close to Dakhli (2022) finding that board gender diversity in French firms spans from a minimum of 0 to a maximum of 0.595 with a mean of 0.255. Over the period 2012- 2021, BND has a mean value of 0.215 with a standard deviation of 0.213; implying that more than 78% of board members in French companies are not French. This result confirms those reported previously by Benaguid and Antari (2024) on a sample of 63 French companies belonging to SBF 120 index. These authors concluded that only 25% of board directors have French nationality. Regarding the board age diversity, the findings report that the average directors' age is approximately 51.7 years, with a maximum age of (73) years, and a minimum of (34) years, which is consistent with Slimani *et al.* (2024) who reported that the average age of directors is 57.86 years. This difference could be explained by their use of a larger sample, i.e. 59 French firms listed on SBF 120 index.

Table no. 3 – Descriptive statistics

Variables	Mean	SD	Min	Max	Skewness	Kurtosis
CONS-ACC	0.007	0.048	-0.253	0.179	1.28	2.36
BAD	51.7	1.71	34	73	0.32	-0.76
BND	0.215	0.213	0	0.916	1.46	0.65
BGD	0.390	0.129	0	0.838	1.02	2.08
LEV	0.719	4.555	0	70.34	1.447	0.461
SIZE	26.107	1.456	11.145	19.458	0.965	-2.897

Notes. CON-ACC is accounting conservatism; BAD is board age diversity; BGD is board gender diversity; BND is board nationality diversity; SIZE is firm size; LEV is firm leverage.

4.2 Testing the Validity of Data for Statistical Analysis

Before performing the regression analysis, several tests need to be conducted, mainly the normality of our data, the presence/absence of a problem of multicollinearity and the heteroscedasticity.

4.2.1 Normal-Distribution Test

The normality test is used to determine whether or not the data on the dependent variable and independent variables have a normal distribution. As suggested by Makhlouf *et al.* (2018), this study adopts skewness within (± 1.96), and kurtosis (± 3) to check for normality. The results of skewness and kurtosis, as reported in Table no. 3, show that the data was normally distributed.

4.2.2 Correlation and heteroscedasticity analysis

Table no. 4 reports the correlations among the variables. As a rule of thumb, a correlation of 0.70 or higher in absolute value may cause multicollinearity between variables (Liu *et al.*, 2020). The highest correlation coefficient is 0.339 via the relationship between SIZE and BND. In addition, the variance inflation factors (VIF) factors are weak (≤1.97). We can confirm the absence of multicollinearity between our model variables (Chatterjee and Hadi, 2015).

Table no. 4 – Pearsons correlations

	CONS-ACC	BAD	BND	BGD	LEV	SIZE	VIF
CONS-ACC	1.000						1.30
BAD	0.078	1.000					1.20
BND	0.046**	0.210***	1.000				1.16
BGD	0.087***	-0.069**	0.075	1.000			1.06
LEV	0.105	0.189	0.145**	0.001	1.000		1.02
SIZE	-0.260***	0.148	0.339***	0.218**	0.039***	1.000	1.12

4.2.3 Autocorrelation and heteroscedasticity analysis

To check for heteroscedasticity, Modified Wald test was used. Results, as reported in Table no. 5, attest that the model is heteroscedastic, where the p-value < 0.05. We also performed the Wooldridge test to examine whether there is an autocorrelation problem in the data. The results in Table no. 5 indicate that autocorrelation does not exist, where the p-value > 0.05.

Table no. 5 – Wald and Wooldridge tests

	Chi 2	(Prob > Chi2)
Wald test	2.00	(0.000)
Wooldridge test	1.35	(0.278)

4.2.4 Choosing the appropriate regression model for Panel Data

This study used the Hausman (1978) test to determine which estimation model, whether the fixed or random effects one, best explains our empirical results. The results of the Hausman specification test (Table no. 6) indicate that the fixed effects model is more suitable and should be used. As presented in Table no. 6, the Fisher test proves to be significant at the 1% threshold for both models, confirming the individual fixed effects.

Table no. 6 – Hausman and Fisher tests

	Chi 2	(Prob > Chi2)
Hausman test	52.79	(0.000)
Fisher test	41.12	(0.000)

Our regressions will be estimated by the generalized least squares (GLS) method that is more suitable for panel data and allows us to correct the problem of heteroscedasticity (Wooldridge, 2003). It is preferred to estimation in accounting research (Larcker and Rusticus, 2010; Schumann *et al.*, 2024).

4.3 Results of structural equation model

The aim of this study is to investigate the impact of the board demographic attributes and firm characteristics on accounting conservatism. Table no. 7 provides evidence on the basic results.

4.3.1 The relationship between BGD and accounting conservatism

Results of the regression analysis are reported in Table no. 7. They indicate, as predicted, that board gender diversity is positively and significantly associated with accounting conservatism (β1= 0.017) which enables us to accept H1. This finding is consistent with agency theory arguing that women are more trustworthy than men, and are, thereby, less likely to manipulate corporate financial and other disclosures. Accordingly, the conservative mindset and ethical leadership of women (Ho *et al.*, 2015; Faccio *et al.*, 2016) may contribute to a better internal control environment with a stronger emphasis on conservative and ethical financial reporting (Francis *et al.*, 2015; Githaiga and Kosgei, 2023). Our results are in line with those reported by the stream majority of prior studies showing a positive association between gender diversity in boards and accounting conservatism (Boussaid *et al.*, 2015; Makhlouf *et al.*, 2018). They argued that female presence on the board builds and maintains ethical standards and assists in more rigorous monitoring in firms' strategic decisions given their personality traits such as conservatism, risk aversion and ethical behaviour. Therefore, board gender diversity may enhance the quality of financial reporting.

Table no. 7 – Results of regression analysis

	CONS-ACC	P value
Constant	0.050	0.042**
BGD	0.017	0.005***
BND	0.016	0.011**
BAD	0.0003	0.219
LEV	0.001	0.395
SIZE	-0.002	0.007***

Notes. CON-ACC is accounting conservatism; BAD is the average age of directors; BGD is board gender diversity; BND is board nationality diversity; SIZE is firm size; LEV is firm leverage; *** p<0.01; ** p<0.05.

4.3.2 The relationship between BND and accounting conservatism

As can be seen from Table no. 7, and in accordance with our expectations, the estimated coefficient of board nationality diversity is significantly positive (β2= 0.016). Such a result indicates that firms with higher level of foreign directors tend to use more conservative accounting procedures. These findings enable us to accept our second hypothesis (H2) and support the resource dependency theory suggesting that the nationality diversity of directors is a resource to the company (Darmadi, 2011) as it provides various perspectives, skills and values (Kaczmarek and Ruigrok, 2013) that may enhance the corporate reporting quality. Our findings are consistent with those given by several previous studies (Plöckinger *et al.*, 2016; Makhlouf *et al.*, 2018; Elleuch Lahyani, 2022) which support the presence of foreign directors in boards. They suggested that board nationality plays a key role in enhancing disclosure quality. They concluded that there is a positive and significant relationship between the existence of foreign members and accounting conservatism. The board of directors dominated by foreign members will require more quality information, so that they tend to use more conservative accounting procedures (Metwally, 2021).

4.3.3 The relationship between the BAD and accounting conservatism

With regard to the average age of directors, the regression results show a positive but not significant coefficient (β3= 0.0003). Hence, H3 is not supported. These results, also, contradict with Upper Echlon theory (Hambrick and Mason, 1984) positing that the young managers develop a strategy more conducive to risk-taking and innovation. However, older managers are more conservative and seek job stability (Matta and Beamish, 2008). Our finding is consistent with Makhlouf *et al.* (2018) who showed that age diversity does not matter to accounting conservatism, which implies that there is no notable distinction between the younger and older directors regarding the accounting conservatism. However, our result contradicts with most of prior researches reporting a positive association between the average age of directors and accounting conservatism (Huang *et al.*, 2012; Almutairi and Quttainah, 2019; Martikainen *et al.*, 2023). According to them, older directors make better acquisition decisions, engage in less earnings management and support more conservative accounting practices. Hence, they will be associated with higher quality financial reporting.

In terms of control variables, firm size has negative and significant impact on accounting conservatism (β6= -0.002). Our results do not align with those of Jarboui (2013); Boussaid *et al.* (2015); Yuliarti and Yanto (2017) who concluded that firm size has a positive effect on

accounting conservatism. The larger the firm size is, the greater the tax imposition for the company will be. The latter tends, therefore, to apply a conservative accounting behavior in order to reduce taxes.

5. CONCLUSION

The purpose of this study is to investigate the impact of board diversity on accounting conservatism among French listed firms during the 2012-2021 period. Four demographic characteristics of directors have been included, namely: gender diversity, average age and nationality diversity. Accounting conservatism was measured by accrual-based conservatism model as developed by Givoly and Hayn (2000). Our findings validate the monitoring role of the board of directors, highlighting the positive impact of board diversity on accounting conservatism and improving the credibility of financial reporting. They show that both gender and nationality diversities are positively and significantly associated with accounting conservatism while the relationship between board age diversity and accounting conservatism is positive but not significant. Overall, our results support the agency and resource dependency theories which opt for more female and foreign directors in boards to improve internal control environment with a stronger emphasis on conservative and ethical financial reporting (Boussaid *et al.*, 2015; Makhlouf *et al.*, 2018; Metwally, 2021). The clear influence of board diversity revealed in this study suggests that it is important to consider directors' demographic characteristics to understand their behavior and decision since their responsibility to assess the main issues on accounting principles and the quality of disclosed financial information.

Our results have practical implications that may be useful to corporate managers, regulators, and investors. The board of directors and the external supervising organizations can explain the purpose of corporate information disclosure and identify its quality by analyzing and comparing the influence of different characteristics of directors on accounting conservatism, so as to better monitor corporate information disclosure behavior and provide reliable and stable accounting information. As the study links board demographic attributes to accounting conservatism, policies can be developed in order to improve the configuration of boards and thus the credibility of financial statements. Precisely, this study clearly shows that the presence of female and foreign directors on the board of directors can have positive impacts on accounting conservatism. Thus, boards seeking to improve accounting conservatism should engage more female and foreign directors and ensure, therefore, a high level of accounting quality. Our results, also, help regulators in the debate on gender quotas in boards and assist in improving investor protection since firms' diversity efforts may result in greater transparency and accountability in financial reporting. Moreover, our findings have potential implications for company' stakeholders, particularly investors and their advisors. These implications are based on the importance of acquiring reliable, trustworthy, timely, relevant and transparent accounting information for investors to make more assertive decisions. Our findings attest that a diversified board in terms of gender and nationality improves the quality of reporting. Therefore, these two demographic characteristics may serve as signals for effective judgement of the quality of financial information and provide a theoretical basis for them to make reasonable decisions and effectively safeguard their own interests.

Despite these contributions, this study has some limitations that could be addressed in future research studies. The first consists in the impossibility of generalizing the results, since only information from directors working in companies belonging to specific index in the

French stock market have been analyzed, precisely CAC 40 index. It is suggested for upcoming research that the study sample be expanded or altered. It is also recommended to consider other variables regarding the profile of managers. Thus, subsequent studies addressing this issue are recommended to extend their samples by including companies belonging to other indexes and other markets. Secondly, the current study was limited to a single measure of accounting conservatism namely the accrual-based measure. Hence, future studies could use different proxies for conservatism such as the market-value based proxy following Beaver and Ryan (2000) to enhance the robustness of the results. Thirdly, although there are various board attributes that can influence accounting conservatism practices, this study is limited to four proxies. The inclusion of more board characteristics in the analysis will offer additional relevant results. Future studies can consider other board diversity attributes that may impact the accounting conservatism and, therefore, the quality of financial reporting, notably ethnicity and professional expertise of directors.

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Remittances and Tax Revenue in SSA Countries: A Panel ARDL Approach

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Abstract: This study evaluates the impacts of remittances on tax revenue in Sub-Saharan African countries. The Kao Cointegration test assesses the presence of long-term relationship between remittances and tax revenues, and Panel ARDL model estimates the impact of remittances on tax revenues. The results of tests show that remittances have a positive impact on both direct and indirect tax revenues. Remittances could be a source of financial resources for entrepreneurs, and facilitate the employment of idle production capacities, leading to an increase in economic activity and employment. Consequently, they could increase direct taxes via income taxes on increased economic activities and employment. In addition, remittances are primarily used for maintaining and improving welfare of family at home, leading to an increase in consumer spending. Consequently, a rise in consumption could increase indirect tax revenues. The study highlights the pivotal role of remittances increasing the tax revenue in Sub-Saharan African countries, underlining the necessity for policymakers to consider remittances in their fiscal planning.

Keywords: remittances; tax revenue; Sub-Saharan Africa.

JEL classification: F24; H2; O55.

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1. INTRODUCTION

International labor migration is becoming a global trend, with the flow of migrants moving predominantly from developing countries to developed countries and emerging economies. The number of migrant workers surged from 20 million in 1970 to 200 million in 2022 (International Organization for Migration, 2022). Inflow of remittances to migrant sending countries accompanied the international labor migration. Remittances increased from 2 billion (current USD) in 1975 to 766 billion in 2022 (Mansoor and Quillin, 2006). The remittances constitute the second largest source of capital inflows into developing countries following Foreign Direct Investment (FDI). Sub-Saharan Africa has experienced a high level of labor migration with remittances play a crucial role in supporting household income and macroeconomic stability (Gonzalez-Garcia *et al.*, 2016; Makina and Mudungwe, 2023). In countries like Coba Verde, The Gambia, and Comoros, remittances account for over 20 percent of GDP underlining their crucial economic importance.

The impact of remittances on the receiving economy, particularly in terms of poverty reduction, education, economic growth, macroeconomic stability has been richly investigated (Acosta *et al.*, 2009a; Fayissa and Nsiah, 2010; Ncube and Brixiova, 2013). However, relatively underexplored dimension is the effect of remittances on government revenue which is crucial for providing public goods and financing development objectives, especially, in the context of Sub-Saharan Africa (Asatryan *et al.*, 2017). By investigating the impact of remittances on tax revenue in Sub-Saharan Africa, this study contributes to the literature on remittances and public finance.

Sub-Saharan African governments struggle with low tax collection rates, which constrain their ability to fund essential public services and development programs (Keen, 2012). Given that understanding the fiscal implications of remittances has important policy relevance. By focusing on this underexplored but important issue, this study contributes novel insights to the literature on remittances and public finance.

The main objective of this study is assessing the impact of remittances on indirect and direct tax revenues. The result of the study shows that remittances are mainly spent on consumption of receiving family members thereby increasing the basis of indirect taxes via stimulation consumption. It therefore could have a positive impact on indirect taxes in the region. Additionally, remittances could spur economic activity by both increasing domestic demand and providing finance for businesses. As a consequence, it could increase the direct tax revenue.

The paper is organized in the following ways. Section 2 introduces the theoretical background of study. Section 3 details the data and empirical methodology. Results and findings are discussed in the Section 4. Section 5 outlines the policy implications of the study and concludes.

2. LITERATURE REVIEW

This section first provides an overview of the differences in public finance and taxation between developed and developing economies. A review of the literature on remittance and taxation is then presented.

2.1 Taxation in developing countries

There are contrasting differences both in level of tax revenue and its structure between developing and developed countries. Developing countries can typically tax 15-20 percent of

GDP, in stark contrast to 40 percent in developed countries. Additionally, the indirect taxes comprise a big share of tax revenues in contrast to richer countries where direct taxes dominate the total tax revenue. The structure of economy, lack of administrative capacity and prevailing political system can mainly explain the lower level of tax revenue and small share of direct tax revenue in developing countries (Abd Hakim *et al.*, 2022). The low value-added sectors are dominant in the economies of developing countries while the higher value-added sectors are small or nearly non-existent. Economic subjects in low value-added activities often earn barely above the subsistence level. Additionally, informality is prevailing in economies of developing countries making it challenging to tax a considerable part of national income. Therefore, overall tax level is low and share of direct taxes is smaller in developing countries. The capacity of tax administration is also considerably lower in developing countries. The staffs are often underpaid, and under-skilled while modern collection procedures, recordkeeping and assessment are absent. Consequently, these factors impede the tax collection, particularly of the technically more complex direct taxes (Avi-Yonah and Margailoth, 2007; Bahl and Bird, 2008). The wealthy elite controls the political arena in most developing countries and political competition is constrained by this elite. In this regard, policies tend to favor those with above-median incomes there is no pressure on political elite to conduct progressive redistributive tax policies. Consequently, the economy is undertaxed.

2.2 Remittances and tax revenue

A huge body of literature exists that analyzes both microeconomic and macroeconomic effects of remittances in the context of developing countries. Regarding microeconomic effects, Khan *et al.* (2022) evaluate the effects of remittances on poverty, Azizi (2018) examines their role in human capital accumulation and Aggarwal *et al.* (2011) explore their influence on financial development. Research on macroeconomic effects analyzes the impact of remittances on various aspects including economic growth and balance of payments (Lartey, 2019) export competitiveness (Ahmadov, 2022) and on quality of institutions (Alamdar *et al.*, 2022).

Remittances flowing into developing countries can exert different effects on direct and indirect taxes in developing countries. This subsection details the conceptual framework to guide the understanding of the causal effect of remittance on direct and indirect taxes.

Direct tax revenue. In practice, it is hard to tax remittances directly. However, the impact of remittances on direct tax revenues can occur in indirect ways. 1) One of the main barriers to the actualization of economic potential in developing countries is the capital deficiency (Beck and Demirguc-Kunt, 2006). Hereof, remittances can facilitate the access to finance and promote the utilization of idle production factors and consequently result in increase in economic activity (Woodruf and Zenteno, 2001). Consequently, this increase in economic activity could lead to higher direct tax revenues. Nonetheless, remittances might also have a negative effect on direct tax revenues via "Dutch Disease" effect. As a foreign capital, remittances could lead to a decline in export competitiveness of economy by causing domestic currency to appreciate (Acosta *et al.*, 2009b). This could consequently lead to the contraction or demise of some production sectors. Remittances could have a negative effect on employment by increasing the receivers` reservation wage (Mansoor and Quillin, 2006). In consequence, weaking of production sectors and decline in employment would result in

contraction of direct tax revenues. In the light of both possible channels of positive and negative effects of remittances on direct tax revenues, the net effect is inconclusive.

Indirect tax revenue: The primary motive of senders is to support consumption of their families back home (Abdih *et al.*, 2012). Therefore, main part of remittances is channeled to consumption, and it could have a positive contribution to indirect tax revenues.

The potential effect of remittances on tax revenues is large in developing countries. Accordingly, they can tailor their policy responses by adjusting the rate of direct and indirect taxes. Given that remittances are mainly destined for consumption, government might target indirect taxes to take a share from remittances. In this context, the rate of indirect taxes could be increased, and their base could be broadened. Secondly, the "Dutch Disease" and employment-reducing effects of remittances can shape the tax policy in receiving countries. To mitigate the decline in competitiveness of domestic economy and promote employment, governments in remittance-receiving countries may reduce direct taxes. Against the backdrop of decline in direct tax rates, these governments could increase the rate of indirect taxes for compensating the loss of tax revenue from stemming direct taxes.

Lastly, the prevailing informal economy offers another perspective to understand the effect of remittances on tax policy in developing countries (Schneider and Enste, 2013). Remittances can increase the potential revenue from indirect taxes. To capitalize on this potential, governments may reduce the indirect tax rates for motivating economic actors make a shift towards formal activity. On the other hand, remittances can have a positive contribution to the receiving countries` financial system (Aggarwal *et al.*, 2011). Development in the financial system allows to reduce the shadow economy, thereby facilitating better enforcement of income taxes. As a result, it would enable to increase direct tax revenues and have a more balanced composition of direct and indirect taxes.

The impact of remittances on the economies of receiving countries from various perspectives is thoroughly studied. However, there are only a few numbers of studies analyzing the impact of remittances on the tax revenues in developing countries. Abdih *et al.* (2012) assess the contribution of remittances to tax revenues in Middle East, North Africa, Central Asia and Caucasia. Their conclusion is that remittances have a positive effect on indirect tax revenues via increased imports and consumptions. Singer (2012) evaluates the effect of remittances on government revenues and concludes that they have a positive effect on tax revenues derived from consumption. Ebeke (2014) evaluates the effect of remittances on level and stability of government revenues in receiving countries, finding that remittance has a positive effect on both level and stability of government revenue primarily through indirect taxes. Asatryan *et al.* (2017) states that the effect of remittances on revenues from direct tax is negligible but it is positive on revenues from indirect tax.

Based on the theoretical explanation of the impact of remittances on direct and indirect taxes, this study tests the following hypothesis.

H1*: Remittances have a positive impact on total tax revenue in Sub-Saharan African countries.*

H2*: Remittances have a positive impact on direct tax revenue in Sub-Saharan African countries.*

H3*: Remittances have a positive impact on indirect tax revenue in Sub-Saharan African countries.*

Derived from the hypotheses of the study, the following research question is raised: What is the impact of remittances on total, direct and indirect tax revenues? To answer the research question, Panel ARDL regression model is conducted.

3. EMPIRICAL STRATEGY

3.1 Data

This study collects annual data from 2000 to 2021 from Cabo Verde, Comoros, The Gambia, Guinea-Bissau, Mali, Senegal, and Togo. The dataset employed in this study is sourced World Development indicator, World Governance indicator and Government Revenue Dataset, UNU-WIDER. In this study, we use 5 percent and above personal remittances received (% of GDP) as a criterion to select the SSA countries. The tax to GDP, direct tax to GDP, and indirect tax to GDP ratios are dependent variables. The existing literature suggests a set of variables that can be determining factors for tax revenues in developing countries (Gupta, 2007; Mahdavi, 2008). These are GDP per capita, exchange rate, net foreign aid and resource rent as a percentage of GDP, trade openness, urban population growth, government effectiveness, vulnerable employment to total employment (an approximate indicator of informal employment) and inflation. The higher GDP per capita means a larger share of the population are earning quite above the subsistence level of income, therefore, it is possible to tax proportionally higher share of national income. Depreciation increases the volume of excise tax and VAT from imports in terms of domestic currency. Citizens always have a resistance to increase in taxes, and it is politically unpopular. Incoming foreign aid creates additional revenue for government makes enable not to conduct unwelcoming policy of increasing taxes. Therefore, foreign aid has a negative impact on the level of taxation. The same logic is applicable in the case of resource rent. The higher level of resource rents frees governments from conducting unpopular taxation policies; therefore, it has a negative effect on the level of taxation. Opening foreign trade results in a decline in tariffs and other revenues. To compensate for this decline, the domestic taxation could be increased. Therefore, trade openness has a positive effect on the level of taxation. The higher share of urban population means a bigger part of population over subsistence income, consequently, it is easier to levy tax. Therefore, it has a positive impact on taxation level. Government effectiveness means that governments are capable of taxing the economy. Consequently, it has a positive effect. Higher level of vulnerable employment indicates the presence of higher share of subsistence level of income which is hard to tax. Therefore, it has a negative association with taxation level. Persisting inflation may confine consumption and consequently reduce the base of indirect taxes. *The main explanatory variable is the remittance to GDP ratio*. The data are transformed into natural logarithmic form except government effectiveness, inflation and urban share of total population.

Table no. 1 – Description of variables

Variable	Data source
Tax-GDP ratio	UNU-WIDER (2023)
Direct tax-GDP ratio	UNU-WIDER (2023)
Indirect tax-GDP ratio	UNU-WIDER (2023)
Remittance-GDP ratio	World Bank (2023)
REER	Darvas (2021)
Real GDP per capita	World Bank (2023)
Aid-GNP ratio	World Bank (2023)
Natural resource rent -GDP ratio	World Bank (2023)
Trade openness	World Bank (2023)

Variable	Data source
Government effectiveness	World Bank (2024)
Urban population growth	World Bank (2023)
Inflation	World Bank (2023)
Vulnerable employment	World Bank (2023)

Source: authors' construction

3.2 Methodology

3.2.1 Panel ARDL

We employ the Panel Autoregressive, Distributed Lag (ARDL) model that was developed by Pesaran *et al.* (1999). This model presents advantages over conventional estimating models. a) Both short and long-run dynamics can be estimated simultaneously (Shin *et al.*, 2014), b) it can be used in both small and large sample size data (Rafindadi and Yosuf, 2013), c) its estimates are more consistent and robust (Gocer and Ongan, 2020), d) it can accommodate variables with different orders of integration (Katircioglu, 2009).

The following equation describes the model:

$$T_{i,t} = \sum_{j=1}^{p} \beta_{i.t} T_{i,t-j} + \sum_{j=1}^{q} \delta_{i,t} X_{i,t-j} + \mu_i + \varepsilon_{i,t} \quad (1)$$

X is the vector of explanatory variables. We reparametrize the model into the following form:

$$\Delta T_{i,t} = \varphi(T_{i,t-1} - \beta_i X_{i,t}) + \sum_{j=1}^{p-1} \alpha^*_{i,j} \Delta T_{i,t-j} + \sum_{j=0}^{q-1} \delta^*_{i.j} X_{i,t-j} + \mu_i + \varepsilon_{i,t} \quad (2)$$

β_i is the coefficient of the long-run effects of the independent variables on tax revenues. φ_i indicates the error correcting term, reflecting the speed at which tax revenues adjust to their long-term equilibrium following a change in the independent variables. α and δ are the short-term coefficients. $\varepsilon_{i,t}$ are the disturbances with zero mean and constant variance and independently distributed across time and units.

The Pooled Mean Group (PMG) allows the heterogeneity in short-term coefficients across units but imposes the homogeneity of long-term coefficients. Therefore, accuracy of short-term coefficients cannot be guaranteed. It cannot provide accurate estimates for short-term coefficients. Therefore, we only present the discussion of long-term coefficients. It is necessary to exist cointegration among variables for the model to be considered an error correcting mechanism. In this respect, the stationarity of data is tested, then cointegration test is conducted. Lastly, discussion of panel estimates is presented.

Table no. 2 – Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Tax	154	11.51	4.286	3.66	21.17
direct tax	154	3.27	1.489	.67	6.91
indirect tax	154	8.162	2.969	2.80	14.84
Remittance	154	8.44	4.421	.37	26.83
Percapita	154	1146.54	791.926	536.56	3690.66
govt effectiveness	154	-.86	.559	-1.81	.34
aid gni	154	9.02	4.502	1.75	31.16
Trade	154	58.71	17.751	31.89	117.81
rent gdp	154	8.95	8.035	1.23	49.20
Inflation	154	-.096	13.754	-89.17	17.03
Reer	154	98.71	9.719	71.89	167.77
urbanpopulationgro~h	154	3.57	1.061	1.57	5.70

Table no. 2 describes the variables used in the analysis. The average total tax, direct tax and indirect tax as a percentage of the GDP are 11.51%, 3.27% and 8.16%, respectively. On average, the remittance inflows as a percentage of the GDP for SSA countries over the period 2000- 2021 is 8.44%.

Table no. 3 – Pairwise Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) lntax	1.00										
(2) lntrade	0.75***	1.00									
(3) lnrent	0.30***	0.67***	1.00								
(4) lnaid	-0.06	0.14*	0.37***	1.00							
(5) lnvulnerable	-0.45***	-0.50***	-0.20**	-0.12	1.00						
(6) govt_effective	0.66***	0.62***	0.20**	0.17**	-0.55***	1.00					
(7) inflation	0.09	0.22***	0.25***	0.01	0.13*	0.31***	1.00				
(8) lnpercapita	0.55***	0.49***	0.08	-0.01	-0.93***	0.56***	-0.17**	1.00			
(9) lnremittance	0.21***	0.16**	-0.06	0.03	-0.42***	0.11	-0.29***	0.37**	1.00		
(10) lnreer	-0.01	0.10	0.08	0.02	-0.09	-0.09	0.23***	0.10	0.31**	1.0	
(11) urbanpopl	0.04	0.01	0.07	0.08	0.67***	-0.09	0.20**	0.68**	0.29**	0.8	1.0

Table no. 3 shows that tax rate is positively correlated with trade openness, natural resource rent, remittance, GDP per capita, government effectiveness, inflation and urban population growth while it is negatively correlated with aid, vulnerable employment and exchange rate.

3.3 Panel Unit Root Test

3.3.1 Cross sectional dependence

Table no. 4 presents the results of cross-sectional dependence tests. The CD-test reveals that the presence of cross-sectional dependence at a 1% level for all the variables except for trade openness. Hence, in this study, Pesaran (2007) unit root tests were implemented to allow for cross-sectional dependence.

Table no. 4 – Cross-sectional dependence test

Variable	CD-test	p-value	corr	abs (corr)
lntax	11.490	0.000	0.534	0.534
lndirect	8.570	0.000	0.399	0.552
lnindirect	6.350	0.000	0.296	0.383
lnvulnerab~t	18.480	0.000	0.860	0.860
lnpercapita	9.910	0.000	0.461	0.650
lntrade	1.200	0.232	0.056	0.198
lnrent	6.870	0.000	0.319	0.466
lnaid	-0.530	0.599	-0.024	0.385
lnremittance	5.660	0.000	0.263	0.567
urbanpopul~h	0.620	0.535	0.029	0.611
inflation	4.900	0.000	0.228	0.418
govt_effec~s	0.170	0.863	0.008	0.402
lnreer	7.090	0.000	0.330	0.635

Notes: Under the null hypothesis of cross-section independence CD ~ N(0,1)
Source: authors' computations

This study performs Fisher type Choi (2001); Levin *et al.* (2002); Im *et al.* (2003); Pesaran (2007) unit roots tests. The Fisher test assumes the data are generated by an AR(1) process while the LLC test assumes the persistence parameters are uniform across cross-sections. Conversely, the Im–Pesaran–Shin test is based on the cross-sectional independence assumption. Lastly, Pesaran (2007) unit root test is based on the cross-sectionally augmented IPS (CIPS) test.

As shown in Table no. 5 total tax, direct tax and indirect tax variables strongly reject the null hypothesis at level for all the unit root tests. Similarly, remittance inflows reject the null hypothesis at 1 percent for all tests at level. We find that, aid to GNP reject the null hypothesis at level. Vulnerable employment, GDP per capita, trade openness, natural resource rent, government effectiveness, real exchange rate, and urban population growth rate series indicate the presence of unit root at level but stationary at first difference.

Table no. 5 – Panel unit root tests

Variables	Fisher type [Philips–Perron] (Inverse normal Z)	LLC (t*-stat)	IPS (w-stat)	Pesaran (2007) (z-stat)* Critical Value at 1%, 5%, and 10%
Level				
Log (Total Tax-GDP ratio)	-2.52***	-2.70**	-1.97**	-3.35***
	(0.0057)	(0.0034)	(0.0243)	
Log (Direct Tax/GDP)	-2.00**	-5.32***	-2.24**	-3.78***
	(0.0226)	(0.0000)	(0.0124)	
Log (Indirect Tax/GDP)	-2.10**	-3.39***	-2.90***	-3.78***
	(0.0175)	(0.0003)	(0.0018)	
Log (Remittance/GDP)	-4.38***	-3.22***	-1.93**	-3.47***
	(0.0000)	(0.0006)	(0.0265)	
Log (VulneraEmpl/GD)	0.42	-0.90	1.34	-2.29
	(0.6636)	(0.1820)	(0.9100)	
Log (GDP Per Capita)	0.37	-0.24	1.48	-2.08
	(0.6474)	(0.4030)	(0.9318)	
Log(TradeOpenness/GDP)	-1.78**	-1.18	-0.81	-2.56
	(0.0373)	(0.1182)	(0.2079)	

Variables	Fisher type [Philips–Perron] (Inverse normal Z)	LLC (t*-stat)	IPS (w-stat)	Pesaran (2007) (z-stat)* Critical Value at 1%, 5%, and 10%
Log (Natural/Resource/GDP)	0.16	-1.45*	-1.00	-2.18
	(0.5641)	(0.0723)	(0.1584)	
Log (Aid/GNP)	-3.89***	-3.03***	-0.20	-3.19**
	(0.0000)	(0.0012)	(0.4175)	
Government Effectiveness	-0.01	-0.09	0.47	-2.92*
	(0.4921)	(0.4614)	(0.6837)	
Log (REER)	-1.56*	-5.10***	-4.12***	-3.28**
	(0.0585)	(0.0000)	(0.0000)	
Urban population growth	1.39	-1.34*	0.81	-2.01
	(0.9179)	(0.0897)	(0.7918)	
Inflation	-5.70***	-0.56	-3.92***	-3.79***
	(0.0000)	(0.2875)	(0.0000)	
First difference				
Δ Log (Total Tax/GDP)				
Δ Lg (Direct TaX/GDP)				
ΔLog(IndirectTax/GDP)				
ΔLog(Remittance/GDP)				
ΔLog(Vulnerable Empl)	-6.01***	-7.88***	-3.48***	-3.50***
	(0.0000)	(0.0000)	(0.0002)	
Δ Log (GDP Per Capita)	-7.88***	-9.37***	-2.98***	-4.09***
	(0.0000)	(0.0000)	(0.0014)	
Δ Log (Trade Openness/GDP)		-9.17***	-5.58***	-4.72***
		(0.0000)	(0.0000)	
ΔLog(NaturalResource/GDP)	-7.42***		-5.78***	-4.56***
	(0.0000)		(0.0000)	
Δ Log (Aid GNP ratio)			-6.69***	
			(0.0000)	
Δ Government Effectiveness	-9.40***	-8.82***	-5.18***	
	(0.0000)	(0.0000)	(0.0000)	
Δ Log (REER)				
Δ Urban population growth	-4.29***		-3.89***	-3.20**
	(0.0000)		(0.0000)	
Δ Inflation		-8.34***		
		(0.0000)		

Note: values in parenthesis denote p-value.

Source: authors' computations

3.4 Cointegration Test

In this paper, Kao's cointegration test is used to test the hypothesis of cointegration among the variables. as depicted in Table no. 6, the result of Kao's cointegration test rejects the null hypothesis of no cointegration. This is true for the five tests statistics reported in the table and provides strong evidence that all panels in the data are cointegrated.

Table no. 6 – Kao cointegration test

Kao test for cointegration	Statistic	p-value
Modified Dickey Fuller t	-2.0588	0.0198
Dickey Fuller t	-1.7149	0.0432
Augmented Dickey Fuller t	-1.5596	0.0594
Unadjusted modified Dickey Fuller t	-2.3542	0.0093
Unadjusted Dickey Fuller t	-1.8384	0.0330

Source: authors' computations

4. RESULTS AND DISCUSSION

The remittance inflow is found to be positive and statistically significant on the total tax and tax structures such as direct tax and indirect taxes (Table no. 7). This finding supports the view that remittances inflow spurs total tax collection in SSA countries, and the finding is in line with the a priori expectations of Ebeke (2014); Asatryan *et al.* (2017). Furthermore, our result corroborates the findings of Yang (2008); Abdih *et al.* (2012) confirming the effect of remittance inflow is larger on indirect taxes than on direct taxes (Table no. 7). The remittances are mainly spent on consumption of receiving family members. They played a positive role in reducing the poverty and smoothing consumption in Sub-Saharan Africa (Akobeng, 2016). By spurring household consumption, remittances may result in an increase in bases of indirect taxes. The following potential channels can explain the positive effect of remittances on rise in direct taxes: Remittances stimulates the household consumption and consequently increase the domestic demand. Additionally, they can provide financial resources for small business. As a result, remittances-driven rise in economic activity could promote employing the idle production factors (Durand *et al.*, 1996; Woodruf and Zenteno, 2001). It would result in rise in employment, entrepreneurship activity and income of workers and firms which in turn translates into expansion of bases for income taxes.

Table no. 7 – PANEL ARDL results

VARIABLES	(1) total	(2) total	(3) direct	(4) direct	(5) indirect	(6) indirect
ECT	-0.808***		-0.609***		-0.745***	
	(0.140)		(0.201)		(0.221)	
Lntrade	0.1419**		-0.275**		0.0849*	
	(0.0761)		(0.126)		(0.0506)	
Lnrent	0.0718***		0.0579*		0.00658	
	(0.0177)		(0.0327)		(0.0204)	
Lnaid	-0.0215		-0.119**		0.00963	
	(0.0327)		(0.0481)		(0.0135)	
lnvulnerable_empt	0.146		0.601***		0.0272	
	(0.0989)		(0.151)		(0.0587)	
govt_effectiveness	0.110**		0.211***		-0.0694***	
	(0.0520)		(0.0688)		(0.0207)	
Inflation	-0.000992		-0.000681		-0.00179***	
	(0.000988)		(0.00113)		(0.000253)	
Lnpercapita	0.650***		0.646***		0.863***	
	(0.110)		(0.193)		(0.0719)	
Lnremittance	0.110***		0.149***		0.286***	
	(0.0324)		(0.0508)		(0.0125)	
Lnreer	-0.999***		-1.493***		-0.00197	
	(0.190)		(0.316)		(0.0831)	
urbanpopulationgrowth	0.154***		0.110**		0.233***	
	(0.0282)		(0.0483)		(0.0235)	
Constant	0.667***		1.586***		-5.067***	
	(0.106)		(0.488)		(1.551)	
Observations	147	147	147	147	147	147

The Sub-Saharan countries investigated in this study are low and lower middle-income economies. At this stage of economic development, the saving rate is typically low which translates to the scarcity of capital - one of the main obstacles to economic growth. Remittances could alleviate the capital scarcity problem thereby promoting the expansion of economic activities and employment. As a result, it could have a solid potential to increase the direct taxes in these countries. However, weakness of administrative capacity to enforce effective tax collection could result in missing of benefit from this opportunity.

An increase in natural resource rent raises total tax rate and direct tax in SSA countries while it is statistically insignificant for indirect tax (Table no. 7). Typically, governments monopolize resource revenue in the developing countries. They may leverage this revenue to create formal employment within the public sector. Consequently, rise in formal employment could expand bases for direct taxes.

Trade openness has a negative effect on direct tax but positive and significant on the indirect tax (Table no. 7). Tariffs and taxes on foreign trade have long been a key pillar of the fiscal revenue in developing countries. Notwithstanding, trade liberalization enforced a reduction in tariffs and tax revenues from foreign trade. Thereupon, increase in indirect taxes was introduced to compensate the loss from tariff and trade taxes in developing countries (Arezki *et al.*, 2021). This tendency could explain the positive association between trade openness and indirect tax revenue.

In addition, an improvement in GDP per capita boosts tax collection in all the specifications in the long run (Table no. 7). In line with Wagner`s law, rise in national income creates a demand for larger public sector that may necessitates more tax revenues. At the same time, increase in national income enables taxation of more of national income. Improvement in economic status raises the income over the subsistence level and reduce the resistance to the taxation.

Government effectiveness has a positive effect on tax collection in all specifications (Table no. 7). Tax collection requires the effective government apparatus and improvement in government effectiveness has a positive contribution to tax collection.

The real effective exchange rate exhibits a negative and significant effect in all specifications (Table no. 7). An increase in the REER would result in a decline in profit of firms in tradable sector and even considerable shrinkage of this sector if the appreciation of domestic currency persists over a long time. In this regard, it could result in decline in tax revenue, especially direct tax revenue via the contraction of employment and business in tradable sector (Niftiyev, 2021).

There is a positive and significant relationship between urban population growth and tax collection in all specifications (Table no. 7). Urbanization spurs the transition from informal to formal economy which makes a rise in tax collection (Chilima, 2005).

Foreign aid has a negative effect on the direct tax collection (Table no. 7). Presence of aid could allow the government to maintain tax collection lower due to political unpopularity of taxing.

Inflation is found to be negative and statistically significant for the indirect tax collection (Table no. 7). Persisting inflation may confine consumption and consequently reduce the base of indirect taxes.

Contrary to theoretical expectation, vulnerable employment has a positive effect on the direct tax revenue (Table no. 7).

5. CONCLUSION AND POLICY RECOMMENDATION

In this study, we evaluated the impact of remittances on the tax revenues in Sub-Saharan countries by employing the Panel ARDL model. Our findings reveal that remittances have a positive effect both on tax revenue and its structures- direct and indirect tax revenue. Given ongoing decline in foreign aid to the developing countries, remittance-driven tax revenue presents a worthwhile alternative source of revenue for governments.

Remittances both play a role in provision of finance for entrepreneurship and increasing demand for goods and services via increased consumption. This in turn could result in an increase in business activity and employment serving as an additional source of income tax revenue. In this consideration, active involvement of governments is required in realizing the potentials of remittances on economic activity. It would support economic and employment growth and increase tax revenue. Accompanying, it is necessary to implement the following measures. 1) Financial system should be restructured to channel remittance-capital towards productive activities. This can be achieved by designing the deposit policies that attracts the remittance into financial system making these funds available for business loans. Simultaneously, the lending practices should prioritize support for productive sectors.

Remittances mainly fuels the consumption, making it easier taxing them by indirect taxes. Consequently, via consumption channel, remittances increase the indirect tax revenue in Sub-Saharan countries. Given their technical easiness, it would result in exploitation of indirect taxes. In this regard, the design of tax structure should take balance between direct and indirect taxes into consideration. Additionally, tax policy should account for progressivity of indirect taxes. The taxes on necessities should be set minimal to ensure affordability for economically vulnerable segment of society.

Previous studies mainly highlight the positive effect of remittance on public finance via indirect taxes. Asatryan *et al.* (2017) is the only study to consider the effect of remittances on direct taxes and they conclude that such effect is not visible. This study demonstrates that remittances have a positive effect on tax revenue including *direct* and indirect taxes.

Remittances enable receivers to have individual solutions for overcoming poverty investment in health and education and other social risks. However, the effect of remittances on social institutions to overcome mentioned social challenges remains unquestioned. Future studies should analyze the interaction between remittances and social institutions in Sub-Saharan countries. Additionally, remittance-driven rise in tax revenue could create a rent-seeking incentives through public spending. Investigation of effect of remittance on rent-seeking behavior in Sub-Saharan Africa worths to focus on.

A considerable share of remittances is sent via informal channels in Sub-Saharan Africa, consequently unreported. The official statistics do not entail remittances that are sent via informal channels. Secondly, remittances can provide opportunities for governments to increase their tax revenues. However, a capable fiscal apparatus is necessary to benefit from this opportunity. The efficiency of tax administration is not considered in assessing the impact of remittances on tax revenues. These mentioned issues are the main limitations of this study.

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Impact of Geopolitical, Economic Policy and Financial Market Uncertainty on the Realized Volatility of G20 Stock Indices: A Panel QARDL Approach

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Abstract: Amid rising uncertainties, the researcher uses the novel panel quantile autoregressive distributive lag approach to examine the long- and short-term effects of geopolitical, economic policy and financial market uncertainties on the realized volatility of G20 stock indices from April 2015 to March 2024. The findings indicate that overall geopolitical risk (GPR) and geopolitical acts (GPA) have a significant impact on the realized volatility of G20 stock indices but only in the long run, while country-specific GPR (GPRH) has an insubstantial impact across all three quantiles. Conversely, an adverse effect of Global Economic Policy (GEPU) has been observed only in the short run. Among financial market uncertainty proxies, the market-based fear index (VIX) has a more pronounced impact than the news-based fear index on overall economic market volatility (EMV). Resilience has been noticed against GPRH, geopolitical threats (GPT) and GEPU, indicating their potential as diversifiers and hedges. Furthermore, the Pairwise Granger Panel Causality Test reveals interconnections among different uncertainty types. The long-term vulnerability to GPR and GPA suggests a decline in international risk diversification benefits due to increasing geopolitical tensions. The policymakers are thus urged to enhance efforts to mitigate geopolitical conflicts and maintain global economic and financial interconnectedness.

Keywords: uncertainty; geopolitical risk; economic policy uncertainty; quantile model; Panel ECM.

JEL classification: C33; C58; G10; F51; F65.

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1. INTRODUCTION

Ever since the evolution of mean-variance portfolio theory (Markowitz, 1952),, different researchers have extended their work as the theories related to well-diversified portfolios have evolved in recognition of the presence of unknown factors by modelling uncertainty (Delage and Ye, 2010; Denis and Kervarec, 2013; Bielecki *et al.*, 2019; Ismail and Pham, 2019). This highlights the significance of uncertain factors that need to be considered when selecting an optimal portfolio. The above studies mainly revolved around parameter uncertainty and a large amount of research prevails to address various forms of model uncertainty (Pham *et al.*, 2022). In addition to parameter uncertainty, a new strand of literature focused on different types of uncertainty is gaining traction among researchers in the face of increasing global uncertainty.

Uncertainty is a nebulous idea, which can be defined as circumstances in which the potential consequences of a decision, such as an investment choice, or the likelihood distribution associated with it, are unclear or unknown to the parties involved (Bloom, 2014; Himounet, 2022). The factors that affect stock market dynamics extend beyond just economic and financial considerations, as they also encompass uncertainty-induced shocks (Antonakakis *et al.*, 2013). With the ever-evolving technology and increasing globalisation, world has become highly interconnected and as a consequence, uncertainty has become more widespread and consequential than it has ever been in the past (Al-Thaqeb and Algharabali, 2019). It can take on many forms and originate from various sources, resulting in a financial landscape that is both intricate and difficult to forecast.

For instance, Geopolitical Uncertainty may arise due to conflict between nations, political instability, war or terrorist acts (Caldara and Iacoviello, 2022). Economic Policy Uncertainty (EPU) is another type which may occur on account of ambiguity surrounding monetary, fiscal or regulatory policies to be announced by the policymakers (Brogaard and Detzel, 2015). Moreover, tariffs are one of the most direct policy tools, and any updates or changes in trade and tariff policies are often interpreted as policy risk signals by the investors, which can also generate significant uncertainty (Baker *et al.*, 2016; Baker *et al.*, 2019). Furthermore, tariffs not only raise economic uncertainty but may also translate into geopolitical risks (exemplified by the U.S tariffs on Chinese goods during 2018-19, repercussions of which were also noticed in Asian and European markets (Handley and Limão, 2017; Goulard, 2020) and potentially leading to amplified volatility. Likewise, the geopolitical risks can also lead to substantial economic policy uncertainty (Dakhlaoui and Aloui, 2016). Nevertheless, both GPR and EPU have the potential to act as stimuli that influence investor sentiment (Al-Thaqeb and Algharabali, 2019; Bossman *et al.*, 2023). Thus, the combination of all these elements can have wide-ranging effects on overall market stability.

In the highly interconnected global world, rising uncertainties hold a risk of financial fragmentation, as a consequence can result in the weakening of international risk diversification (Catalán and Tsuruga, 2023). For instance, the group of twenty (G20) nations serves as a premier forum for international economic cooperation, aiming to maintain economic stability and growth (Hasnain, 2023). Despite the importance G20 holds in the global economy, it is not free from uncertainties and risks that come with its operation. Brexit, the U.S-China trade tensions, disagreements on global policy issues in the United Nations and the Russia-Ukraine conflict are some enduring shocks that have contributed to sustained uncertainty (Ahir *et al.*, 2022).

Over time, different researchers came up with a number of proxies such as geopolitical risk (GPR), economic policy uncertainty (EPU), market-based fear index (VIX) and news-based NVIX & economic market volatility (EMV) index with respect to distinct types of uncertainty (Baker *et al.*, 2016; Manela and Moreira, 2017; Baker *et al.*, 2019; Caldara and Iacoviello, 2022). Post development of these proxies, many researchers have tried to explore distinct aspects concerning different types of uncertainties such as in relation to GPR and financial development (Alsagr and van Hemmen, 2021), EPU and stock markets (Arouri *et al.*, 2016; Batabyal and Killins, 2021), implied volatility and stock returns (Sarwar and Khan, 2017). The majority of past literature establishes that increased uncertainty often results in increased market volatility and tends to impact volatility more than the returns (Asgharian *et al.*, 2018; Mitsas *et al.*, 2022; Salisu *et al.*, 2023). Moreover, it has also been identified that different assets can behave differently to distinct types of uncertainty (Qin *et al.*, 2020; Dutta and Das, 2022). However, such studies typically restrict their focus to a specific type of uncertainty about a particular class of assets with respect to a specific region or country and do not distinguish between short-term and long-term relationships. Furthermore, the interconnectedness of different types of uncertainty is conjectured but there is a lack of empirical evidence pertaining to the same (Al-Thaqeb and Algharabali, 2019). Understanding the impact of various types of uncertainty on volatility is essential, as it plays a significant role in investment decisions and policy-making, and enables individuals to navigate uncertainty more effectively.

To this end, we propose to explore the influence of distinct types of uncertainty on the realized volatility of G20 stock indices. The G20, consisting of the most significant economies globally, presents a comprehensive and diverse sample for studying the intricate relationship between uncertainty and market volatility. By examining realized volatility, which reflects genuine price variations within particular timeframes, we can attain valuable insights into the practical consequences of uncertainty on market dynamics. In this study, we broadly categorise the distinct types of uncertainty considered in this study into three categories, namely i) Geopolitical Uncertainty, ii) Policy Uncertainty and iii) Financial Market Uncertainty. Wherein four variants of geopolitical uncertainty comprising, global geopolitical risk (GPR), home country GPR (GPRH), decomposed elements of GPR namely, geopolitical threat (GPT) and geopolitical acts (GPA), two proxies representing financial market uncertainty including one options market based implied volatility index (VIX) and one text-based overall economic market volatility index (EMV). Besides, with regard to policy uncertainty, the researcher's initial intent was to consider both global and home country EPU indices but due to the unavailability of home country EPU for all sample entities, only global EPU (GEPU) represented by U.S.'s EPU is considered.

Our study distinguishes itself from prior research on several fronts. First, we examine the impact of various uncertainty types on G20 stock indices' realized volatility across different market conditions (vulnerable or resilient) in both the short and long term. Additionally, we assess whether these global indices lose diversification benefits under different uncertainties. Second, we employ the modified panel quantile autoregressive distributed lags approach proposed by Arshed *et al.* (2022), which offers a more comprehensive analysis of stock volatility under varying market conditions (Peng *et al.*, 2022). Third, we use Pairwise Panel Causality Tests to empirically investigate the relationship between different uncertainty types and the realized volatility of G20 stock indices. To the best of our knowledge, no prior study has explored the behaviour of G20 stock indices concerning distinct uncertainties. Understanding this relationship helps investors develop effective hedging strategies to minimize potential risks.

The results of this study highlight that different types of uncertainty have varying effects on the realized volatility of G20 stock indices across different quantiles. Wherein overall GPR and GPA significantly increase long-run volatility, their short-run impact remains muted, reflecting resilience to immediate shocks. In contrast, GPEU exerts short-lived but sharp effects, which can result in hot money flows. Moreover, VIX has been found to exert a stronger influence than the EMV. Besides, it's also the most influential compared to other uncertainties. The results of pairwise Granger causality showed a mix of no relation, unidirectional and bidirectional causal relations among the variables under consideration. Wherein geopolitical risks have been reported to affect the realized volatility indirectly through uncertainty and volatility channels rather than directly, while evidence of strong bidirectional systemic linkages between geopolitical, policy and financial uncertainties points towards their tight interconnection. For investors, these findings underscore the need to account for long term vulnerability of global portfolios to escalating GPR while recognizing the short-term resilience, which may provide tactical diversification and hedging opportunities. For policymakers, interconnections among uncertainty measures and erosion of diversification benefits highlight the need for stronger international cooperation, clear policy communication and timely actions to curb uncertainty driven volatility.

The remainder of the study has been planned as follows. Section 2 presents a brief overview of related literature. Section 3 details the data and its origin. Section 4 outlines the methodology employed, while section 5 explores the empirical findings. Lastly, section 6 concludes the study and offers recommendations for future research.

2. LITERATURE SURVEY

Based on the selected variables considered in this study, the literature reviewed concerning uncertainty and stock market volatility is presented in three sub-sections (i.e., i) Geopolitical Risk, ii) Economic Policy Uncertainty and iii) Financial Market Uncertainty, which is discussed as follows:

2.1 Geopolitical Uncertainty

Geopolitical risk (GPR) can be referred to as the potential danger linked to conflicts, terroristic acts, and the disruption of international relations that impacts the typical and tranquil progression of international connections (Caldara and Iacoviello, 2022). Geopolitical incidents can cause fluctuations in the market values of all types of assets, asset classes, sectors, and nations (Engle and Campos-Martins, 2020). According to Balcilar *et al.* (2018), GPR significantly affects the volatility of the stock market, particularly in terms of bringing about adverse fluctuations. Utilizing the panel GARCH approach, Bouras *et al.* (2019) highlighted the dominance of shocks induced by global GPR over domestic shocks, suggesting that the global GPR has a stronger impact than the country-specific GPR on the volatility of 18 emerging markets. Besides, just like the conventional stock markets, Islamic equity and bond markets were also found to be affected by GPR, which could be ascribed as a consequence of GPR's effect on the country's political situation, finances and the credit risk of the issuer (Bouri *et al.*, 2019). Further delving deeper into the GPR, Salisu *et al.* (2022) and Yang *et al.* (2021) investigated the decomposed elements of GPR (namely, GPA and GPT) wherein GPA in particular was reported to be a better forecaster of stock market volatility than GPT or the

composite GPR itself. In the same conjecture, Mitsas *et al.* (2022) conducted a study concerning commodity futures and the composites of GPR wherein they found a weak positive impact of GPT on corn futures volatility. In another study, Qin *et al.* (2020) reported a positive impact of GPR on crude oil volatility while an insignificant negative impact on gas and heating volatility under different market conditions. On the other hand, employing Markov regime-switching and the GARCH model, Dutta and Dutta (2022) provide empirical evidence of a negative association between the volatility of renewable energy ETFs and the GPR, which could be attributed to the high sensitivity of traditional energy sources to the GPR due to which investors tend to switch towards clean energy. Based on the above literature it can be said that the impact of GPR tends to vary depending on the type of asset class and market conditions (Qin *et al.*, 2020). Recognizing the influence of geopolitical events on volatility could be crucial due to its significant bearing on investment decisions and policy-making processes, and it enables one to evaluate the systemic nature of geopolitical risk (Smales, 2021). Thus, it would be interesting to see how global indices behave in response to GPR. The hypothesis framed concerning geopolitical risks based on the above literature is as follows:

H1*: GPR has a significant positive influence on the realized volatility of G20 stock indices.*

H1a*: GPT has a significant positive influence on the realized volatility of G20 stock indices.*

H1b*: GPA has a significant positive influence on the realized volatility of G20 stock indices.*

H2*: GPRH has a significant positive influence on the realized volatility of G20 stock indices.*

2.2 Economic Policy Uncertainty

Uncertainty regarding government policies and regulatory frameworks in the future can be referred to as policy uncertainty, which poses economic risks (Al-Thaqeb and Algharabali, 2019). Research has repeatedly demonstrated that EPU has a considerable influence on stock market volatility (Sum, 2012, 2013; Brogaard and Detzel, 2015). According to Pástor and Veronesi (2012), the extent and the magnitude of the effect, either good or bad, depends on the certainty associated with the policy changes. In an attempt to measure this particular type of uncertainty, Baker *et al.* (2016) designed an index to measure economic policy uncertainty, encompassing uncertainties derived from news, policy, market indicators, and economic indicators. The recent literature on EPU establishes a positive connection between EPU and volatility (Su *et al.*, 2019; Mishra and Debata, 2020; Kundu and Paul, 2022; Ghani and Ghani, 2024). Delving deeper into this relationship, Asgharian *et al.* (2018) uncovered that US EPU shocks have a positive impact on long-term stock market correlation and volatility in its own stock market as well as the UK Stock market. Additionally, Salisu *et al.* (2023) also discussed the significance of signal quality in predicting stock market volatility, with high-quality signals enhancing the predictive ability of EPU. Moreover, in contrast to André *et al.* (2017); Salisu *et al.* (2023)'s findings, Balcilar *et al.* (2019) and Asgharian *et al.* (2023) suggest that the EPU lacks the predictive ability for stock market volatility. Despite the increasing interest of researchers in this particular area, there is a scarcity of studies exploring alternatives to manage the risks associated with EPU. The researcher intends to explore the impact of GEPU on the volatility of G20 stock returns. The hypothesis formulated for this purpose is as follows:

H3*: GEPU has a significant positive influence on the realized volatility of G20 stock indices.*

2.3 Financial Market Uncertainty

Another strand of literature considered in this study relates to uncertainty associated with financial markets, often proxied by investor sentiments. Sentiment indicators for investors can be broadly categorized into three types, based on the data sources they utilize, namely i) market-based, ii) survey-based and iii) text & media-based (Zhou, 2018). The Chicago Board Options Exchange's Volatility Index (VIX) (i.e., a market-based market sentiment index), frequently referred to as the investor fear gauge, is a widely recognized measure of uncertainty in the past literature (Sarwar, 2012; Zhu *et al.*, 2019; Bossman *et al.*, 2023). This index reflects the US stock market's anticipated short-term volatility, inferred from S&P 500 index option prices (Whaley, 2009). Several authors have explored the relationship between realized volatility and implied volatility (Bekaert and Hoerova, 2014; Liang *et al.*, 2020). In a recent study, Dutta and Das (2022) provided evidence of the positive impact of jumps in the VIX on the realized volatility of the S&P 500 index. According to Wang (2019), the larger VIX can better explain the international stock market volatility. However, VIX classically reflects significant economic changes, with only minimal impact from social media trends or shifts in investor perceptions (Zhu *et al.*, 2019; Dutta *et al.*, 2021). To this end, Manela and Moreira (2017) came up with a text-based implied volatility index (NVIX) utilizing the front-page articles of the Wall Street Journal. In extension, Baker *et al.* (2019) concocted a unique fear index based on 11 major U.S. newspapers, referred to as the Economic Market Volatility (EMV) index, that closely mirrors the behaviour of VIX and the realized volatility of returns on the S&P 500. Among the few studies related to EMV, Dutta *et al.* (2021) document evidence of the asymmetric influence of EMV on crude oil volatility over various states. Comparing the VIX and EMV, Zhu *et al.* (2019) reported that VIX has a larger in-sample influence on the stock market volatility than the EMV. Besides both Dutta *et al.* (2021) and Zhu *et al.* (2019) found EMV trackers to have improved predicting ability than the VIX. However, EMV is relatively a new index as very few studies were found in relation to EMV and stock volatility. Thus, which one is a better representative remains unclear. The hypothesis developed to investigate their impact on the volatility of the G20 stock indices is as follows:

H4*: VIX has a significant positive influence on the realized volatility of G20 stock indices.*

H5*: EMV has a significant positive influence on the realized volatility of G20 stock indices.*

In summary, most of the past studies have typically restricted their focus to a specific type of uncertainty about a particular class of assets with respect to a specific region or country and did not distinguish between short-term and long-term relationships. However, despite the geopolitical and economic importance that the G20 nations hold, the collective behaviour of G20 stock indices with respect to distinct uncertainty types remains understudied. Moreover, the majority of the above-mentioned studies rely on linear frameworks and overlook regime-switching behaviour or quantile-based differences, which are critical for capturing tail-risk events. Thus, by employing the advanced panel QARDL approach, this study proposes to examine the impact of distinct uncertainty types on the realized volatility of G20 stock indices.

Table no. 1 – Sample Description

No.	Region	Country	Global indice name	Symbol
1	America	USA	MSCI USA	MIUS00000PUS
2	America	Argentina	MSCI Argentina	MIAR00000PUS
3	America	Brazil	MSCI Brazil	MIBR00000PUS
4	America	Canada	MSCI Canada Net USD	MICA00000NUS
5	America	Canada	Dow Jones Canada USD	CADOWD
6	America	Mexico	MSCI Mexico	MIMX00000PUS
7	America	Mexico	Dow Jones Mexico USD	MXDOWD
8	Africa	South Africa	Dow Jones South Africa USD	ZADOWD
9	Africa	South Africa	MSCI South Africa NR USD	MIZA00000NUS
10	Asia-Pacific	Australia	Dow Jones Australia USD	AUDOWD
11	Asia-Pacific	Australia	MSCI Australia USD	MIAU00000NUS
12	Asia-Pacific	China	MSCI China Net USD	MICN00000NUS
13	Asia-Pacific	India	MSCI India Net USD	MIIN00000NUS
14	Asia-Pacific	Indonesia	MSCI Indonesia Net USD	MIID00000NUS
15	Asia-Pacific	Indonesia	Dow Jones Indonesia USD	IDDOWD
16	Asia-Pacific	Japan	MSCI Japan Net USD	MIJP00000NUS
17	Asia-Pacific	Japan	Dow Jones Japan USD	JPDOWD
18	Asia-Pacific	South Korea	MSCI Korea Net USD	MIKR00000NUS
19	Asia-Pacific	South Korea	Dow Jones South Korea USD	KRDOWD
20	Europe	France	Dow Jones France USD	FRDOWD
21	Europe	Germany	Dow Jones Germany USD	DEDOWD
22	Europe	Turkey	DJ Turkey Titans 20 TR USD	TR20DT
23	Europe	United Kingdom	Dow Jones UK USD	GBDOWD
24	Europe	Italy	Dow Jones Italy USD	ITDOWD
25	Europe	European Union	MSCI Europe ex UK Net USD	MIUG00000NUS

Source: the author.

3. DATA

Our sample includes 25 global indices representing 18 countries from the G20 nations. It is to be noted that the sample covers approximately 86 per cent of G20 composition, only Russia, Saudi Arabia and the African Union are not included in the sample due to the unavailability of global indices for the same as of 31st March 2024. The reason for choosing global indices in U.S. dollar denomination is to avoid the non-synchronisation between the different stock exchanges, and exchange rate variations. The researcher covers a 10-year tenure from 1st April 2015 to 31st March 2024 in this study. The selection of 2015 as the starting point for this study is driven by the significance of data and elements of global uncertainty. This timeframe marks the onset of major global events that heightened economic, geopolitical and financial unpredictability, such as: The China stock market crash (2015), the rise of trade tensions during the Trump era (from the 2016 onwards), the Brexit referendum and its aftermath (from 2016 onwards), the COVID-19 pandemic (2020) (which changed global volatility patterns) and the ongoing Russia Ukraine conflict (2022). These developments make the years following 2015 especially pertinent for examining how uncertainty affects stock market volatility in the globally interconnected G20 economies.

Following (Qin *et al.*, 2020; Zhang *et al.*, 2023), the sum of squared daily global indices return is used to calculate the realized volatility and then transformed to a monthly frequency on an average basis because the other variables considered in this study are of monthly

frequency only. The researcher utilizes the monthly geopolitical risk index (comprising global geopolitical risk, its composites a. geopolitical threat, b. geopolitical actions), country-specific geopolitical risk and global economic uncertainty index as a stand-in for geopolitical and economic policy uncertainty. Following Zhu *et al.* (2019), the researcher uses CBOE-VIX also known as "the fear index" and the U.S overall economic market volatility index which is built on text counts of 11 major U.S. newspapers (containing at least one term each from E (including economic, economy, and financial), M (comprising "stock market", equity, equities, "Standard and Poors") and V (consisting volatility, volatile, uncertain, uncertainty, risk, risky) as a proxy for market sentiments concerning the stock market globally. The historical data for daily prices of the 25 global indices and monthly data for the CBOE-VIX index are collected from Investing.com whereas the data for the geopolitical risk index and economic policy uncertainty index, overall EMV are collected from the official website of Economic Policy Uncertainty (https://www.policyuncertainty.com).

The denotations used are as follows:

Y1 = realized volatility
LX1 = log Global geopolitical risk (GPR)
LX1H = log Country Specific geopolitical risk (GPRH)
LX1T = log Geopolitical Threat (GPT)
LX1A = log Geopolitical Action (GPA)
LX2 = log Overall Economic Market Volatility Index (EMV)
LX3 = log Implied Volatility (VIX)
LX4 = log Global Economic Policy Uncertainty (GEPU)

Table no. 2 exhibits the summary statistics related to the realized volatility and variables concerning various uncertainty representatives namely, global geopolitical risk (GPR) and its composites (i.e., geopolitical threat (GPT), geopolitical acts (GPA), country-specific geopolitical risk (GPRH), overall economic market volatility (EMV), CBOE- volatility index (VIX) and global economic policy uncertainty (GEPU) in this study. The mean values reported were 4.006 for Y1, 4.619 for the LX1, 4.747 for LX1T, 4.397 for LX1A, negative 1.798 for LX1H, 2.551 for LX2, 2.866 for LX3 and 5.360 for the LX4. Among the variables in consideration, Volatility, LX1, LX1T, LX1A and LX3 show positive skewness while LX1H, LX2 and LX4 suggest negative skewness. Meanwhile, only Y1, LX1, LX1T, and LX2 were found to be leptokurtic with a kurtosis value greater than 3. The highest standard deviation observed was for Y1 (46.969) and the lowest for LX1 (0.273). Nevertheless, the Jarque-Bera statistics reported for all the variables were substantially high and statistically noteworthy at a 1 per cent level. Thereby, suggesting that the series were not normally distributed.

Table no. 3 reports the results of correlation analysis, wherein Y1 has been found to have weak insignificant positive correlation with all explanatory variables under consideration. While LX1 has been recorded to have a strong and statistically significant correlation with LX1T (0.8718) and LX1A (0.8001), suggesting potential multicollinearity concerns. In addition, a moderate but statistically significant correlations were also observed between LX3 & LX4 (0.4728) and between LX1H & LX2 (0.3369), reflecting partial co-movements. By contrast, most other correlations were close to zero, implying weak association. The above findings are consistent with econometric literature emphasizing the importance of identifying significant pairwise correlations to avoid the multicollinearity issue (Gujarati and Porter, 2009; Wooldridge, 2016). Therefore, while the majority of variables do not exhibit problematic correlation, as none of the variables in consideration (except for LX1T and LX1A

with respect to LX1) were found to have a correlation coefficient greater than 0.8. However, as a precaution (to address the potential multicollinearity concerns), the composites (GPT & GPA) and the global GPR are not considered in the same equation simultaneously.

Table no. 2 – Descriptive Statistics

	Y1	LX1	LX1T	LX1A	LX1H	LX2	LX3	LX4
Mean	4.006	4.619	4.747	4.397	-1.798	2.551	2.866	5.360
Median	1.067	4.627	4.727	4.402	-1.735	2.909	2.802	5.421
Maximum	1532.078	5.765	6.001	5.525	1.365	4.149	3.980	6.067
Minimum	-2.992	4.068	4.159	3.348	-5.508	-5.371	2.252	4.623
Std. Dev.	46.969	0.273	0.293	0.436	1.132	1.575	0.341	0.312
Skewness	25.626	0.943	1.211	0.289	-0.341	-3.252	0.640	-0.333
Kurtosis	715.337	5.128	5.918	2.919	2.949	12.329	3.059	2.534
Jarque-Bera	56488175	895.307	1592.31	37.776	51.927	14323.9	181.587	73.134
Probability	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	2658	2658	2658	2658	2658	2658	2658	2658

Source: the author.

Table no. 3 – Correlation Matrix

	Y1	LX1	LX1T	LX1A	LX1H	LX2	LX3	LX4
Y1	1							
LX1	0.0024 (0.9000)	1						
LX1T	0.0034 (0.8600)	0.8718[a] (0.0000)	1					
LX1A	0.0063 (0.7465)	0.8001[a] (0.0000)	0.4224[a] (0.0000)	1				
LX1H	0.0256 (0.1862)	0.1964[a] (0.0000)	0.2114[a] (0.0000)	0.1135[a] (0.0000)	1			
LX2	0.0249 (0.1980)	-0.0519[a] ((0.0074)	-0.0175 (0.3675)	-0.0744[a] (0.0001)	0.3396[a] (0.0000)	1		
LX3	0.0386[b] (0.0464)	-0.0921[a] (0.0000)	0.0950[a] (0.0000)	-0.2581[a] (0.0000)	-0.0085 (0.6626)	0.1273[a] (0.0000)	1	
LX4	0.0269 (0.1651)	-0.0371[c] (0.0557)	0.1902[a] (0.0000)	-0.2494[a] (0.0000)	0.0647[a] (0.0009)	0.1056[a] (0.0000)	0.4728[a] (0.0000)	1

Note: i) The value in the parentheses is the p-value. ii) The significance levels of 1%, 5%, and 10% are depicted through a, b and c, respectively.

Source: the author.

4. METHODOLOGY

The researcher has applied the panel quantile autoregressive distributive lag approach proposed by Cho *et al.* (2015) to investigate the influence of geopolitical risk, overall economic market volatility, CBOE-VIX volatility index, and economic policy uncertainty on the realized volatility of global indices representing G20 nations. The panel QARDL method is preferred in panel models for several reasons. This technique offers several advantages, as it allows the examination of the long-run and short-run effects of explanatory variables across different quantiles (Peng *et al.*, 2022). Additionally, panel QARDL effectively addresses the concerns of serial correlation, miss-specification and non-normality (Arshed *et al.*, 2022)

while allowing for the exploration of heterogeneity across entities in the panel data (Du, 2023). Following Tiwari *et al.* (2024), the mathematical equation to apply the panel quantile ARDL framework is as follows:

$$\Delta Y1^{\theta}_{it} = \alpha_{0i} + \alpha_1 \Delta LX1^{\theta}_{it} + \alpha_2 \Delta LX1H^{\theta}_{it} + \alpha_3 \Delta LX2^{\theta}_{it} + \alpha_4 \Delta LX3^{\theta}_{it} + \alpha_5 \Delta LX4^{\theta}_{it} + \beta_1 LX1^{\theta}_{it-1} + \beta_2 LX1H^{\theta}_{it-1} + \beta_3 LX2^{\theta}_{it-1} + \beta_4 LX3^{\theta}_{it-1} + \beta_5 LX4^{\theta}_{it-1} + \varepsilon^{\theta}_{t} \quad (1)$$

$$\Delta Y1^{\theta}_{it} = \alpha_{0i} + \alpha_1 \Delta LX1T^{\theta}_{it} + \alpha_1 \Delta LX1A^{\theta}_{it} + \alpha_3 \Delta LX1H^{\theta}_{it} + \alpha_4 \Delta LX2^{\theta}_{it} + \alpha_5 \Delta LX3^{\theta}_{it} + \alpha_6 \Delta LX4^{\theta}_{it} + \beta_1 LX1T^{\theta}_{it-1} + \beta_1 LX1A^{\theta}_{it-1} + \beta_2 LX1H^{\theta}_{it-1} + \beta_3 LX2^{\theta}_{it-1} + \beta_4 LX3^{\theta}_{it-1} + \beta_5 LX4^{\theta}_{it-1} + \varepsilon^{\theta}_{t} \quad (2)$$

To not encounter any problem of multicollinearity, two separate equations are framed to examine to impact of overall GPR and decomposed elements of GPR (i.e., GPT and GPA). Equation (1) is framed to examine the impact of overall GPR, GPRH, EMV, VIX and GEPU on the realized volatility of G20 stock indices. With other specifications remaining the same, in equation (2) overall GPR is replaced with the decomposed elements. In the above equations, α_i represents the short-run coefficients while long-run coefficients are denoted with β_i and ε^{θ}_{t} denotes the convergence coefficient which should be negative and significant (the value for the same should fall in the range -1 and 0). It is to be noted that the convergence coefficient is the lagged residual of long-run estimates (Arshed *et al.*, 2022). Besides, θ in the above equations represents the quantile level. Following Cho *et al.* (2015), three quantiles (i.e., 0.25, 0.5, 0.75) are used wherein the lower quantile (0.25) represents bearish market conditions, median quantile (0.5) and upper quantile (0.75) represent the normal and bullish market respectively and Schwarz information criterion (SIC) is followed for lag selection criteria (Du, 2023).

All studies that involve time-dependent data in the panel are mandated to go through a series of assessment processes to realize the desired results (Bekele *et al.*, 2024). This involves a thorough examination of cross-sectional dependence, slope homogeneity, and stationarity tests, followed by an investigation of the co-integration relationship among the variables under consideration.

5. EMPIRICAL FINDINGS

The cross-section dependency (CSD) tests have been conducted for country-specific variables only because values for the global variables remain the same across all the cross-sections (Lee *et al.*, 2021). Table no. 4 exhibits the outcomes of cross-sectional dependency tests under which both Realized Volatility and GPRH were found to be statistically significant. Thereby suggesting the existence of cross-sectional dependency in the country-specific variables, which could be ascribed to the economic integration among G20 nations.

Table no. 4 – Cross-sectional Dependence Test

Variable	Breausch Pagan	CD Statistic	Decision
Y1	9454.021[a]	54.45 [a]	Cross-sectionally dependent
LX1H	4531.061 [a]	50.04 [a]	Cross-sectionally dependent

Note: The significance levels of 1%, 5%, and 10% are depicted through a, b and c, respectively.
Source: the author.

Table no. 5 exhibits the results of the slope homogeneity test conducted using the Hsiao method developed by Khouiled (2018). The results revealed that the null hypothesis of uniformity in the slope coefficients cannot be rejected for both panels in consideration.

Table no. 5 – Slope homogeneity test

Hypotheses	Panel A	Panel B
H1	0.685 (0.998)	0.592 (0.999)
H2	0.609 (0.999)	0.516 (1.000)
H3	1.089 (0.348)	1.075 (0.364)

Note: The value in parentheses depicts the p-value corresponding to each value.
Source: the author.

Following the evidence on cross-sectional dependence in the country-specific variables (see Table no. 4), in addition to the first-generation unit root test, the researcher also utilises a second-generation unit root test to ensure the robustness of the results. Table no. 6 presents the unit root test results for both the country-specific variables and global variables, revealing that none of the variables considered in this study were non-stationary or second-order stationary.

Table no. 6 – Panel unit root test

A. Country Specific Variables					
Variable	**Im-Pesaran**		**CIPS Test**		**Order**
	Constant	**Trend**	**Constant**	**Trend**	
Y1	-22.959 [a]	-21.828[a]	-8.134 [a]	-8.099 [a]	I(0)
LX1H	-12.001[a]	-12.660[a]	-3.858 [a]	-4.507[a]	I(0)
B. Global Variables					
Variable	**Im Pesaran**		**Levin-chu**		
	Constant	**Trend**	**Constant**	**Trend**	**Order**
LX1	-9.957[a]	-7.566 [a]	-7.491[a]	-7.619[a]	I(0)
LX1T	-11.292[a]	-10.255[a]	-7.281[a]	-6.282 [a]	I(0)
LX1A	-4.782[a] -34.556[a]	-0.951 -34.299[a]	-7.979[a] -26.034[a]	-10.391[a] -26.873 [a]	I(1)
LX2	-13.652[a]	-11.778[a]	-16.920[a]	-20.247[a]	I(0)
LX3	-7.439[a]	-4.805[a]	-7.661[a]	-7.509[a]	I(0)
LX4	-7.760[a]	-4.357[a]	-6.05[a]	-5.412[a]	I(0)

Note: The significance levels of 1%, 5%, and 10% are depicted through a, b and c, respectively.
Source: the author.

The Koa residual cointegration test results reveal that the null hypothesis of no cointegration among the variables cannot be accepted, as the reported test statistics exhibit statistical significance at a 1 per cent level (see Table no. 7). This indicates the presence of long-run relationships among the variables in both panels.

Table no. 8 presents the outcomes of the panel QARDL approach. In this study, the impact of three distinct categories of uncertainty namely, Geopolitical Uncertainty, Economic policy Uncertainty and Financial Uncertainty on the realized volatility of G20 stock indices over three different market conditions in the long run as well as short-run have been explored wherein (0.5)

quantile represents normal market conditions and (0.25 & 0.75) represent bearish and bullish market conditions respectively. Aligning with the conclusions of Salisu *et al.* (2022) and Yang *et al.* (2021), the results report a positive association between the GPR and realized volatility of G20 stock indices. This suggests that an increase in overall GPR leads to a significant increase in the volatility of G20 stock indices in the long run, which could be attributed to the high level of integration among the panel entities (Salisu *et al.*, 2022). Besides, in terms of the magnitude of effect, GPR was least affecting during bearish regimes than bullish or normal market conditions. Though in the short run, GPR was found to have a positive but statistically insubstantial influence on the G20 stock indices volatility. On the other hand, an insignificant negative impact was recorded with respect to GPRH both in the long term as well as short period, suggesting that the realized volatility of G20 stock indices was not much affected by country-specific GPR (Bouras *et al.*, 2019). Thereby portentous that G20 stock indices can used to diversify against country-specific GPR. Moreover, among the decomposed elements of overall GPR (refer to equation 2), contrary to (Mitsas *et al.*, 2022) GPT was observed to have a significant negative association with the dependent variable over all three quantiles in the long period as well as the short period. Conversely, GPA was found to have a significant positive influence on the volatility of G20 stock indices, which was recorded to be more pronounced during the bullish period than normal and bear market conditions in the long run scenario. Meanwhile, in the short run, an insignificant impact of GPA was recorded (see Panel B of Table no. 8).

Table no. 7 – Cointegration test

Kao Residual Cointegration test	Statistic
Panel A	4.671[a]
Panel B	4.669[a]

Note: The significance levels of 1%, 5%, and 10% are depicted through a, b and c, respectively.
Source: the author.

In line with Dutta *et al.* (2021), the impact of the news-based fear index (EMV) was observed to vary depending on different market conditions. As shown in Table no. 8, an increment in the EMV leads to a statistically significant rise in realized volatility of the G20 stock indices during a bearish market, whereas an insignificant positive and a significant negative impact has been recorded over normal and bullish market conditions, respectively. Furthermore, consistent with the findings of Dutta and Das (2022), the options market-based fear index (VIX) was revealed to have a significant positive influence on the realized volatility of G20 stock indices over all three market conditions in both the long run and short run. Another observation could be made from these results, the long-run impact of financial uncertainty happens to be more pronounced than the short-run impact (see Table no. 8).

Regarding the uncertainty associated with global economic policy, G20 stock indices were found not to be affected by the GEPU in the long term across all three market conditions. In contrast, a significant positive relationship with the realized volatility of G20 stock indices was revealed in the short run over all three quantiles. Thereby indicating that an increment in GEPU in the short run would lead to an increase in the realized volatility of G20 stock indices. The insignificant influence in the long period was quite within the expectations of the researcher as the surprise element around the policy announcement is likely to disappear with time (Bernanke, 1983; Pástor and Veronesi, 2012). The above insignificance can also on account of the market's tendency to absorb the uncertainty shocks, adapt to new realities and return to fundamentals, unless they escalate into long-term crises (Bloom, 2009).

Additionally, the convergence coefficient over all quantiles was found to be negative and significant, which reconfirms the results of the cointegration test (see Table no. 7). Hence, there exists a long-run relationship among the variables in both panels in consideration. Besides, any convergence to the long-run equilibrium gets corrected over a month. Furthermore, the results of Panel B for other variables reconfirm the findings of Panel A, as no significant change in the findings related to GPRH, EMV, VIX, or GEPU was recorded.

Table no. 8 – Panel QARDL estimates

Variable	Coefficient	t-Stat	Coefficient	t-Stat	Coefficient	t-Stat
Quantiles	0.25		0.5		0.75	
Panel A						
Long Run Estimates						
LX1	0.165[b]	2.420	0.327[a]	2.942	0.301[b]	2.058
LX1H	-0.001	-0.073	-0.036[c]	-1.888	-0.033	-1.070
LX2	0.115[a]	8.398	0.057	1.547	-0.055[b]	-2.319
LX3	0.780[a]	12.352	1.578[a]	16.772	2.885[a]	18.882
LX4	-0.030	-0.454	-0.092	-1.205	0.069	0.509
C	-2.479[a]	-5.184	-4.537[a]	-6.772	-7.829[a]	-9.905
Short Run Estimates						
Δ(LX1)	0.021	0.257	0.059	0.597	0.068	0.799
Δ (LX1H)	-0.062[c]	-1.874	-0.063[c]	-1.670	-0.051	-1.212
Δ (LX2)	0.284[a]	3.936	0.291[a]	3.557	0.322[b]	2.298
Δ (LX3)	1.101[a]	12.207	1.080[a]	10.002	1.104[a]	6.202
Δ (LX4)	0.508[a]	4.636	0.601[a]	4.562	0.679[a]	6.144
ECT1(-1)	-0.999[a]	-10263.780	-0.999[a]	-7636.063	-0.903[a]	-12.028
Pseudo R-squared	0.639		0.399		0.144	
Adjusted R-squared	0.638		0.398		0.143	
Panel B						
Long Run Estimates						
LX1T	-0.161[b]	-2.309	-0.244[b]	-2.520	-0.665[a]	-3.689
LX1A	0.245[a]	5.934	0.416[a]	7.119	0.739[a]	7.212
LX1H	-0.010	-0.710	-0.022	-1.112	0.002	0.088
LX2	0.116[a]	8.346	0.052	1.440	-0.079[a]	-3.280
LX3	0.833[a]	13.011	1.617[a]	17.969	2.932[a]	16.840
LX4	0.082	1.257	0.033	0.411	0.196	1.248
C	-2.784[a]	-6.176	-4.455[a]	-7.189	-7.230[a]	-8.084
Short Run Estimates						
Δ (LX1T)	-0.252[a]	-2.804	-0.236[b]	-2.230	-0.148[c]	-1.647
Δ (LX1A)	0.081	1.415	0.105[a]	1.527	0.093	1.617
Δ (LX1H)	-0.035	-1.041	-0.035	-0.883	-0.039	-1.216
Δ (LX2)	0.394[a]	6.167	0.396[a]	5.179	0.416[a]	6.199
Δ (LX3)	0.871[a]	9.796	0.878[a]	8.380	0.925[a]	9.494
Δ (LX4)	0.910[a]	7.006	0.964[a]	6.362	1.059[a]	7.727
ECT2(-1)	-0.999[a]	-9806.418	-0.999[a]	-7426.563	-0.924[a]	-290.405
Pseudo R-squared	0.641		0.401		0.146	
Adjusted R-squared	0.640		0.399		0.144	

Note: The significance levels of 1%, 5%, and 10% are depicted through a, b and c, respectively.
Source: the author.

Diagnostic

Table no. 9 details the outcomes of the Variance Inflation Factor (VIF) test, revealing that each variable has a VIF score under 5, thereby indicating that the previously mentioned QARDL estimates are free from multicollinearity concerns (Gujarati and Porter, 2009; Tiwari *et al.*, 2024). Furthermore, in line with the methodologies of Du (2023) and Razzaq *et al.* (2021), the Wald test has been utilized to assess the dependency of long-term and short-term estimates of Panel QARDL. Table no. 10 reveals the results of the Wald test, wherein the null hypothesis of all the long-run parameters (except for GPRH, EMV and GEPU) stands rejected in both panels, as these variables were found to be statistically significant at a 1 per cent level. For short-run dynamics, all the parameters (except for GPR & GPRH) were highly significant, indicating that the significant parameters are nonlinear and symmetric (Du, 2023). Additionally, the error correction terms in both panels prove to be significant at a 1 per cent level. Consequently, the null hypothesis asserting parameter constancy around the quantile grid has been rejected (Razzaq *et al.*, 2021).

Table no. 9 – Variance Inflation Factor (VIF) test

Variance Inflation Factor Test (VIF)					
Panel A			**Panel B**		
Variable	**Coefficient Variance**	**Uncentered VIF**	**Variable**	**Coefficient Variance**	**Uncentered VIF**
D(LX1)	0.0098	1.2445	**D(LX1T)**	0.0104	1.4196
D(LX1H)	0.0014	1.2813	**D(LX1A)**	0.0043	1.2039
D(LX2)	0.0067	1.1422	**D(LX1H)**	0.0014	1.3031
D(LX3)	0.0117	1.0739	**D(LX2)**	0.0056	1.0594
D(LX4)	0.0174	1.0992	**D(LX3)**	0.0091	1.0304
ECT1(-1)	0.0000	1.0429	**D(LX4)**	0.0170	1.0717
			ECT2(-1)	0.0000	1.0382

Source: the author.

Table no. 10 – Wald Test

Panel A			**Panel B**		
Variable	**F-Statistic**	**P-value**	**Variable**	**F-Statistic**	**P-value**
LX1	8.6580[a]	0.0033	**LX1T**	6.3510[a]	0.0118
LX1H	3.5661	0.0591	**LX1A**	50.6859[a]	0.0000
LX2	2.3933	0.1220	**LX1H**	1.2375	0.2661
LX3	281.3069	0.0000	**LX2**	2.0743	0.1499
LX4	1.4522	0.2283	**LX3**	322.8727[a]	0.0000
C	45.8638[a]	0.0000	**LX4**	0.1691	0.6809
D(LX1)	0.3564	0.5506	**C**	51.6885[a]	0.0000
D(LX1H)	2.7878	0.0951	**D(LX1T)**	6.7574[a]	0.0094
D(LX2)	12.6536[a]	0.0004	**D(LX1A)**	17.6987[a]	0.0000
D(LX3)	100.0305[a]	0.0000	**D(LX1H)**	0.7274	0.3938
D(LX4)	20.8111[a]	0.0000	**D(LX2)**	17.9384[a]	0.0000
ECT1(-1)	58309454.0000[a]	0.0000	**D(LX3)**	131.7268[a]	0.0000
			D(LX4)	37.6352[a]	0.0000
			ECT2(-1)	53625662.0000[a]	0.0000

Source: the author.

Robustness Check

Following the evidence on long-run homogeneity in both the panels in consideration (see Table no. 5), the researcher uses PMG ARDL to check the robustness of panel QARDL estimates (Tiwari *et al.*, 2024). Coinciding with the quantile results, Table no. 9 shows that (except for GPRH, GPT and GEPU) all the variables were found to have a significant positive effect on the realized volatility of G20 stock indices in the long run. Nevertheless, in harmony with the short-run QARDL results, realized volatility of the G20 stock indices was found to be not affected by GPR, GPA or the GPRH alongside signs of resilience against GPT. Moreover, EMV and VIX had a significant positive influence in the short run. While GEPU was also recorded to have a positive but insignificant impact in the short run. Nevertheless, the convergence coefficient recorded in the PMG ARDL was also found to be negative and significant when considered collectively or cross-sectionally for the majority. The presence of a long-term relationship among variables in both panels was thereby reaffirmed. Moreover, as per the short run PMG results, most G20 markets were found resilient to immediate uncertainty shocks wherein certain emerging markets (India, South Africa & Turkey) and globally integrated markets (China, Japan & EU) show statistically significant short run-exposure, particularly to country-specific geopolitical risk, geopolitical threats and global policy uncertainty – see Table no. A1 no. A2, provided in Annexes. Thereby suggesting the short-run adjustment paths are market specific, can be ascribed to the degree of market openness & exposure to financial flows. Another interesting observation to be noted with respect to the considered countries, for which two indices have been used (particularly for Australia and South Africa), wherein the MSCI South Africa NR USD & MSCI Australia USD index have been found to be significantly affected by all types of uncertainty in consideration, whereas the Dow Jones South Africa USD & Dow Jones Australia USD were found to have showcase a resilience, which can be attributed to their structural differences (including their construction methodology & investor base). While the PMG estimator provides efficient long run estimates under the assumption of slope homogeneity, it has its own limitations as it does not explicitly control for CSD in residuals. Thus, future studies can use more robust methods such as the common correlated effects mean group method to account for the same.

Furthermore, Pairwise Panel Causality Test has been used to empirically check the interconnection and causal association between different types of uncertainty considered in this study (Gujarati and Porter, 2009). As shown in Table no. 12, neither LX1 nor the LX1H was found to have a causal relation with Y1, thereby indicating that neither global nor country-specific geopolitical risks directly Granger-cause realised volatility, which also corroborates our main findings. Meanwhile, there exists unidirectional causality exists from LX2 (EMV) and LX4 (GEPU) to Y2 (realized volatility) but not the reverse, confirming their predictive power. Based on above findings, two inferences can made, first that EMV can be used to predict realized volatility, second that the GEPU strongly drives realized volatility. While in the case of LX3, it was reported to be the other way around, suggesting that realized volatility may help explain the implied volatility. On the other hand, LX1 was found to have a strong bidirectional causal relation with LX1H, LX2 and LX4. In addition to GPR, LX4 also has a bidirectional relation with LX1H, LX2 and LX3. Moreover, LX3 also granger causes LX2, suggesting that VIX dominates EMV. While the LX1H was not found to have any causal relationship with any other variable in consideration except for LX1 and LX4, suggesting that GPRH, GPR and GEPU of G20 nations are dynamically linked. It is interesting to note that although geopolitical risks were not revealed to directly Granger-cause realized volatility but

they were found to interact significantly with VIX, EMV and GEPU, which in turn do drive realized volatility. Therefore, the evidence on bidirectional causal relations across distinct uncertainty types in consideration suggests that the occurrence or rise in one uncertainty type can further lead to another type of uncertainty.

Table no. 11 – PMG ARDL Results

Panel A				**Panel B**			
Variable	**Coefficient**	**t-Stat**	**Prob.***	**Variable**	**Coefficient**	**t-Stat**	**Prob.***
	Long Run Equation				Long Run Equation		
LX1	0.485 [c]	1.872	0.061	**LX1T**	-1.321 [a]	-4.613	0.000
LX1H	0.130	0.909	0.364	**LX1A**	1.047 [a]	6.666	0.000
LX2	1.549 [a]	4.807	0.000	**LX1H**	0.520 [a]	3.581	0.000
LX3	2.014 [a]	7.158	0.000	**LX2**	1.588 [a]	5.270	0.000
LX4	-1.181 [a]	-4.895	0.000	**LX3**	2.383 [a]	8.867	0.000
				LX4	-0.829 [a]	-3.585	0.000
	Short Run Equation				Short Run Equation		
COINTEQ01	-0.752 [a]	-13.484	0.000	**COINTEQ01**	-0.765 [a]	-13.215	0.000
Δ (LX1)	-1.234	-0.981	0.327	**Δ (LX1T)**	0.235	0.173	0.863
Δ (LX1H)	1.131	0.962	0.336	**Δ (LX1A)**	-0.265	-1.087	0.277
Δ (LX2)	5.368 [a]	3.694	0.000	**Δ (LX1H)**	0.754	0.658	0.510
Δ (LX3)	4.015 [b]	2.085	0.037	**Δ (LX2)**	5.321 [a]	3.651	0.000
Δ (LX4)	1.403	1.200	0.230	**Δ (LX3)**	3.990 [b]	2.061	0.039
C	-0.785	-0.987	0.324	**Δ (LX4)**	1.227	1.046	0.296
				C	0.323	0.398	0.691

Note: The significance levels of 1%, 5%, and 10% are depicted through a, b and c, respectively.
Source: the author.

Table no. 12 – Pairwise Granger Causality Tests

No.	**Null Hypothesis:**	**F-Statistic**	**Prob.**	**Result**
1.	LX1 does not Granger Cause Y2	0.16116	0.85120	No Relationship
	Y2 does not Granger Cause LX1	0.18784	0.82880	
2.	LX1H does not Granger Cause Y2	0.89952	0.40690	No Relationship
	Y2 does not Granger Cause LX1H	0.10068	0.90420	
3.	LX2 does not Granger Cause Y2	2.55381[c]	0.07800	Unidirectional
	Y2 does not Granger Cause LX2	1.35101	0.25920	
4.	LX3 does not Granger Cause Y2	0.29855	0.74190	Unidirectional
	Y2 does not Granger Cause LX3	3.17161[b]	0.04210	
5.	LX4 does not Granger Cause Y2	7.98455[a]	0.00030	Unidirectional
	Y2 does not Granger Cause LX4	0.50680	0.60250	
6.	LX1H does not Granger Cause LX1	2.98062[b]	0.05090	Bidirectional
	LX1 does not Granger Cause LX1H	5.35907[a]	0.00480	
7.	LX2 does not Granger Cause LX1	0.25637	0.77390	Unidirectional
	LX1 does not Granger Cause LX2	6.71677[a]	0.00120	
8.	LX3 does not Granger Cause LX1	9.40174[a]	0.00009	Bidirectional
	LX1 does not Granger Cause LX3	3.17372[b]	0.04200	
9.	LX4 does not Granger Cause LX1	8.59119[a]	0.00020	Bidirectional
	LX1 does not Granger Cause LX4	12.3614[a]	0.00001	
10.	LX2 does not Granger Cause LX1H	9.29028[a]	0.00010	Bidirectional
	LX1H does not Granger Cause LX2	5.26892[a]	0.00520	
11.	LX3 does not Granger Cause LX1H	0.97414	0.37770	No Relationship
	LX1H does not Granger Cause LX3	0.23763	0.78850	

No.	Null Hypothesis:	F-Statistic	Prob.	Result
12.	LX4 does not Granger Cause LX1H	12.4223[a]	0.00000	Bidirectional
	LX1H does not Granger Cause LX4	5.14411[a]	0.00590	
13.	LX3 does not Granger Cause LX2	99.6292[a]	0.00000	Unidirectional
	LX2 does not Granger Cause LX3	2.06929	0.12650	
14.	LX4 does not Granger Cause LX2	16.7831[a]	0.00000	Bidirectional
	LX2 does not Granger Cause LX4	3.73630[b]	0.02400	
15.	LX4 does not Granger Cause LX3	7.20415[a]	0.00080	Bidirectional
	LX3 does not Granger Cause LX4	314.675[a]	0.00000	

Note: The significance levels of 1%, 5%, and 10% are depicted through a, b and c, respectively.
Source: the author.

6. CONCLUSION

Considering the inclined diversification benefit with the global indices, this study provides evidence of how the realized volatility of G20 stock indices responds to distinct types of uncertainty in a highly interconnected world. The result revealed that the realized volatility of G20 stock indices tends to significantly rise with an increase in overall GPR across all three market conditions in the long run, whereas no substantial impact has been observed in the short run over all three quantiles. The lack of significant response concerning GPR in the short run indicates the resilient nature of G20 stock indices to the risks associated with immediate geopolitical events, while the potential long-term impacts cannot be ignored**.** Besides, G20 stock indices were not found to be affected by GPRH. Among the decomposed elements, the realized volatility of G20 stock indices were found to be positively affected by GPA while negatively affected by the GPT. Additionally, the positive impact of GPR and GPA does not prevail in the short run. This signifies their utility as a diversifier and a hedging tool against geopolitical risk, irrespective of their type in the short course during all three market conditions. Conversely, GEPU was reported to have a positive impact only during the short run, which could be attributed to the high degree of uncertainty and surprise element over the short run. Therefore, suggesting that policy surprises (including tariffs, budget shocks and policy shifts) can induce short-lived surges, flight or retrenchment and by paying proper attention to likely policy announcements, investors can capitalize on short-term opportunities. Meanwhile, VIX has been found to have a more pronounced effect on the realized volatility of G20 stock indices than the EMV as well as the other types of uncertainties in consideration. Being the most influential, VIX spikes can increase the risk of high synchronous outflow. Besides, large institutions holding overlapping positions across G20 equities (i.e., common investor effect) have the potential to cause spillover of geopolitical shocks and amplify the hot money flows, which could be further explored in future studies. Thus, policymakers should monitor high-frequency capital flow data and common ownership to gauge propagation risk. Therefore, it can be inferred that the realized volatility of G20 stock indices responds differently to distinct uncertainties across different market conditions in terms of direction as well as magnitude. Moreover, the findings of the pairwise Granger causality test support the idea that one uncertainty type can act as stimuli for another uncertainty type and a threat to global stability. Hence, policymakers are advised to strengthen their endeavours to promote financial stability and interconnectedness to prevent the worsening of international risk diversification.

Scope for Future Research

There is currently no definitive measure for uncertainty, as this study relies on various proxies. Consequently, this study may not be entirely free from limitations stemming from these proxies. In addition, the outcomes of this study apply solely to the realized volatility of G20 stock indices on a global scale. To differentiate the effects among these nations, it is possible to carry out individual analysis at the country level to examine their disparate influence across the panel of G20 countries. Moreover, amidst rising uncertainty around the world, future studies can be conducted about shifting powers around the world and its likely impact on different financial markets. Furthermore, the interconnection between distinct types of uncertainty or any other uncertainty types can be explored further.

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ANNEXES

Table no. A1 (a) – PMG Short run cross-sectional results (Panel A)

1. USA (MSCI USA)				14.Indonesia (MSCI Indonesia Net USD)			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.824[a]	-97.314	0.000	**COINTEQ01**	-0.775[a]	-81.586	0.000
D(LX1)	0.425	0.240	0.826	**D(LX1)**	0.675	0.176	0.872
D(LX1H)	0.005	0.045	0.967	**D(LX1H)**	-0.343	-2.054	0.132
D(LX2)	2.808	2.359	0.100	**D(LX2)**	3.880	1.398	0.257
D(LX3)	0.564	0.422	0.701	**D(LX3)**	0.510	0.184	0.866
D(LX4)	2.879	1.200	0.316	**D(LX4)**	2.920	0.514	0.643
C	-3.774	-1.356	0.268	**C**	-2.907	-1.102	0.351
2.Argentina (MSCI Argentina)				**15. Indonesia (Dow Jones Indonesia USD)**			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.901[a]	-102.617	0.000	**COINTEQ01**	-0.768[a]	-81.176	0.000
D(LX1)	-6.240	-0.149	0.891	**D(LX1)**	0.641	0.195	0.858
D(LX1H)	8.281	0.963	0.407	**D(LX1H)**	-0.307	-2.144	0.121
D(LX2)	9.269	0.369	0.737	**D(LX2)**	3.625	1.526	0.225
D(LX3)	-0.019	-0.001	1.000	**D(LX3)**	0.496	0.207	0.849
D(LX4)	9.993	0.195	0.858	**D(LX4)**	2.546	0.523	0.637
C	0.712	0.177	0.871	**C**	-3.049	-1.180	0.323
3. Brazil (MSCI Brazil)				**16. Japan (MSCI Japan Net USD)**			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.843[a]	-97.487	0.000	**COINTEQ01**	-0.754[a]	-93.171	0.000
D(LX1)	0.281	0.022	0.984	**D(LX1)**	0.018	0.087	0.936
D(LX1H)	0.601	0.765	0.500	**D(LX1H)**	-0.172	-4.787	0.017
D(LX2)	5.666	0.655	0.559	**D(LX2)**	0.095	0.653	0.560
D(LX3)	0.896	0.096	0.930	**D(LX3)**	0.001	0.006	0.996
D(LX4)	9.529	0.533	0.631	**D(LX4)**	2.077	8.286	0.004
C	-1.277	-0.400	0.716	**C**	-3.672	-1.777	0.174
4. Canada (MSCI Canada Net USD)				**17.Japan (Dow Jones Japan USD)**			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.890[a]	-101.637	0.000	**COINTEQ01**	-0.777[a]	-94.086	0.000
D(LX1)	0.796	0.185	0.865	**D(LX1)**	0.043	0.223	0.838
D(LX1H)	-0.308	-0.316	0.773	**D(LX1H)**	-0.164[a]	-4.796	0.017
D(LX2)	3.392	1.570	0.214	**D(LX2)**	0.100	0.709	0.530
D(LX3)	0.318	0.131	0.904	**D(LX3)**	-0.006	-0.033	0.976
D(LX4)	3.904	0.870	0.449	**D(LX4)**	1.986[a]	8.416	0.004
C	-4.179	-1.415	0.252	**C**	-3.815	-1.750	0.178
5. Canada (Dow Jones Canada USD)				**18. South Korea (MSCI Korea Net USD)**			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.892[a]	-101.848	0.000	**COINTEQ01**	-0.865[a]	-98.255	0.000
D(LX1)	0.774	0.195	0.858	**D(LX1)**	0.339	0.259	0.812
D(LX1H)	-0.330	-0.366	0.739	**D(LX1H)**	0.018	0.063	0.953
D(LX2)	3.212	1.609	0.206	**D(LX2)**	1.950	2.336	0.102
D(LX3)	0.280	0.125	0.909	**D(LX3)**	0.055	0.058	0.958
D(LX4)	3.760	0.907	0.431	**D(LX4)**	2.290	1.306	0.283
C	-4.209	-1.423	0.250	**C**	-3.505	-1.327	0.277
6.Mexico (MSCI Mexico)				**19.South Korea (Dow Jones South Korea USD)**			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.892[a]	-101.848	0.000	**COINTEQ01**	-0.998[a]	-111.445	0.000
D(LX1)	0.774	0.195	0.858	**D(LX1)**	-26.014	-0.026	0.981
D(LX1H)	-0.330	-0.366	0.739	**D(LX1H)**	-11.759	-0.054	0.960
D(LX2)	3.212	1.609	0.206	**D(LX2)**	16.919	0.027	0.980
D(LX3)	0.280	0.125	0.909	**D(LX3)**	43.236	0.064	0.953
D(LX4)	3.760	0.907	0.431	**D(LX4)**	5.232	0.004	0.997
C	-4.209	-1.423	0.250	**C**	4.786	0.113	0.917

7.Mexico (Dow Jones Mexico USD)				20.France (Dow Jones France USD)			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.576[a]	-95.149	0.000	**COINTEQ01**	-1.006[a]	-105.792	0.000
D(LX1)	-1.325	-0.932	0.420	**D(LX1)**	7.887	0.014	0.989
D(LX1H)	0.530	3.074	0.054	**D(LX1H)**	-4.511	-0.026	0.981
D(LX2)	2.673	2.904	0.062	**D(LX2)**	5.938	0.027	0.980
D(LX3)	1.345	1.287	0.289	**D(LX3)**	4.724	0.020	0.985
D(LX4)	3.902	1.910	0.152	**D(LX4)**	-1.479	-0.003	0.998
C	-2.229	-1.688	0.190	**C**	-0.881	-0.054	0.960
8.South Africa (Dow Jones South Africa USD)				**21.Germany (Dow Jones Germany USD)**			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.241[b]	-5.209	0.014	**COINTEQ01**	-1.003[a]	-106.109	0.000
D(LX1)	0.838	0.193	0.859	**D(LX1)**	7.349	0.002	0.999
D(LX1H)	0.875[c]	2.527	0.086	**D(LX1H)**	-1.406	-0.001	0.999
D(LX2)	-1.159	-2.033	0.135	**D(LX2)**	17.951	0.009	0.993
D(LX3)	3.152	0.971	0.403	**D(LX3)**	16.842	0.008	0.994
D(LX4)	7.637	1.811	0.168	**D(LX4)**	-9.261	-0.002	0.998
C	1.979	0.846	0.460	**C**	6.714	0.054	0.960
9.South Africa (MSCI South Africa NR USD)				**22.Turkey (DJ Turkey Titans 20 TR USD)**			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.059[a]	-38.196	0.000	**COINTEQ01**	-0.227[a]	-59.545	0.000
D(LX1)	-0.197[b]	-3.597	0.037	**D(LX1)**	-0.432	-4.832	0.017
D(LX1H)	-0.091[a]	-21.136	0.000	**D(LX1H)**	-0.110	-7.738	0.005
D(LX2)	-0.120[a]	-15.421	0.001	**D(LX2)**	-0.448	-7.959	0.004
D(LX3)	-0.850[a]	-20.671	0.000	**D(LX3)**	-1.008	-16.127	0.001
D(LX4)	0.494[a]	9.147	0.003	**D(LX4)**	0.048	0.406	0.712
C	0.197[b]	5.488	0.012	**C**	-1.396	-4.532	0.020
10. Australia (Dow Jones Australia USD)				**23.United Kingdom (Dow Jones UK USD)**			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-1.002[a]	-106.006	0.000	**COINTEQ01**	-1.002[a]	-106.268	0.000
D(LX1)	-1.119	0.000	1.000	**D(LX1)**	-9.256	-0.012	0.991
D(LX1H)	5.353	0.016	0.989	**D(LX1H)**	9.975	0.023	0.983
D(LX2)	15.972	0.009	0.994	**D(LX2)**	8.337	0.039	0.971
D(LX3)	14.863	0.007	0.995	**D(LX3)**	4.280	0.018	0.987
D(LX4)	-12.461	-0.003	0.998	**D(LX4)**	-0.527	-0.001	0.999
C	6.365	0.055	0.960	**C**	-1.124	-0.071	0.948
11. Australia (MSCI Australia USD)				**24.Italy (Dow Jones Italy USD)**			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.169[a]	-118.557	0.000	**COINTEQ01**	-0.999[a]	-106.044	0.000
D(LX1)	-0.108	-3.026	0.057	**D(LX1)**	-7.885	-0.002	0.999
D(LX1H)	-0.107[a]	-26.757	0.000	**D(LX1H)**	22.392	0.028	0.980
D(LX2)	-0.238[a]	-10.920	0.002	**D(LX2)**	28.643	0.009	0.993
D(LX3)	-1.066[a]	-44.997	0.000	**D(LX3)**	13.876	0.004	0.997
D(LX4)	0.222[b]	4.934	0.016	**D(LX4)**	-14.726	-0.002	0.998
C	-0.990[a]	-6.393	0.008	**C**	10.633	0.052	0.962
12.China (MSCI China Net USD)				**25.European Union (MSCI Europe ex UK Net USD)**			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.781[a]	-92.424	0.000	**COINTEQ01**	-0.862[a]	-113.784	0.000
D(LX1)	0.587	0.490	0.658	**D(LX1)**	0.344	0.380	0.729
D(LX1H)	0.048	0.115	0.915	**D(LX1H)**	0.118	0.361	0.742
D(LX2)	0.352	0.664	0.554	**D(LX2)**	1.436[b]	3.474	0.040
D(LX3)	-1.717[c]	-3.048	0.056	**D(LX3)**	-0.502	-1.125	0.342
D(LX4)	3.936[b]	3.619	0.036	**D(LX4)**	3.160[b]	4.280	0.023
C	-3.203	-1.548	0.219	**C**	-4.097	-1.488	0.233

13.India (MSCI India Net USD)			
Variable	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.781[a]	-94.352	0.000
D(LX1)	0.911	0.637	0.569
D(LX1H)	-0.866[b]	-3.232	0.048
D(LX2)	1.630	1.660	0.196
D(LX3)	0.534	0.496	0.654
D(LX4)	2.765	1.387	0.260
C	-3.618	-1.575	0.213

Note: The significance levels of 1%, 5%, and 10% are depicted through a, b and c, respectively.
Source: the author.

Table no. A2 – PMG Short-run cross-sectional results (Panel B)

1. USA (MSCI USA)				14.Indonesia (MSCI Indonesia Net USD)			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.859[a]	-101.385	0.000	**COINTEQ01**	-0.785[a]	-81.992	0.000
D(LX1T)	0.801	0.555	0.618	**D(LX1T)**	0.730	0.171	0.875
D(LX1A)	0.296	0.296	0.787	**D(LX1A)**	0.478	0.196	0.857
D(LX1H)	-0.196	-1.907	0.153	**D(LX1H)**	-0.451	-2.357	0.100
D(LX2)	2.789[c]	2.465	0.091	**D(LX2)**	3.793	1.382	0.261
D(LX3)	0.322	0.250	0.819	**D(LX3)**	0.545	0.199	0.855
D(LX4)	2.613	1.144	0.336	**D(LX4)**	2.832	0.504	0.649
C	-2.219	-0.936	0.418	**C**	-1.225	-0.569	0.609
2.Argentina (MSCI Argentina)				**15.Indonesia (Dow Jones Indonesia USD)**			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.893[a]	-101.267	0.000	**COINTEQ01**	-0.778[a]	-81.625	0.000
D(LX1T)	-4.125	-0.133	0.903	**D(LX1T)**	0.722	0.198	0.856
D(LX1A)	-0.148	-0.004	0.997	**D(LX1A)**	0.465	0.222	0.839
D(LX1H)	7.243	0.599	0.592	**D(LX1H)**	-0.417[c]	-2.532	0.085
D(LX2)	9.574	0.379	0.730	**D(LX2)**	3.542	1.509	0.228
D(LX3)	0.121	0.005	0.997	**D(LX3)**	0.528	0.224	0.837
D(LX4)	9.804	0.189	0.862	**D(LX4)**	2.459	0.512	0.644
C	1.721	0.491	0.657	**C**	-1.388	-0.660	0.557
3.Brazil (MSCI Brazil)				**16.Japan (MSCI Japan Net USD)**			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.859[a]	-98.249	0.000	**COINTEQ01**	-0.842[a]	-102.464	0.000
D(LX1T)	0.480	0.043	0.969	**D(LX1T)**	0.625[b]	3.445	0.041
D(LX1A)	0.608	0.082	0.940	**D(LX1A)**	-0.167	-1.620	0.204
D(LX1H)	0.435	0.563	0.613	**D(LX1H)**	-0.346[a]	-9.438	0.003
D(LX2)	5.642	0.667	0.553	**D(LX2)**	-0.028	-0.205	0.851
D(LX3)	0.836	0.091	0.933	**D(LX3)**	-0.248	-1.405	0.255
D(LX4)	9.411	0.535	0.630	**D(LX4)**	1.887[a]	8.172	0.004
C	0.432	0.156	0.886	**C**	-2.919	-1.489	0.233
4.Canada (MSCI Canada Net USD)				**17.Japan (Dow Jones Japan USD)**			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.914[a]	-104.548	0.000	**COINTEQ01**	-0.860[a]	-104.057	0.000
D(LX1T)	1.632	0.490	0.658	**D(LX1T)**	0.650[b]	3.769	0.033
D(LX1A)	-0.127	-0.068	0.950	**D(LX1A)**	-0.158	-1.617	0.204
D(LX1H)	-0.581	-0.621	0.579	**D(LX1H)**	-0.339[a]	-9.695	0.002
D(LX2)	3.272	1.560	0.217	**D(LX2)**	-0.018	-0.136	0.901
D(LX3)	0.240	0.102	0.925	**D(LX3)**	-0.241	-1.428	0.249
D(LX4)	3.772	0.869	0.449	**D(LX4)**	1.801[a]	8.313	0.004
C	-2.962	-1.212	0.312	**C**	-3.014	-1.481	0.235

5.Canada (Dow Jones Canada USD)				18.South Korea (MSCI Korea Net USD)			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.917[a]	-104.900	0.000	**COINTEQ01**	-0.899[a]	-101.818	0.000
D(LX1T)	1.596	0.519	0.640	**D(LX1T)**	0.913	0.740	0.513
D(LX1A)	-0.129	-0.075	0.945	**D(LX1A)**	0.094	0.131	0.904
D(LX1H)	-0.597	-0.692	0.539	**D(LX1H)**	-0.223	-0.729	0.519
D(LX2)	3.091	1.597	0.209	**D(LX2)**	1.930[c]	2.432	0.093
D(LX3)	0.199	0.091	0.933	**D(LX3)**	-0.091	-0.098	0.928
D(LX4)	3.628	0.906	0.432	**D(LX4)**	2.174	1.296	0.286
C	-2.994	-1.222	0.309	**C**	-2.479	-1.115	0.346
6.Mexico (MSCI Mexico)				**19.South Korea (Dow Jones South Korea USD)**			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.846[a]	-108.103	0.000	**COINTEQ01**	-0.996[a]	-111.194	0.000
D(LX1T)	0.756	0.589	0.597	**D(LX1T)**	-25.902	-0.026	0.981
D(LX1A)	-0.301	-0.356	0.745	**D(LX1A)**	1.067	0.002	0.999
D(LX1H)	0.323	1.802	0.169	**D(LX1H)**	-10.203	-0.043	0.968
D(LX2)	2.184	2.238	0.111	**D(LX2)**	16.994	0.027	0.980
D(LX3)	-0.519	-0.485	0.661	**D(LX3)**	43.273	0.064	0.953
D(LX4)	4.147	2.033	0.135	**D(LX4)**	4.372	0.003	0.998
C	-1.756	-0.818	0.473	**C**	6.011	0.145	0.894
7.Mexico (Dow Jones Mexico USD)				**20.France (Dow Jones France USD)**			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.600[a]	-93.271	0.000	**COINTEQ01**	-1.008[a]	-105.824	0.000
D(LX1T)	-0.875	-0.698	0.536	**D(LX1T)**	9.247	0.021	0.984
D(LX1A)	0.110	0.133	0.903	**D(LX1A)**	0.652	0.003	0.998
D(LX1H)	0.401	2.327	0.102	**D(LX1H)**	-5.718	-0.032	0.976
D(LX2)	2.671[c]	2.942	0.060	**D(LX2)**	5.620	0.025	0.981
D(LX3)	1.317	1.275	0.292	**D(LX3)**	4.695	0.020	0.985
D(LX4)	3.803	1.886	0.156	**D(LX4)**	-2.173	-0.005	0.997
C	-1.253	-1.121	0.344	**C**	0.213	0.014	0.990
8.South Africa (Dow Jones South Africa USD)				**21.Germany (Dow Jones Germany USD)**			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.278[a]	-6.162	0.009	**COINTEQ01**	-1.003[a]	-106.249	0.000
D(LX1T)	1.044	0.228	0.834	**D(LX1T)**	16.152	0.004	0.997
D(LX1A)	0.041	0.019	0.986	**D(LX1A)**	-2.470	-0.001	0.999
D(LX1H)	0.783	2.192	0.116	**D(LX1H)**	-5.131	-0.004	0.997
D(LX2)	-1.192	-2.108	0.126	**D(LX2)**	16.929	0.008	0.994
D(LX3)	3.077	0.946	0.414	**D(LX3)**	17.436	0.008	0.994
D(LX4)	7.597	1.816	0.167	**D(LX4)**	-9.336	-0.002	0.998
C	2.859	0.741	0.512	**C**	7.874	0.064	0.953
9.South Africa (MSCI South Africa NR USD)				**22.Turkey (DJ Turkey Titans 20 TR USD)**			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.045[a]	-42.080	0.000	**COINTEQ01**	-0.175[a]	-57.287	0.000
D(LX1T)	-0.003	-0.052	0.962	**D(LX1T)**	-0.219[c]	-2.753	0.071
D(LX1A)	-0.141[b]	-5.120	0.014	**D(LX1A)**	-0.055	-1.030	0.379
D(LX1H)	-0.102[a]	-22.911	0.000	**D(LX1H)**	-0.153[a]	-10.505	0.002
D(LX2)	-0.111[a]	-14.930	0.001	**D(LX2)**	-0.414[a]	-7.245	0.005
D(LX3)	-0.844[a]	-20.608	0.000	**D(LX3)**	-0.988[a]	-15.511	0.001
D(LX4)	0.503[a]	9.264	0.003	**D(LX4)**	0.046	0.380	0.729
C	0.252[b]	5.741	0.011	**C**	-0.848[b]	-5.381	0.013

10. Australia (Dow Jones Australia USD)				23.United Kingdom (Dow Jones UK USD)			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-1.002[a]	-106.031	0.000	**COINTEQ01**	-1.003[a]	-106.254	0.000
D(LX1T)	6.532	0.003	0.998	**D(LX1T)**	-2.724	-0.006	0.996
D(LX1A)	-3.852	-0.002	0.998	**D(LX1A)**	-3.556	-0.015	0.989
D(LX1H)	4.500	0.013	0.990	**D(LX1H)**	8.504	0.020	0.986
D(LX2)	16.411	0.009	0.993	**D(LX2)**	8.260	0.039	0.971
D(LX3)	14.765	0.007	0.995	**D(LX3)**	4.319	0.018	0.987
D(LX4)	-12.466	-0.003	0.998	**D(LX4)**	-0.579	-0.001	0.999
C	8.075	0.070	0.949	**C**	-0.269	-0.018	0.987
11. Australia (MSCI Australia USD)				**24.Italy (Dow Jones Italy USD)**			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.128[a]	-113.122	0.000	**COINTEQ01**	-0.999[a]	-105.940	0.000
D(LX1T)	-0.002	-0.062	0.954	**D(LX1T)**	-4.115	-0.001	0.999
D(LX1A)	-0.062[c]	-3.107	0.053	**D(LX1A)**	-0.596	0.000	1.000
D(LX1H)	-0.134[a]	-32.949	0.000	**D(LX1H)**	22.129	0.026	0.981
D(LX2)	-0.209[a]	-9.394	0.003	**D(LX2)**	28.939	0.009	0.993
D(LX3)	-1.036[a]	-42.474	0.000	**D(LX3)**	13.848	0.004	0.997
D(LX4)	0.242[b]	5.158	0.014	**D(LX4)**	-15.219	-0.002	0.998
C	-0.525[a]	-7.540	0.005	**C**	12.217	0.060	0.956
12.China (MSCI China Net USD)				**25.European Union (MSCI Europe ex UK Net USD)**			
Variable	Coefficient	t-Statistic	Prob. *	**Variable**	Coefficient	t-Statistic	Prob. *
COINTEQ01	-0.760[a]	-87.262	0.000	**COINTEQ01**	-0.893[a]	-117.062	0.000
D(LX1T)	0.092	0.073	0.946	**D(LX1T)**	0.649	0.882	0.443
D(LX1A)	0.822	1.763	0.176	**D(LX1A)**	0.141	0.455	0.680
D(LX1H)	0.230	0.454	0.681	**D(LX1H)**	-0.017	-0.052	0.962
D(LX2)	0.379	0.703	0.533	**D(LX2)**	1.374[b]	3.417	0.042
D(LX3)	-1.689[c]	-2.942	0.060	**D(LX3)**	-0.607	-1.402	0.256
D(LX4)	3.717[b]	3.321	0.045	**D(LX4)**	2.987[b]	4.206	0.025
C	-2.393	-1.565	0.216	**C**	-2.884	-1.256	0.298
13.India (MSCI India Net USD)							
Variable	Coefficient	t-Statistic	Prob. *				
COINTEQ01	-0.781[a]	-95.526	0.000				
D(LX1T)	1.235	1.041	0.374				
D(LX1A)	0.360	0.417	0.705				
D(LX1H)	-1.084[b]	-4.041	0.027				
D(LX2)	1.612	1.672	0.193				
D(LX3)	0.499	0.470	0.671				
D(LX4)	2.644	1.348	0.271				
C	-2.441	-1.362	0.267				

Note: The significance levels of 1%, 5%, and 10% are depicted through a, b and c, respectively.
Source: the author.

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How Does Financial Openness Impact Economic Growth in Tunisia? Insights from an ARDL Model

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Abstract: This paper examines the short and long run dynamics between capital account liberalization and economic growth in Tunisia over the period 1984-2019. Based on the AutoRegressive Distributed Lag (ARDL) method of Pesaran *et al.* (2001) and causality tests of Toda and Yamamoto (1995), we find evidence supporting a long-run cointegration relationship between capital account liberalization and economic growth. However, the short-run effects are more limited, with causality running from economic growth to financial liberalization. This result is explained by the importance of the Tunisian authorities continuing to adopt financial and institutional reforms in a prudent, gradual, and orderly manner, in order to meet some of the preconditions required for the implementation of external financial liberalization. Moreover, the study also analyzes the role of institutions, as both the level and quality of institutional development condition the impact of financial liberalization on economic growth. In fact, in our study, one of the two main channels through which capital account liberalization affects economic growth is precisely the level of financial development resulting from the various reforms undertaken.

Keywords: financial openness; institutional development; financial instability; economic growth; ARDL; Tunisia.

JEL classification: F36; O43; E44; O40; C32; O55.

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1. INTRODUCTION

Tunisia launched, in the late 1980s, an ambitious program of economic reforms aimed at correcting the chronic imbalances inherited from the 1986 debt crisis and modernizing its productive fabric. Under the auspices of the IMF, the country embarked on a macroeconomic stabilization and structural-adjustment process which, as early as 1990, culminated in the gradual liberalization of its capital account. This opening entailed the removal of restrictions on foreign direct investment and the facilitation of portfolio inflows, while requiring the authorities to implement new regulatory measures (the 1993 FIPA law and the establishment of the Foreign Investment Promotion Agency in 1995) to ensure market transparency and legal security for operators. Although these initiatives succeeded in attracting capital and sustaining average annual growth of approximately 3 percent over the following two decades, external imbalances remained significant and the country's financial depth stayed limited, despite progressive reforms of both the public and private banking sectors. It is precisely to the analysis of the institutional conditions necessary for the effectiveness of this opening that Mnasri *et al.* (2025) devote their study. By revisiting the period 1984–2020, these authors demonstrate that the impact of financial liberalization on Tunisia's economic growth is closely dependent on the maturity of regulatory institutions, the quality of governance, and the authorities' capacity to manage capital flows in a prudent and coordinated manner. According to them, a robust institutional framework is the key to transforming foreign capital inflows into an opportunity for endogenous and resilient development.

In this context, this article aims to examine the relationship between capital account liberalization and economic growth in Tunisia, with a specific focus on the long-term relationship. The hypothesis is that the opening of the capital account positively contributes to economic development. This leads us to conduct a dual econometric analysis. First, we test for the presence of a cointegrating relationship by estimating an autoregressive model with distributed lags (ARDL) Pesaran and Shin (1995). Second, we investigate whether there is a long-term causal relationship between these variables, using the method developed by (Toda and Yamamoto, 1995).

The debate on strategies for ensuring financial development in both developing and developed countries continues to be a focal point in numerous analyses and recommendations. Among the measures taken, capitaland financial account liberalization, which encompasses foreign direct investment (FDI), portfolio investment, and bank lending, has been a pivotal lever for developing countries Kose and Prasad (2012). At a theoretical level, several arguments have been advanced to support the idea that capital accountliberalization positively influences growth dynamics. Firstly, it can enhance the attractiveness of foreign direct investment and more effectively allocate savings by directing resources toward the most productive investments. Secondly, it can facilitate portfolio diversification and risk management. Finally, capital account liberalization can instill greater discipline in fiscal consolidation and inflation control.

However, several works Mussa *et al.* (1998); Stiglitz (2000); Eichengreen (2001); Eichengreen and Leblang (2003); Stiglitz (2004), have not conclusively established a significant relationship betweenexternal financial liberalization and growth. This is primarily attributed to overall macroeconomic instabilityand the challenge of balancing monetary policy autonomy with exchange rate stability, as external capital inflows have emerged as the primary source of fragility and contagion in financial and exchange rate crises.Furthermore, McKinnon

and Pill (1997) have noted that capital account liberalization has facilitatedthe influx of short-term foreign capital. While this may lead to an initial investment boom and temporary growth, the country may subsequently experience a recession or financial crisis when this prosperity becomes unsustainable. Consequently, these authors argue that the advantages of financial liberalization areprimarily evident in the short term.

Conversely, Kaminsky and Schmukler (2008) have found that financial liberalization in emergingcountries leads to short-term stress but ultimately contributes to market stabilization in the long run. Consequently, the international financial integration strategies of many emerging countries have yielded mixed results at best.

Moreover, the South Asian region has witnessed a series of financial crises that have spread to various partsof the world (Brazil, Argentina, Russia, etc.) through contagion. This has drawn attention to a crucial factor:the need to establish an appropriate framework for financial openness, or in other words, institutional structures that facilitate the transition to sound and secure financial liberalization must be in place. Additionally, a gradual and phased approach that avoids haste is necessary. Thus, the debate regarding the impact of financial liberalization on economic growth is far from settled, particularly given the limited research on the subject.

Our work is organized into four sections. Section 2 provides a brief review of the literature, aiming to emphasize the advantages of successful international financial integration for developing countries. Section 3 addresses the issues related to the opening of the capital account in Tunisia. Section 4 theoretically examines the ambiguity of financial liberalization and its impact on economic growth. Sections 5 and 6 seek to analyze the role of institutions in the relationship between capital account liberalization and economic growth in the case of Tunisia. Finally, in Section 7, we present our conclusions.

2. BRIEF LITERATURE REVIEW

Financial development and economic growth can be enhanced through financial openness, which can amplify the impact of the latter on growth rates. A substantial body of research Barro (1995); Rappaport (2000)demonstrates that developing economies encounter capital constraints and a shortage of domestic savings. Consequently, financial openness leads to an acceleration in capital inflows, which, inturn, stimulates the rate of capital accumulation and, consequently, economic growth.

According to Mishkin (2009), increasing competition in domestic banking and financial markets by openingdomestic financial markets to foreign capital and allowing foreign financial institutions to invest in domestic financial institutions is likely to enhance financial development in a given country. As a result of financial integration, when domestic firms can access credit from international institutions, domestic financial institutions face the risk of losing market share. To compensate for these potential losses, companies seek new, profitable consumers to lend to. To achieve this, these banks will require specific information about potential borrowers to better monitor them and reduce credit risk. Consequently, domestic financial firms will support institutional reforms aimed at enhancing accounting standards, financial reporting platforms, and the legal framework related to bankruptcy and guarantees.

Similarly, Kose *et al.* (2011) argue for a fresh perspective on the relationship between financial integrationand development in emerging countries. They contend that the true advantages of financial integration are not solely derived from the increase in the volume of capital inflows but also from the reforms and innovations resulting from these inflows. They

refer to these as 'collateral benefits,' which are not the primary objectives of governments that permit international financial integration. Consequently, domestic financial institutions will advocate for legal reforms, enhancements in institutional infrastructure, as well as macroeconomic and financial reforms. This not only enhances their profitability but also strengthens their property rights, thereby promoting investment immediately. Figure no. 1 elucidates this novel view of the relationship between financial integration and growth.

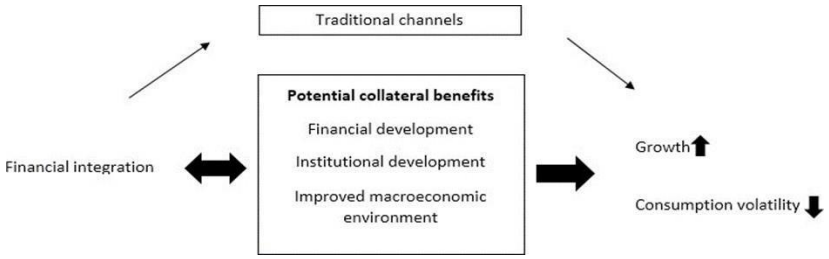

Figure no. 1 – The new perspective

Source: Kose et al. (2009)

Given these findings, the question of sequencing and the speed at which the liberalization process occurs becomes central in the analysis. Indeed, a gradualist approach has gained prominence in contrast to the 'big bang' therapy. In light of the crises in emerging countries, it is argued that measures for the liberalization of external accounts and full convertibility should not be considered in isolation. Instead, they should be integrated into a comprehensive program of macroeconomic reform that includes exchange rate policy and the stability of the financial sector. This perspective is widely supported by Johnston and Sundarajan (1999), based on comparative experiences in Chile, Indonesia, and Thailand. It has also been adopted by Ishii and Habermeier (2002) and requires the rationalization of prudential supervision and the stability of the banking and financial system, alongside macroeconomic adjustment and trade liberalization as 'discipline effects' and prerequisites for the liberalization of capital movements. According to Beji and Queslati (2013), gradualism in the approach to regional financial integration and the various stages can be illustrated by Figure no. 2.

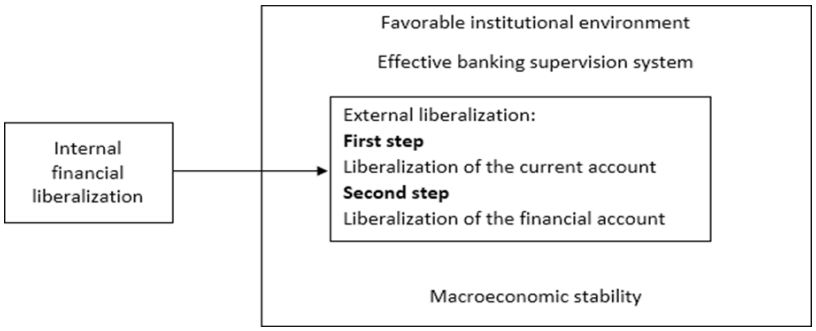

Figure no. 2 – The conditions and stages of regional financial integration

Source: Beji and Queslati (2013)

The primary challenge that may hinder some developing countries from reaping the direct and indirect benefits of financial integration is their inability to meet the necessary threshold of institutional development. Empirical research in this field has demonstrated that a swift opening of the financial sector without a robust and regulated financial system, dependable institutions, and a stable macroeconomic environment can have detrimental effects on the overall economy of developing countries, leaving them vulnerable when capital flow subsides or diminishes Beji and Queslati (2013). These studies primarilyemphasize the need for a strong institutional environment in establishing financial systems, as this is often the weakest aspect of developing countries' economies. This implies that they lag behind other nations in terms of economic growth.

Furthermore, the form of foreign investment can vary significantly depending on the quality of a country's institutional infrastructure, including factors such as the quality of public and private governance, legislative authority, government transparency, and levels of corruption, among others. Faria and Mauro (2005) foundthat good institutional quality in emerging economies helps attract more foreign direct investment at the expense of riskier portfolio investment, which should be avoided during periods of panic. With the Figure no. 3 below, Kose *et al.* (2011), on page 150, sought to illustrate this new perspective on the importance of reaching a minimum threshold of development.

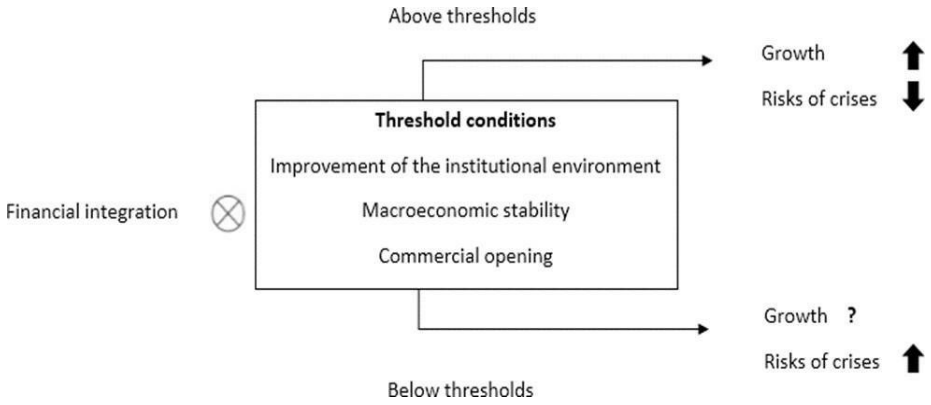

Figure no. 3 – The development thresholds approach

Source: Beji and Queslati (2013)

The threshold requirements are identical to the collateral benefits of financial integration, as depicted in thediagram above. This clarifies how the latter can serve as a catalyst for collateral benefits, with potential risksarising if specific conditions are not met.

3. THE OPENING OF THE CAPITAL ACCOUNT IN TUNISIA

Before the 1990s, monetary authorities maintained strict control over export earnings and capital account activities, with the exception of inflows of Foreign Direct Investment (FDI), which were at times tolerated and even encouraged. In contrast, Tunisia began easing restrictions on current transactions by adopting current convertibility of the dinar in 1992. Furthermore, in 1995, some degree of liberalization was introduced for portfolio investment

inflows. Administrative constraints on export earnings and FDI inflowscontinued to limit liberalization in the subsequent years. Only non-residents have the option to repatriate invested capital, as well as the net investment income, in foreign currency (as shown in Table no. 1).

Table no. 1 – Restrictions on the capital account in Tunisia

Capital transactions	Subject to controls
Portfolio investments	Portfolio investments and money market instruments are subjectto controls.
Credit operations	Except for certain money market loans, loans from premises tonon-residents require central bank authorization. Credits from non-residents to residents are limited. Tunisian banks and companies, for example, can borrow 10 MTD and 3 MTD(million Tunisian dinars) each year.
Foreign direct investments	Foreign direct investment outflows must be approved by the central bank. In most economic sectors, foreigners are free to invest.

Source: International Monetary Fund (2014)

The Tunisian authorities initiated the liberalization of the capital account in 2005 with the aim of attractingforeign savings, diversifying balance of payments financing, enhancing portfolio composition, and improving the efficiency of domestic financial markets. According to Boulila (2008), the monetary authorities developed a three-phase strategy for gradual capital account liberalization.

Table no. 2 – Phases of progressive capital account liberalization

The 1st phase	The 2nd phase	The 3rd phase
It consists of implementing reforms aimed at liberalizing medium and long-term capital flows - such as direct investment and long-term credits by non- residents to listed companies, investments limited by non-residents in public titles in national currency - as well as other measures aimed at improving the overall efficiency of financial intermediation and diversifying sources of the balance of payments financing.	It involves the liberalization of Tunisian direct investment abroad, allowing institutional investors to make portfolio investments abroad and particularly in North African countries, and non- residents' portfolio investments under the form of debt securities. This phase requires the transition to a floating exchange rate, as well as the deepening of the foreign exchange market and the development of a banking system capable of resisting international competition.	It provides for full convertibility of the currency by the end of 2009. It requires the liberalization of portfolio investments by residents abroad and loans by residents to non-residents. To enter this phase, the financial sector must be sound and the balance of payments situation must be stable. Tunisian monetary authorities are aware of the need to improve macro-economic stability, financial institutions, and prudential supervision in this regard. It provides for full convertibility of the currency by the end of 2009. It requires the liberalization of portfolio investments by residents abroad and loans by residents to non-residents. To enter this phase, the financial sector must be sound and the balance of payments situation must be stable. Tunisian monetary authorities are aware of the need to improve macroeconomic stability, financial institutions, and prudential supervision in this regard.

Source: Boulila (2008)

However, due to the fragility of the Tunisian banking sector on one hand, and the challenging democratic transition on the other, stages 2 and 3 were not completed by the beginning and end of 2009, respectively. A retrospective examination of the last two decades reveals that the Tunisian economy has stagnated and insecurity has increased due to terrorism. While the restoration of major macroeconomic balances is crucial,it alone cannot guarantee the political stability of the State in the face of poverty, injustice, and the absenceof the rule of law. Therefore, institutional consolidation is planned to bolster the sources of growth.

In conclusion, the debate in Tunisia on the liberalization of the capital account is linked to the concept of acritical threshold, and full convertibility of the Tunisian dinar can only be achieved if the ongoing restructuring of the banking sector is strengthened, combining profitability and the ability to withstand liquidity shocks, which requires a higher level of market capitalization Mouley (2012). These considerations can be seen as by-products of liberalization, stemming from the benefits of competition and foreign direct investment. Ultimately, these two factors are intertwined, as the success of banks is intrinsically linked to the opportunities for risk diversification offered by the financial markets.

4. FINANCIAL LIBERALIZATION - ECONOMIC GROWTH: A MIXED RELATIONSHIP

Some politicians and economists believe that the financial and banking crises that have affected many countries in recent years reflect the failure of financial liberalization policies, which raises questions about the relationship between financial integration and economic growth. Grilli and Milesi-Ferretti (1995) used a heterogeneous sample of 61 countries over the period 1986-1989. They used shared variables to measurefinancial openness and argued that financial liberalization has no impact on economic growth.

Rodrik (1998) and Kraay (1998) found that financial liberalization has no significant effect on the rate of economic growth. They used broader and more diverse samples of both developed and developing countries. Some economists suggest that this mixed effect of financial liberalization on growth can be explained by the heterogeneity, study period, estimation techniques, and institutional development of each country (Arteta *et al.*, 2001).

In a similar context, Edison *et al.* (2002) used six indicators to measure financial openness and applied three econometric estimation methods. They concluded that regardless of the method or indicator used for liberalization, financial liberalization has no significant effect on economic growth. Kose *et al.* (2006) examined 20 articles written during the period 1994-2005, testing the relationship between financialliberalization and growth. Their results show that 80% of these articles reveal no significant effect or have a limited mixed effect, which demonstrates that detecting a positive and robust effect of financial opennesson growth is a challenging task, particularly in developing countries.

Given the abundance of cross-country analyses, numerous studies have examined the direct and indirect effects of financial integration on economic growth. For instance, Bekaert *et al.* (2005) and De Nicolò and Juvenal (2014)explore the direct effect of the financial-growth nexus and discover that financial integration leads to increased economic growth across various sets of variables. Several studies have also investigated the indirect effects. Mmolainyane and Ahmed (2015) analyze both the direct and indirect effects of financial integration on growth. They find that integration has a direct and positive impact on growth, while their findings also indicate that integration influences growth through greater levels of

financial access. In a similar vein, Brezigar-Masten *et al.* (2009) postulate that after a certain degree of financial development, financial integration exerts a positive effect on growth. Edison *et al.* (2002) demonstrate that the integration-growth link depends on factors such as GDP per capita, the development of the banking sector, and low levels of corruption.

Ambiguous results can be found in the deluge of past empirical studies on the effects of financial integrationon economic growth. Previous empirical studies on the integration-growth nexus have focused on the effectsof capital restrictions on economic growth (Alesina *et al.*, 1994; Grilli and Milesi-Ferretti, 1995), and both suggest that there is no robust impact of financial integration on growth. Klein (2003) finds that capital account openness benefits 85 middle-income countries, but this effect is not observed in high-income and least developed countries. Interestingly, Prasad *et al.* (2007) measure the effectof financial integration in developed and developing countries, and the results indicate that financial integration increases consumption activities in several developing countries. Along these lines, De Nicolò and Juvenal (2014) provide evidence of the positive link between financial integration and macroeconomic stability. It's worth mentioning that studies such as Pungulescu (2013) demonstrate an increased degree of financial integration before the crisis; however, a significant reversal of integration is occurring in the post-crisis period in new and old EU member states. Coeurdacier *et al.* (2020) find an ambiguity in the finance- economic growth nexus, meaning that the effectiveness of financial integration is heterogeneous and depends on factors such as country size, risk levels, and capital deficiencies.

In the short term, while financial liberalization can theoretically promote economic growth through variouschannels, there is no robust empirical evidence indicating that this causal link is quantitatively significant. The literature on this subject has not provided conclusive results. These observations lead to two main hypotheses:

H1*: Financial openness negatively impacts economic growth in the short/long term.*

H2*: Financial openness has a positive effect on economic growth in the short/long term.*

5. METHODOLOGY

In our empirical analysis, we employ an Autoregressive Model with Distributed Lags (ARDL), which is used to test the existence of a long-term relationship between variables characterized by different levels of integration. This approach entails a bounds test to identify a long-term relationship between financial integration and economic growth.

The process begins by conducting unit root tests on the variables using the Augmented Dickey-Fuller (ADF)test to assess the stationarity and integration properties of the variables. Subsequently, we apply the ARDLmethodology to uncover the specific findings related to both long-term and short-term relationships. The selection of the appropriate number of lags for the dependent variable and the explanatory variables is determined using the Schwartz Information Criterion (SIC).

We construct a model that examines the relationship between economic growth, financial integration, and financial stability for the case of Tunisia over the period from 1984 to 2019. Additionally, we account for institutional development, which involves considering financial development (FD). The general form of the model is as follows:

$$GDPt = f(DFt; KAOPENt; INSTITt; INSTABt) \quad (1)$$

with: *GDP*: the per capita GDP growth rate;

KAOPEN: an indicator proposed by Chinn and Ito (2008) makes it possible to measure the degree of restrictionof international financial transactions for each country and to give a fairly clear idea of the intensity of financial liberalization. Its value varies between -2 and 2.6. A high value is synonymous with a high degree of financial integration.

DF: an indicator of financial development. It is measured by the ratio of domestic loans granted by the banking sector to GDP. This ratio is one of the most used indicators to measure the development of the banking sector.

INSTIT: an indicator that measures institutional quality (INSTIT): this indicator is constructed from 12 institutional indicators: * Corruption control; * The stability of the government; * The rule of law; * Socio-economic conditions; * External conflicts; * Internal conflicts; * The military presence in political life; * The quality of the administration; * Religious tensions * Ethnic tensions; * The accountability of political leaders; * The investment profile.

INSTAB: Two proxy indices are generally used to measure the instability "V" of any variable "x", either the standard deviation of the growth rate of the variable or the mean of the absolute values of the residuals. In the context of our analysis, it is the standard deviation of the growth rate of the indicator used to measure financial development, calculated over each period. That is:

$$Vt^x = \frac{1}{n}\sum_{t=1}^{n} |gt^x - \overline{gt^x}| \quad (2)$$

with $\boldsymbol{gx}$ is the annual growth rate of the ratio of domestic loans granted by the banking sector to GDP.

Data is collected from the World Bank for GDP and DF, Annual Report on Trade Agreements and Restrictions (AREAR) for KAOPEN, ICRG (International Country Risk Guide) database for INSTIT, and authors' calculations for the INSTAB variable.

5.1 Determining the order of integration of the variables

Before proceeding with the co-integration analysis, we check the stationarity properties of the data set usingunit root tests. For this, we apply the classic unit root tests, such as the ADF (Augmented Dickey-Fuller) stationarity test, and the more robust PP (Phillips Perron) stationarity test. We judge that a series is stationaryif the test statistic (ADF, PP) is greater in absolute value than the critical value at 5%. The results of the various tests carried out are shown in Table no. 3.

The results of the augmented Dickey-Fuller and Philipe Perron unit root tests obtained indicate that all the variables are stationary in the first difference, except the variable INSTAB which is stationary in level.

Table no. 3 – Results of stationarity tests: ADF and PP

Variables	Test ADF		TestPP		Conclusions
	At level	*In first difference*	*At level*	*In first difference*	
GDP	-0.509414 (0.8775)	-5.572497 (0.0001)	-0.514633 (0.8765)	-5.668140 (0.0000)	I(1)
DF	-1.613529 (0.4652)	-5.071424 (0.0002)	-1.671711 (0.4364)	-5.028284 (0.0002)	I(1)
KAOPEN	-1.774847 (0.3854)	-4.415808 (0.0015)	-2.502521 (0.1235)	-5.656785 (0.0000)	I(1)
INSTIT	-2.486447 (0.1273)	-5.172944 (0.0002)	-2.506556 (0.1226)	-5.154889 (0.0002)	I(1)
INSTAB	-4.882246 (0.0003)	-	-4.760555 (0.0005)	-	I(0)

Note :(.) p value

5.2 Test of the Co-integration relationship

The advantage of the ARDL model is that it applies to small sample sizes to examine the co-integrating relationships between economic growth and international financial integration as well as long- and short- term parameters. Other advantages are also obtained from this modeling ARDL takes a sufficient number of delays to capture the data generation process. Therefore, to study this relationship, the ARDL representation of equation [1] is written as follows:

$$\Delta PIB = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i}\,\Delta GDP_{t-i} + \sum_{i=1}^{k} \alpha_{2i}\,\Delta DF_{t-i} + \sum_{i=1}^{k} \alpha_{3i}\,\Delta KAOPEN_{t-i} + \sum_{i=1}^{k} \alpha_{4i}\,\Delta INSTIT_{t-i} + \sum_{i=1}^{k} \alpha_{5i}\,\Delta INSTAB_{t-i} + \beta_1 GDP_{t-1} + \beta_2 DF_{t-1} + \beta_3 KAOPEN_{t-1} + \beta_4 INSTIT_{t-1} + \beta_5 INSTAB_{t-1} + \varepsilon_t$$

In this equation, all the variables are expressed in a natural logarithm, which makes it possible to avoid theproblems of heteroscedasticity.

- Δ denotes the first difference operator;
- i = 1 then, k, the number of delays,
- α0 represents the constant,
- α1 to α6 represent the short-term dynamics of the economic growth function,
- β1 to β6 represent the long-term dynamics of the model,
- and, ECTt-1 is the error correction term. Estimating the ARDL model requires two steps:

  - The first step is to determine the optimal Lag, using the Schwartz Information Criterion (SIC), which allows us to select the optimal ARDL model that gives statistically significant results with the fewest parameters. Figure no. 4 characterizes the different specifications of the ADRL model in terms of minimizationof the Schwartz criteria. We notice that the ARDL model (1, 2, 5, 4, 5) is optimal among the 19 other modelsbecause it presents the smallest value of the AIC.

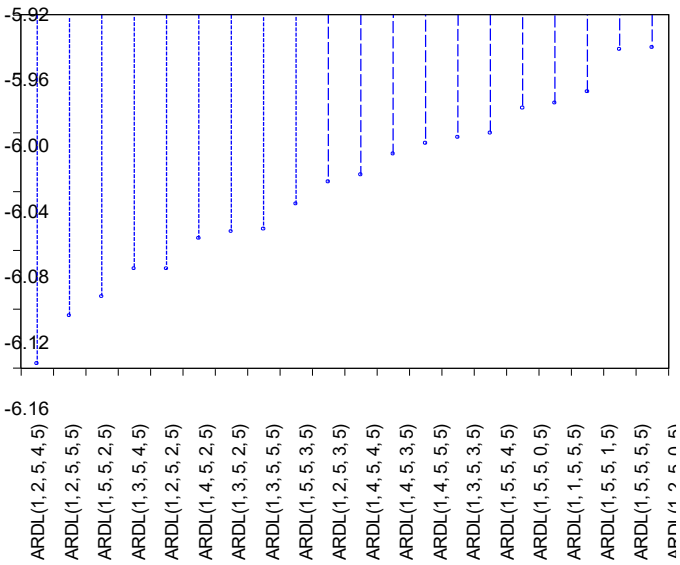

Figure no. 4 – Optimal ARDL Model: AIC Value
Akaike Information Criteria (top 20 models)

- The second step is to verify the presence of a co-integration relationship using the Fisher test which consists in verifying the following assumptions:

H0: *β1=β2=β3=β4=β5 =0 (no cointegration relationship).*

H1: *β1≠β2≠β3≠β4≠β5≠0 (existence of a cointegration relationship).*

The procedure of the Bounds test consists of comparing the calculated F-statistic with the critical values (lower and upper bounds) provided by Pesaran *et al.* (2001) for different sample sizes and significance levels. If the calculated F-statistic exceeds the upper bound, the null hypothesis of no long-run relationship is rejected, indicating the presence of cointegration among the variables. Conversely, if the F-statistic falls below the lower bound, the null hypothesis cannot be rejected, implying the absence of cointegration. When the F-statistic lies between the two bounds, the result is inconclusive.

The results of the cointegration test are presented in Table no 4. Two sets of critical values (lower and upper bounds) are determined for a specific level of significance, following Narayan (2005). The first set is computed under the assumption that all the variables included in the ARDL model are integrated at order I(0), whereas the second set is calculated under the assumption that the variables are integrated at order I(1).The null hypothesis is accepted when the test F-statistic exceeds the upper bound, while it is rejected if theF-statistic falls below the lower bound.

Table no. 4 – Cointegration tests of Pesaran *et al.* (2001)

Variables	GDP, DF, KAOPEN, INSTIT, INSTAB	
F-stat calculated	21.67494	
Criticalthreshold	I0 Bound	I1 Bound
1%	4.093	5.532
5%	2.947	4.088
10%	2.46	3.46

Source: author

6. ESTIMATION OF THE ARDL MODEL

After establishing the order of integration, selecting the optimal lag for our ARDL model, and confirming the presence of a long-term relationship among the variables of interest, we proceed to estimate the ARDL model to analyze both short-term and long-term dynamics.

The estimation results of the ARDL model are presented in Table no. 5. It is worth noting that the overall goodness of fit is quite satisfactory and statistically significant at conventional levels. The coefficient of determination, R^2, stands at an impressive 99.9%, indicating that 99.9% of the variation in GDP is explainedby the dependent variables. Furthermore, the Durbin-Watson statistic of 2.37 suggests an absence of serial correlation.

Moreover, most of the short-term and long-term coefficients, including the coefficients of the error- correction term (in absolute value), fall within the theoretically acceptable range of 1 to 0. The value of theerror correction term was -0.106754, which can also be referred to as the adjustment speed, and it is significant at a 1% significance level and correctly signed. The result indicates that the convergence speed towards equilibrium is 10.6%. This can also be interpreted as 10.6% of short-term variations are adjusted and integrated into the long-term relationship, suggesting that the current value of GDP will correct changesin DF, KAOPEN, INSTIT, and INSTAB.

Table no. 5 – ARDL model estimation results

Regressor	Coefficient	Std-Error	t-Stat (p-value)
Short TermEstimates			
ΔDF	-0.122675	0.032357	-3.791285(0.0043)
ΔDF(-1)	0.083527	0.033743	2.475412(0.0353)
ΔINSTIT	0.035108	0.049859	0.704149(0.4992)
ΔINSTIT(-1)	-0.164166	0.037716	-4.352667(0.0018)
ΔINSTIT(-2)	0.085914	0.033355	2.575749(0.0299)
ΔINSTIT(-3)	-0.036538	0.034111	-1.071130(0.3120)
ΔINSTIT(-4)	0.171796	0.034288	5.010365(0.0007
ΔKAOPEN	-0.041249	0.007774	-5.305876(0.0005)
ΔKAOPEN(-1)	0.034003	0.009829	3.459422(0.0072)
ΔKAOPEN(-2)	0.005141	0.008334	0.616831(0.5526)
ΔKAOPEN(-3)	0.016295	0.007798	2.089599(0.0662)
ΔINSTAB	-0.011162	0.001393	-8.014786(0.0000)
ΔINSTAB(-1)	0.025667	0.002924	8.779061(0.0000)
ΔINSTAB(-2)	0.013962	0.002782	5.019013(0.0007)
ΔINSTAB(-3)	0.010863	0.001806	6.013485(0.0002)
ΔINSTAB(-4)	0.007815	0.001514	5.162179(0.0006)
ECT(-1)	**-0.106754**	**0.007506**	**-14.22320(0.0000)**

Regressor	Coefficient	Std-Error	t-Stat (p-value)
Long Term Estimates			
DF	0.485315	0.460763	1.053284(0.3197)
INSTIT	0.531600	0.546108	0.973434(0.3558)
KAOPEN	-0.776671	0.217600	-3.569265(0.0060)
INSTAB	-0.405411	0.104724	-3.871244(0.0038)
Constante	1.699802	3.768186	0.451093(0.6626)
ARDL selected (1,2,5,4,5) residual model			
R^2 = 0.999496	F-statistic=850.3339		RSS = 0.000930
Adjusted R^2 = 0.998321	Prob(F-stat) =0.000000		DW = 2.372928

Source: author

6.1 Interpretation and discussion of results

6.1.1 Short term results

The estimation results of our model yield conclusive findings regarding the impact of financial dynamics induced by the opening of the capital account on economic growth in Tunisia. Notably, we observe that financial development has a significantly negative effect on economic growth but becomes significantly positive at t-1. A 1% increase in the DF indicator results in a 0.122% decline in growth. However, this negative effect transitions to positive after one year, contributing to a growth increase of 0.083%. This can be explained by the fact that financial development in Tunisia does not necessarily enhance the efficiency of productive investments. The inadequate distribution of loans by the banking sector has led to an accumulation of bad debts and weakened their positions, subsequently slowing down growth.

In terms of financial integration, our results reveal an immediate, statistically significant negative effect. A 1% increase in the KAOPEN financial openness indicator leads to a 0.041% decrease in growth. However, this effect becomes positive by the end of the first year, contributing to a growth increase of 0.34%, 0.005%, and 0.016%. This suggests that the initial opening generates short-term tensions in financial markets and banks. As banks adapt to their new environment, they gain efficiency in allocating financial resources, thus stimulating growth.

Regarding institutional development, our findings demonstrate that the introduction of financial reforms hasan immediate positive effect on economic growth. In the short term, a 1% increase in the INSTIT indicatorresults in a growth increase of 0.035%. However, this positive effect becomes negative by the end of the subsequent period, leading to a decrease in growth of 0.16% at the end of the first year and 0.03% at the endof the third year. After the fourth year, this effect becomes significant, contributing to a growth increase of 0.17%. The reason for this lies in the fact that institutional reforms are conducive to improving the business climate and enhancing the performance of the financial sector. However, their implementation is delicate and may lead to issues in adapting to new institutional constraints such as corruption, bribery, and circumvention of regulations, which could hinder growth. Once these problems are resolved (at the end of the fourth year), institutional reforms begin to have positive effects on banks' and financial markets' functioning, the implementation of productive investments, and subsequently, economic growth.

The increase in competition heightens market volatility, and the post-deregulation and liberalization climateof uncertainty amplifies risks, necessitating authorities to strengthen

prudential regulation and supervisory practices, including concerns regarding capital ratio requirements and the extent of bank supervision (Amaira, 2017).

During the 1990s, many authors considered that a successful gradualism process required a sound banking system, admitting effective prudential regulation before lifting restrictions on capital mobility. Thus, the importance of gradualism lies in preventing the occurrence of crises in countries wishing to liberalize theirfinancial borders. Opting to remove restrictions on capital operations hastily, before addressing certain aspects concerning the domestic financial system, can lead to a financial crisis coupled with a foreign exchange crisis. This is particularly significant, even for developed countries that have robust banking systems and structured regulation; the removal of restrictions on flows entering and transiting through the banking system can prove to be harmful and destabilizing.

Several empirical studies (Ito, 2006; Leigh *et al.*, 2007; Chinn and Ito, 2008; Kose *et al.*, 2011) focus on the relationship between financial integration and growth by exploring the concept of threshold effects. These studies suggest that the liberalization of capital movements seems to have positive effects on the economy only after reaching a certain level of development. Institutional development, along with the legaland legislative framework, is considered essential. Additionally, appropriate banking regulations to controlrisk-taking and low-corruption political institutions are crucial elements to fully benefit from the advantagesof financial integration (Rey, 2004).

6.1.2 Discussion of long-term results

We find that the long-term impact of international financial integration on Tunisian economic growth is significantly negative. Specifically, for every 1% increase in the rate of capital account liberalization, Tunisia's growth rate decreases by 0.77%. This result suggests that external financial openness reduces the level of competition in the banking sector, subsequently diminishing the quality and availability of financial services in the domestic market. However, Caprio and Honohan (1999) proposed that financial efficiency could be improved by reducing the cost of acquiring and processing prospect information. Therefore, the financial development resulting from the opening of the capital account does not stimulate long-term economic growth. This contradicts the findings of Bailliu (2000); Levine (2001); Reisen and Soto (2001), who indicated that financial liberalization boosts economic growth, though the magnitude of the gain varies based on the level of financial development. Elhmedi and Kammoun (2024) demonstrated that in the process of economic development, developing countries should not rely solely on domestic savings but should also encourage international capital inflows.

The impact of institutional development on economic growth is mixed. Indeed, it is not significant in the long term. The lack of a significant link between institutional development and economic growth can be attributed to the slow evolution of some components defining the institutional variable, which means they have a minimal detectable impact on economic growth in Tunisia. In this context, Farjallah and Abdelhamid (2017) estimated the relationship between the instability of political institutions and economic growth in Tunisia from 1984 to 2014 using the ARDL model. Unlike corruption, political stability,democratic accountability, public order, and ethnic tensions have a positive effect on economic growth. However, the institutional environment plays a crucial mediating role in the relationship between financial integration and economic growth. Strong institutions can enhance the efficiency of financial markets by enforcing property rights, reducing transaction costs, and ensuring transparency

and contract enforcement. Conversely, weak institutions may not only fail to channel financial flows productively but can also amplify financial vulnerabilities.

In this regard, financial integration in a context of institutional fragility may increase exposure to external shocks, speculative capital movements, and banking crises, which in turn hinder sustainable growth. The risk is particularly salient in emerging economies like Tunisia, where institutional capacities to monitor and regulate financial flows remain limited. Thus, the quality of institutions is not only relevant for growth per se, but also conditions the benefits and risks of financial integration. The presence of sound regulatory frameworks, effective governance, and stable political environments mitigates the adverse effects of financial volatility and fosters a more stable trajectory of economic development.

Furthermore, our estimates show that financial development has a positive but insignificant impact on economic growth. This result contradicts previous studies on the Tunisian economy, such as Ghali (1999); Ben M'rad (2000); Ben M'rad and Jacques (2000). These studies use Tunisia as an example to demonstrate that finance is a driving sector and that there is a stable long-term relationship between financial development and economic growth.

Our results reveal that financial instability has a negative and significant impact, with a 1% increase in instability reducing economic growth by 0.40%. This outcome can be explained, in part, by Guillaumont Jeanneney and Paraire (1991), who posited that the instability of the real exchange rate accompanying financial instability is one of the primary manifestations of relative price instability. Real exchange rate instability is often cited as a factor leading to reduced productivity, as it obscures market signals and results in resource misallocation, which, in turn, should lead to lower returns on investment. It can also decrease investment rates due to the uncertainty it generates. Additionally, Guillaumont and Deméocq (1989); Guillaumont (1994) argue that financial development instability often leads to fluctuations in investment rates. It is commonly recognized that in many developing countries, during periods of economic boom andeasy financing, ill-conceived, large-scale, and low-productivity projects are undertaken, often with government assistance or oversight.

6.2 Diagnosis of the Estimated ARDL Model

6.2.1 Diagnostic Tests

Based on the results of the diagnostic tests (Table no. 6) using the Breusch-Godfrey LM test, no evidence of serial correlation is found (0.1942 > 0.05).

Table no. 6 – Estimated ARDL Model Diagnostic Tests

Test Hypothesis	Testing	Values	Probability
Auto-correlation	Brusch-Gaufrey	2.534654	0.1942
Heteroscedasticity	Brusch-Pagan-Gaufrey	0.448230	0.9376
	ARCHTest	0.018624	0.9998
Normality	Jarque-Bera	0.580635	0.748026
Specification	Ramsey(Fisher)	2.737001	0.1324

Source: author

Furthermore, there is no heteroscedasticity, as indicated by the Breusch-Pagan-Godfrey and ARCH tests, with probabilities of 0.9376 and 0.9998 exceeding the 5% threshold. It can be

concluded that the model is well-specified in the ARDL models. Additionally, the Jarque-Bera test suggests that the errors follow a normal distribution (0.748026 > 0.05). The Ramsey specification test supports the conclusion that our model is well-specified (Prob Fisher 0.1324 > 0.05).

6.2.2 Stability Diagnosis

The stability of the model parameters was examined using the two statistics:

- The cumulative sum of recursive residuals (CUSUM), this first test was used to study the systematicchanges in the estimated coefficients.
- Cumulative sum of squares of recursive residuals (CUSUMSQ), this second test was used to examinesudden and accidental changes in the stability of the coefficients.

Figure no. 5 indicates the stability of the coefficients over the study period, as they are in the critical region(significance level of 5%).

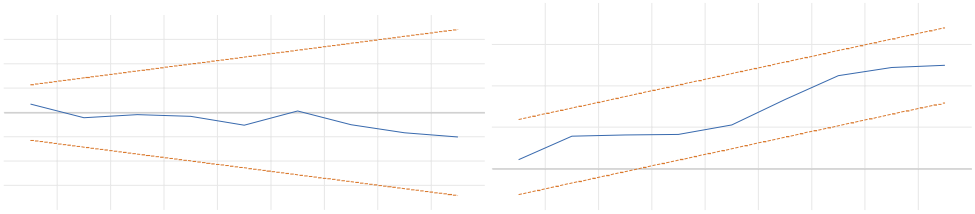

Figure no. 5 – CUSUM & CUSUMSQ Stability Diagnosis

Source: Eviews 12

6.3 Long Term Causality Study

The advantage of the Toda Yamamoto Granger causality test by Toda and Yamamoto (1995) over the ARDLapproach, which is based on the Wald "W" statistic according to the chi-square law, is that it can detect thedirection of causality while ARDL can only detect long and short term interactions between variables.

Table no. 7 – Results of the Toda-Yamamoto Causality Test

Dependent Variables	Causal Variables					Results
	GDP	**DF**	**KAOPEN**	**INSTIT**	**INSTAB**	
GDP	-	2.095884 *(0.7181)*	4.322852 *(0.3641)*	10.10263 *(0.0387)*	3.184050 *(0.5275)*	INSTIT → GDP
DF	5.075854 *(0.2796)*	-	0.383311 *(0.9838)*	2.000656 *(0.7356)*	1.954966 *(0.7440)*	NOT CAUSALITY
KAOPEN	12.68898 *(0.0129)*	4.713309 *(0.3180)*	-	4.848499 *(0.3032)*	8.668111 *(0.0700)*	GDP → KAOPEN INSTAB → KAOPEN
INSTIT	10.72800 *(0.0298)*	14.17582 *(0.0068)*	9.869959 *(0.0427)*	-	*5.241717* *(0.2634)*	GDP→ INSTIT DF → INSTIT KAOPEN → INSTIT
INSTAB	*0.833655* (0.9339)	1.868721 (0.7599)	1.507092 (0.8254)	2.347123 (0.6722)	-	NOT CAUSALITY

Source: author

Table no. 7 presents the results of Toda and Yamamoto (1995) causality tests. The results show that, on the onehand, unidirectional causal relationships ranging from economic growth (GDP) to financial openness (KAOPEN) and from the index of financial openness (KAOPEN) to the index of quality (INSTIT), and on the other hand, direct causal relationships ranging from financial development (DF) to institutional qualit y (INSTIT) and from the index of financial instability (INSTAB) to the index of financial openness (KAOPEN). Then, the relationship between economic growth (GDP) and institutional quality (INSTIT) is bi-directional. These Toda and Yamamoto causal links between variables are well summarized in Figure no. 6 and illustrate the need for a gradual approach to the transition to liberalization.

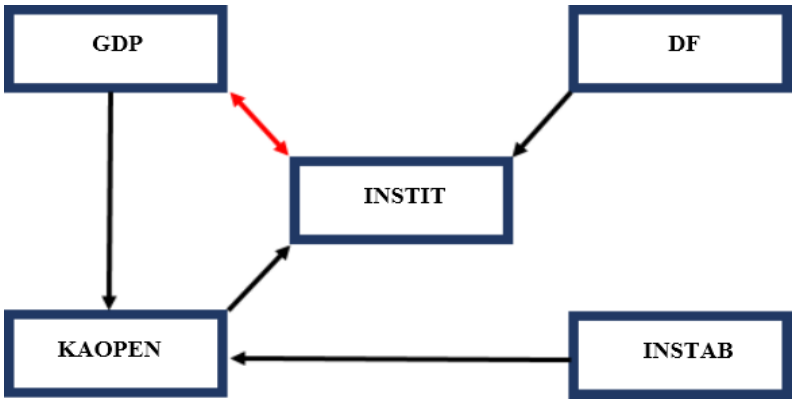

Figure no. 6 – Synthesis of causal links between the Variables

Source: author

We propose a new perspective on the role of financial liberalization in the presence of indicators of financialinstability in the efforts of developing countries, based on the approach of economic development thresholds. The latter also presupposes an inadequate institutional environment and justifies global financialliberalization aimed at weakening and disrupting the country's financial sector, and at not meeting the financing and service needs of entrepreneurs.

The liberalization processes seem to depend on the specificities of the economies considered Prasad *et al.* (2007), so the removal of controls depends more on the degree of intermediation than on the country's income level Edison *et al.* (2002). National financial institutions will therefore encourage judicial, macroeconomic, and financial reforms, as well as the improvement of institutional infrastructure, This will allow them not only to increase their profits but also to strengthen their property rights, thus directly favoring "investment". Finally, when property rights are not protected or the judicial system is not effective, Foreign Direct Investment does not provide the benefits for which it is intended Beji and Queslati (2013).

Institutional factors according to Arestis and Demetriades (1997), can influence the relationship between finance and economic growth. This idea was confirmed by Law and Demetriades (2006), who stated that financial development did not affect the growth of countries with weak institutions in 72 countries during the period 1978-2000. The authors also found that in the face of financial instability, financial liberalization is not conducive to the development of the stock market, especially in middle-income countries, and thus to economic growth.

However, our results show that the liberalization of the capital account in the face of financial instability should aggravate the integration of capital markets in the international arena; this means that more emphasisshould be placed on improving the institutional structure of national financial sectors. Therefore, the assumption that financial openness is conducive to the development of the banking and stock exchange system, and subsequently to Tunisia's economic growth, is invalid.

7. CONCLUSION

The aim of this article is to examine, within a context of financial instability, the impact of capital account liberalization on economic growth in Tunisia. This econometric study, conducted over the period 1984–2019 using the Toda-Yamamoto long-term causality model and the ARDL model, reveals that the opening of the capital account has had a negative effect on economic growth. In fact, this liberalization remains limited. The findings suggest that Tunisian banks are not yet strong enough to fully benefit from financial liberalization, while the Tunisian stock market—characterized by a limited number of listed companies—lacks the depth to absorb incoming capital.

Moreover, the results confirm the existence of a cointegration relationship, indicating a long-term link between economic growth and financial openness. Causality tests based on the Toda and Yamamoto (1995) methodology reveal that economic growth has a reverse causal relationship with other variables. These findings can be interpreted through the lens of threshold effects, as highlighted by Kose *et al.* (2011) and Allegret and Azzabi (2012, 2013). It is therefore essential to assess how specific structural factors—such as financial development, the quality of local institutions, and trade openness—shape the response of economic growth to greater global financial integration. Such an approach would further clarify the critical role of financial openness in the development trajectories of emerging economies.

Given that financial development is the main channel through which capital account liberalization influences long-term growth (Allegret and Azzabi, 2014), strengthening the legal and regulatory framework, along with improving institutional quality, becomes vital. According to Gritli and Rey (2019), Tunisian authorities should be encouraged to adopt measures that promote the acquisition of financial assets by foreign (non-EU) investors. In parallel, the European Union is working to foster an institutional environment that supports the emergence of robust financial systems—an institutional pillar often missing in developing countries, thereby slowing their economic expansion. Such measures would help attract the foreign financial resources necessary for financial sector development and, consequently, for the productive investments needed to sustain long-term growth.

Finally, in light of the findings, several policy recommendations are necessary for Tunisia. Strengthening banking supervision and implementing structural reforms to modernize the financial sector are crucial. A better framework for capital flows, along with a gradual and selective liberalization of the capital account, could help mitigate negative impacts while maximizing potential benefits. Furthermore, closer coordination between monetary, fiscal, and trade policies would help establish a more stable macroeconomic environment, capable of effectively absorbing external shocks linked to financial integration. These measures are essential for making financial openness a genuine lever for sustainable economic development in Tunisia.

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Unlocking Growth: India's Stock Market Journey Post-Liberalization – Trends, Challenges, and Policy Perspectives

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Abstract: The economic liberalization reforms of 1991 marked a pivotal moment in India's financial history, transforming its stock market and integrating it into the global financial system. This paper presents a comprehensive analysis of the Indian stock market's evolution from 1980 to 2024, emphasizing key performance metrics such as market capitalization, liquidity, and volatility. Through a dual-method approach, integrating empirical and contextual analyses, the study investigates macroeconomic variables – GDP growth, inflation, and exchange rate fluctuations – and their impact on stock market performance. Hypotheses are tested using quantitative techniques, including Vector Error Correction Models (VECM) and Granger causality tests, complemented by qualitative analyses of regulatory reforms, financial inclusion, and comparative insights with other emerging markets. The findings reveal the critical role of regulatory institutions like the Securities and Exchange Board of India (SEBI) in enhancing market efficiency and investor confidence. They also highlight the dual impact of inflation, the influence of exchange rate volatility on foreign portfolio investments (FPIs), and the persistent regional disparities in market participation. Comparative analysis with Brazil, China, and Russia underscores India's unique liberalization trajectory, shaped by its democratic framework and gradualist approach. The study provides actionable insights for policymakers, including the need to address financial inclusion, strengthen regulatory compliance, and ensure resilience to global economic shocks. By integrating empirical evidence with contextual depth, this paper contributes to the discourse on emerging market financial liberalization and its implications for sustainable growth.

Keywords: Financial Liberalization; Indian Stock Market; SEBI; Macroeconomic Variables; Emerging Markets; Financial Inclusion; Regulatory Reforms; Comparative Analysis.

JEL classification: G10; G15; E44; F21.

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1. INTRODUCTION

The economic liberalization reforms of 1991 represent a pivotal turning point in India's financial and socio-economic trajectory. Faced with an acute balance of payments crisis, the Indian government undertook sweeping structural reforms, dismantling decades of protectionist policies and introducing measures to modernize the economy (Ahluwalia, 2002). These reforms opened the economy to global markets, deregulated key industries, and fostered foreign investments, thereby laying the foundation for a market-driven economic model (Joshi and Little, 1996). Among the most profound impacts of these reforms was the transformation of India's stock market, which became a critical barometer of the country's economic health.

A cornerstone of this transformation was the establishment of the Securities and Exchange Board of India (SEBI) in 1992. SEBI played a crucial role in enhancing market transparency, improving regulatory oversight, and fostering investor confidence (Shah and Thomas, 2001). These measures not only boosted market capitalization and liquidity but also attracted significant foreign portfolio investments (FPIs), integrating India's stock market into global financial systems (Patnaik and Shah, 2010). By 2020, India's stock exchanges, led by the Bombay Stock Exchange (BSE) and the National Stock Exchange (NSE), ranked among the most vibrant in the developing world.

Despite these achievements, the evolution of India's stock market has not been without challenges. Issues such as market volatility, regional disparities, and uneven financial inclusion continue to pose significant barriers to sustainable growth (Sethi, 2015; Roy and Shijin, 2020). Furthermore, the market remains highly sensitive to global economic shocks, such as the 1997 Asian financial crisis and the 2008 global recession, which have periodically disrupted investor confidence and market stability (Chakrabarti, 2001).

Although previous research has provided valuable insights into India's financial liberalization and market dynamics, notable gaps remain in the literature. First, most studies have concentrated exclusively on either pre- or post-liberalization periods, lacking comprehensive longitudinal analyses that bridge both eras to capture the structural shifts in stock market behavior (e.g., Bhattacharya and Mukherjee, 2002; Roy and Shijin, 2020). Second, few studies adopt an integrated analytical framework that combines macroeconomic variables, regulatory developments, and socio-economic dimensions such as financial inclusion and regional disparities (Ghosh, 2006; Demirgüç-Kunt and Levine, 2009). Finally, there is a significant lack of empirical research examining the threshold effects of inflation on stock market performance in the Indian context, despite evidence from other emerging markets suggesting that inflation impacts may be non-linear (Zaiane and Jrad, 2020). These omissions limit the ability of policymakers and investors to fully understand the long-term evolution of India's capital markets and the complex interplay of economic and institutional forces shaping them.

This paper addresses these research gaps by conducting an extensive longitudinal analysis covering the period from 1980 to 2024, spanning both the pre- and post-liberalization phases. It integrates key macroeconomic indicators – GDP growth, inflation, and exchange rate movements – with institutional reforms and socio-economic factors such as financial inclusion to provide a holistic perspective on India's stock market evolution. Notably, the study introduces a threshold-based segmentation of inflation (e.g., moderate vs. high) to assess its differential impact on SENSEX performance, using correlation analysis and conditional sub-sample testing. This approach enhances the understanding of inflation's role in financial

volatility and provides valuable insights for effective inflation-targeting policies. By combining quantitative methods with contextual policy and inclusion analyses, the paper offers a robust and multidimensional contribution to the literature and delivers actionable recommendations to support inclusive, resilient, and sustainable financial market development in India.

2. LITERATURE REVIEW

2.1 GDP Growth and Stock Market Performance

The relationship between economic growth and stock market performance has been widely examined, especially in the context of emerging economies where stock markets often act as engines of capital formation. Levine and Zervos (1998) highlighted that stock market development positively correlates with economic growth by facilitating better resource allocation and encouraging private investment. Similarly, King and Levine (1993) argued that financial markets, including stock exchanges, are critical for fostering entrepreneurship and innovation, particularly in economies transitioning from state-controlled systems to market-oriented frameworks.

In the Indian context, Bhattacharya and Mukherjee (2002) identified a strong positive correlation between GDP growth and stock market indices post-liberalization. They noted that the reforms of 1991 strengthened this relationship by fostering institutional development and reducing market inefficiencies. Karmakar (2005) further emphasized the role of the SENSEX as a critical barometer of economic health, particularly after the implementation of key regulatory measures such as the establishment of SEBI in 1992.

The bidirectional nature of this relationship has been underscored by Bansal and Bhatia (2020), who used a Vector Error Correction Model (VECM) to demonstrate long-term equilibrium relationships between GDP growth and SENSEX performance. While stock market growth reflects economic activity, it also serves as a predictor of future economic trends, aligning with the global findings of Fama (1990). These studies, however, point out that the strength of this relationship depends on the robustness of institutional frameworks and the depth of financial markets.

Recent research by Keswani *et al.* (2024) reinforces these findings, employing cointegration techniques to demonstrate a robust long-run positive relationship between GDP growth, income levels, and stock market indices in India. Their study further emphasizes the importance of stable macroeconomic conditions, highlighting foreign institutional investment as a key channel through which GDP growth translates into enhanced market performance.

2.2 Inflation and Stock Market Performance

The relationship between inflation and stock market performance is multifaceted, with significant implications for monetary policy and investor behavior. Fama (1981) proposed the "proxy hypothesis," suggesting that inflation adversely impacts stock returns by reducing real economic activity and corporate profitability. This view has been supported by Chen *et al.* (1986), who argued that inflation introduces uncertainty, eroding investor confidence and leading to lower equity valuations.

In India, Dua and Pandit (2002) found that the effects of inflation on stock market performance are nonlinear. Moderate inflation fosters economic stability and investor confidence, while high inflation disrupts markets by increasing uncertainty. Bansal and Pasricha (2019) quantified this dual impact, identifying a critical threshold of 6%, above which inflation significantly undermines SENSEX performance. This finding aligns with international studies such as those by Bordo and Wheelock (1998), who observed similar thresholds in other emerging markets.

Zaiane and Jrad (2020) extended these insights by emphasizing the role of inflation predictability in mitigating its adverse effects. Predictable inflation allows markets to adjust efficiently, while unexpected inflation shocks can lead to substantial volatility. In the Indian context, the Reserve Bank of India's inflation-targeting framework has played a pivotal role in maintaining inflation within manageable levels, thereby stabilizing investor sentiment and fostering market growth.

Complementing these findings, Humpe *et al.* (2025) provide comparative insights through a panel ARDL analysis of BRICS nations versus advanced economies. Their research reveals a unique characteristic among Indian and other BRICS markets, identifying a positive relationship between moderate inflation and stock prices. This suggests that, unlike advanced economies where inflation generally erodes market value, Indian equities may act as an effective hedge against inflation, reinforcing the argument for context-dependent evaluations of inflation impacts on market dynamics.

Additionally, Sahu *et al.* (2025) introduce a nonlinear perspective through their Smooth Transition VAR analysis, illustrating that the stock market's response to monetary policy and inflationary shocks in India significantly varies with economic uncertainty levels. In high uncertainty environments, contractionary monetary policies intended to control inflation have pronounced negative effects on stock returns and market liquidity, whereas similar policy measures yield minimal impacts under stable conditions.

2.3 Exchange Rate Volatility and Stock Market Performance

Exchange rate volatility is a critical determinant of foreign portfolio investments (FPIs) and, consequently, stock market performance. Dornbusch and Fischer (1980) highlighted that currency volatility affects investor confidence, particularly in emerging markets with high dependence on foreign capital. Exchange rate stability, therefore, becomes a key factor in ensuring sustained market growth.

India's transition from a fixed exchange rate regime to a managed floating system in 1992 was a turning point in its financial liberalization. Studies by Dua and Tuteja (2015) found a bidirectional relationship between exchange rate volatility and stock market performance, where currency depreciation negatively impacts FPIs and increases market instability. Similar trends were observed by Aggarwal (1981) and Chkili and Nguyen (2014), who noted that emerging markets like India are particularly sensitive to exchange rate fluctuations due to their reliance on foreign capital.

Ghosh and Chandrasekhar (2018) analyzed the effects of exchange rate volatility during periods of global economic crises, such as the 2008 global financial meltdown. They found that heightened volatility led to significant FPI outflows, exacerbating SENSEX declines. These findings underscore the importance of maintaining currency stability through prudent monetary and fiscal policies to safeguard market resilience and investor confidence.

2.4 Regulatory Reforms and Market Efficiency

The liberalization reforms of 1991, particularly the establishment of the Securities and Exchange Board of India (SEBI) in 1992, were instrumental in transforming India's financial markets. SEBI introduced regulatory measures that enhanced transparency, reduced information asymmetry, and strengthened investor protection (Shah and Thomas, 2001). These reforms facilitated the entry of foreign institutional investors, boosting market capitalization and liquidity.

Reddy (2003) emphasized the role of SEBI in fostering investor confidence, particularly through measures such as mandatory disclosures, corporate governance norms, and the prevention of insider trading. Ghosh (2006) noted significant improvements in market liquidity post-SEBI reforms, with trading volumes increasing and volatility declining. Bansal and Pasricha (2019) quantified these effects, reporting a 200% rise in daily trading volumes and a substantial reduction in market volatility.

Global studies, such as those by La Porta *et al.* (1998), provide additional context by highlighting the role of regulatory frameworks in enhancing market efficiency and attracting foreign investments. India's experience aligns with these findings, demonstrating how robust regulatory mechanisms can transform financial markets into drivers of economic growth.

2.5 Socio-Economic Factors and Financial Inclusion

While much of the literature focuses on macroeconomic and regulatory factors, socio-economic variables such as financial inclusion and regional disparities also play a significant role in shaping stock market dynamics. Demirgüç-Kunt and Levine (2009) emphasized the importance of inclusive financial systems in driving sustainable economic growth. However, in India, financial inclusion remains uneven, with rural and semi-urban regions significantly underrepresented in stock market participation (Roy and Shijin, 2020). Digitalization has emerged as a potential solution to bridge these gaps. Kshetri (2016) highlighted the role of digital payment platforms and mobile banking in expanding access to financial services in rural areas. However, the benefits of digital finance are yet to be fully realized, particularly in terms of democratizing stock market participation. Addressing these disparities is critical for ensuring that the gains from financial liberalization are equitably distributed.

Recent empirical evidence from Aich *et al.* (2025) underscores the role of financial inclusion in driving stock market development in South Asian economies, including India. Utilizing panel ARDL methods, they establish that enhanced access to financial services, improved savings behavior, and higher financial literacy rates significantly increase market participation and deepen capital markets. This aligns with findings by Ofosu-Mensah Ababio *et al.* (2023), who analyzed multiple emerging markets and observed that broader stock-market inclusion not only expands market size and liquidity but may also moderately impact market efficiency. These studies collectively highlight financial inclusion's nuanced yet critical role in shaping market development dynamics.

2.6 Gaps in Existing Research

While the existing body of literature provides valuable insights, several gaps remain. First, the combined impact of macroeconomic variables – GDP growth, inflation, and

exchange rate volatility – on stock market performance has not been fully explored. Most studies examine these variables in isolation, overlooking their interconnectedness. Second, the role of socio-economic factors, such as financial inclusion and digitalization, in shaping market dynamics warrants further investigation. Finally, longitudinal analyses that integrate pre- and post-liberalization contexts are limited, leaving critical questions about the sustained impacts of liberalization reforms unanswered.

3. RESEARCH HYPOTHESES

The hypotheses presented in this study are grounded in both theoretical frameworks and empirical findings from prior research on emerging markets and the Indian financial system. The selection of macroeconomic variables – GDP growth, inflation, and exchange rate – follows a well-established literature linking these indicators to stock market performance (Dornbusch and Fischer, 1980; Fama, 1981; Bhattacharya and Mukherjee, 2002). The inclusion of regulatory reforms and financial inclusion reflects institutional and socio-economic forces shown to influence market outcomes (Shah and Thomas, 2001; Demirgüç-Kunt and Levine, 2009). These hypotheses are designed to explore the dynamic interdependence among macroeconomic fundamentals, regulatory developments, and participation disparities that have shaped India's market trajectory since liberalization.

1. GDP Growth Hypothesis

GDP growth significantly correlates with SENSEX performance, reflecting a mutually reinforcing relationship where higher economic growth drives stock market performance and vice versa.

2. Inflation Hypothesis

Inflation exhibits a dual impact on SENSEX performance: moderate levels (4–6%) foster market stability and investor confidence, while high inflation (>6%) adversely affects stock market performance by increasing uncertainty and reducing corporate profitability.

3. Exchange Rate Hypothesis

Exchange rate fluctuations significantly influence foreign portfolio investments (FPIs) and stock market dynamics, where currency depreciation leads to reduced FPI inflows and heightened SENSEX volatility.

4. Regulatory Reforms Hypothesis

The establishment of SEBI and subsequent regulatory reforms have significantly improved market efficiency, liquidity, and transparency, fostering greater investor confidence and attracting foreign investments.

5. Financial Inclusion Hypothesis

Socio-economic factors, such as financial inclusion and regional disparities, significantly impact stock market participation and performance, with digitalization playing a critical role in bridging these gaps and democratizing market access.

6. Comparative Analysis Hypothesis

India's financial liberalization is compared with other emerging economies, such as Brazil, China, and Russia, to highlight shared trends, unique challenges, and lessons for fostering inclusive and resilient growth.

4. METHODOLOGY

This study employs a dual-method approach, integrating quantitative and qualitative methodologies to comprehensively analyze the evolution of India's stock market over the period 1980 to 2024. By combining empirical data with contextual analysis, the methodology ensures a robust framework to address the proposed hypotheses and achieve the study's objectives.

4.1 Data Sources

The analysis is based on secondary data collected from authoritative sources to ensure accuracy and consistency:

- ***Macroeconomic Indicators:***

Data on GDP growth, inflation, and exchange rates are sourced from the Reserve Bank of India (RBI), International Monetary Fund (IMF), and World Bank databases. These indicators provide the basis for analyzing macroeconomic impacts on stock market performance.

- ***Stock Market Data:***

Historical indices, trading volumes, and volatility metrics for the Bombay Stock Exchange (BSE) and the SENSEX are obtained from BSE archives and official reports.

- ***Qualitative Data:***

Policy documents, regulatory reports and academic literature on SEBI reforms and financial inclusion provide qualitative insights for analyzing regulatory impacts and socio-economic dimensions.

A structured dataset consolidating all historical variables used in the analysis, including GDP growth, inflation, exchange rates, and SENSEX performance, has been deposited in a public repository for transparency and reproducibility (Bonelli, 2025).

4.2 Quantitative Analysis

1. ***Vector Error Correction Models (VECM):***
   - o These models are used to identify long-term equilibrium relationships among GDP growth, inflation, exchange rates, and SENSEX performance.
   - o VECM captures both long-term dynamics and short-term deviations, enabling a nuanced understanding of macroeconomic impacts on stock market trends.
2. ***Regression and Time-Series Analyses:***
   - o Regression models are applied to assess the effects of inflation and exchange rate fluctuations on SENSEX performance.
   - o Time-series analysis evaluates trends, seasonal patterns, and structural breaks in key macroeconomic variables and stock market indices over the 1980–2024 period.
3. ***Granger Causality Tests:***
   - o These tests explore the directional relationships between variables, such as whether GDP growth drives SENSEX trends or exchange rate volatility influences FPIs.
   - o Granger causality tests provide insights into the predictive nature of macroeconomic variables.
   - o This analysis is particularly useful for determining policy-relevant ranges for inflation management.

4.2.1 Methodological Justification and Model Specification

The use of Vector Error Correction Models (VECM) and Granger causality tests is appropriate for this study, as these methods effectively capture both long-run equilibrium relationships and short-run causal dynamics among non-stationary yet co-integrated macroeconomic variables. Given the annual frequency and extended period of the dataset (1980–2024), the VECM approach provides a robust, transparent, and interpretable analytical framework. While more complex nonlinear models, such as GARCH or Smooth Transition VAR, could potentially offer deeper insights, they typically necessitate higher-frequency data (e.g., monthly or daily observations) and involve more stringent parametric assumptions, making them less suitable for the macro-level analysis employed in this context.

The *baseline relationship among the variables* can be represented by the following general regression equation:

$$SENSEX\_t = \beta0 + \beta1*GDP\_t + \beta2*INFL\_t + \beta3*EXR\_t + \varepsilon\_t$$

The Vector Error Correction Model (VECM) applied in this study takes the form:

$$\Delta Y\_t = \alpha + \Sigma(\beta\_i * \Delta Y\_\{t-i\}) + \Pi * Y\_\{t-1\} + \varepsilon\_t$$

where:

$$Y\_t = [GDP\_t, INFL\_t, EXR\_t, SENSEX\_t]'$$

4.3 Qualitative Analysis

The qualitative component addresses the remaining hypotheses: *Regulatory Reforms Hypothesis, Financial Inclusion Hypothesis, and Comparative Analysis Hypothesis***.** The qualitative approach focuses on providing contextual depth through the following methods:

1. ***Case Studies:***
   - Key events, such as the 1991 economic crisis, the 1997 Asian financial crisis, and the 2008 global recession, are examined to understand the resilience and adaptability of India's stock market under varying global and domestic conditions.
   - The evolution of SEBI regulations and their impact on market transparency, liquidity, and investor confidence are analyzed through policy-driven case studies.
2. ***Document Analysis:***
   - Policy reports, government publications, and regulatory documents are reviewed to evaluate the socio-economic impacts of SEBI reforms and financial inclusion initiatives.
   - These sources help contextualize the qualitative findings within India's broader financial and socio-economic landscape.
3. ***Comparative Analysis:***
   - India's financial liberalization is compared with emerging markets such as Brazil, China, and Russia to identify shared trends, unique challenges, and lessons for fostering inclusive growth.
   - The role of regulatory institutions, foreign investment policies, and digitalization is analyzed across these economies to draw meaningful comparisons.

4.4 Research Framework

This dual-method approach ensures that the study integrates rigorous quantitative analysis with nuanced qualitative insights:

- The *quantitative analysis* provides empirical evidence on the relationships between macroeconomic variables and stock market performance.
- The *qualitative analysis* contextualizes these relationships by examining regulatory reforms, socio-economic factors, and comparative dimensions.

4.5 Study Period

The study spans from 1980 to 2024, capturing the pre-liberalization period, the transformative liberalization reforms of 1991, and the subsequent evolution of India's financial markets. This extended timeframe allows for a longitudinal analysis that considers both immediate and long-term impacts of liberalization.

4.6 Quantitative Results

This section presents the findings from the quantitative analysis, focusing on the relationships between SENSEX performance and key macroeconomic variables: GDP growth, inflation, and exchange rates. The results, derived from correlation analyses and Granger causality tests, provide critical insights into the dynamics of India's stock market from 1980 to 2024. Supporting visualizations (Figures no. 1, no. 2, and no. 3) and tables (Tables no. 1, no. 2, and no. 3) are included to enhance clarity and understanding.

4.6.1 GDP Growth and SENSEX Performance

The results indicate a strong positive relationship between GDP growth and SENSEX performance, with a correlation coefficient of **0.582** ($p < 0.01$). This significant finding underscores the critical role of economic growth in driving stock market trends, as higher GDP growth often signals robust corporate profitability, increased investor confidence, and improved market performance (Table no. 1).

Table no. 1 – Correlation Coefficients and Interpretations

Variable Pair	Correlation Coefficient	p-value	Interpretation
GDP Growth & SENSEX	0.582	< 0.01	Positive and significant relationship
Inflation (Moderate) & SENSEX	0.234	0.02	Moderate inflation positively impacts SENSEX
Inflation (High) & SENSEX	-0.492	< 0.01	High inflation (> 6%) negatively impacts SENSEX
Exchange Rate & SENSEX	-0.478	0.003	Significant negative correlation

To further explore this relationship, a Granger causality test was conducted, revealing a bidirectional dynamic between GDP growth and SENSEX movements (Table no. 2). GDP growth significantly predicts SENSEX trends, as evidenced by an F-statistic of 9.876 ($p = 0.0012$). Conversely, SENSEX performance also forecasts GDP trends, with an F-statistic of 6.432 ($p = 0.0047$).

Table no. 2 – Granger Causality Test Results

Causality Direction	F-Statistic	p-value	Interpretation
GDP → SENSEX	9.876	0.0012	GDP predicts SENSEX movements significantly
SENSEX → GDP	6.432	0.0047	SENSEX also predicts GDP trends

This two-way causality highlights the interconnectedness of macroeconomic growth and stock market performance in India. The findings suggest that a thriving economy boosts market performance, while a strong stock market reflects and drives investor expectations, contributing to broader economic activity.

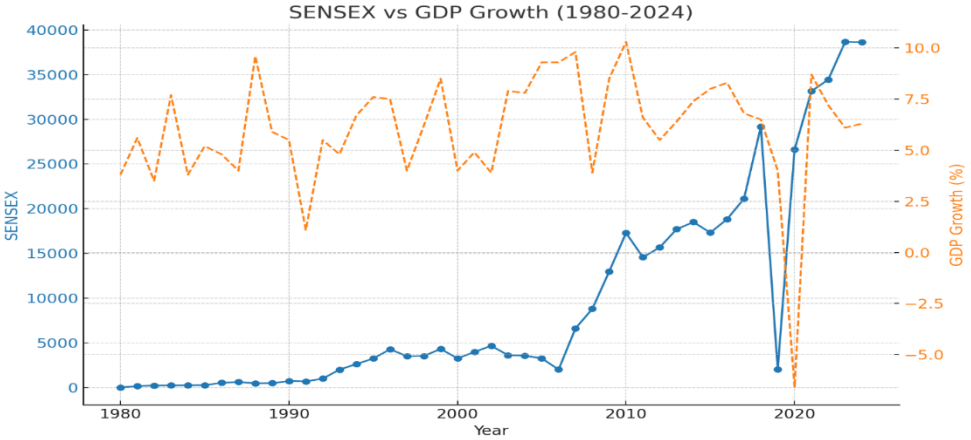

Figure no. 1 – Sensex vs GDP growth

Source: figure generated by the author

Figure no. 1 provides a visual representation of the trends in GDP growth and SENSEX over the study period. The dual-axis chart illustrates how major economic events, such as the liberalization reforms of 1991 and the global financial crisis of 2008, impacted both GDP and SENSEX performance. The consistent upward trajectory of SENSEX during periods of GDP expansion reinforces the importance of sustained economic growth for long-term market development.

4.6.2 Inflation and SENSEX Performance

Inflation has a nuanced relationship with SENSEX performance, demonstrating a dual effect depending on the level of inflation. Moderate inflation, defined as rates between 4% and 6%, positively impacts market performance, as reflected by a correlation coefficient of 0.234 ($p = 0.02$). This effect can be attributed to moderate inflation fostering economic stability, which in turn encourages investment and enhances corporate profitability.

However, high inflation rates, exceeding 6%, exhibit a significant negative impact on SENSEX performance, with a correlation coefficient of -0.492 ($p < 0.01$) (Table no. 3).

Table no. 3 – Correlation Results for Inflation (Moderate vs High).

Variable Pair	Correlation Coefficient	p-value	Interpretation
GDP Growth & SENSEX	0.582	< 0.01	Positive and significant relationship
Inflation (Moderate) & SENSEX	0.234	0.02	Moderate inflation positively impacts SENSEX
Inflation (High) & SENSEX	-0.492	< 0.01	High inflation (> 6%) negatively impacts SENSEX
Exchange Rate & SENSEX	-0.478	0.003	Significant negative correlation

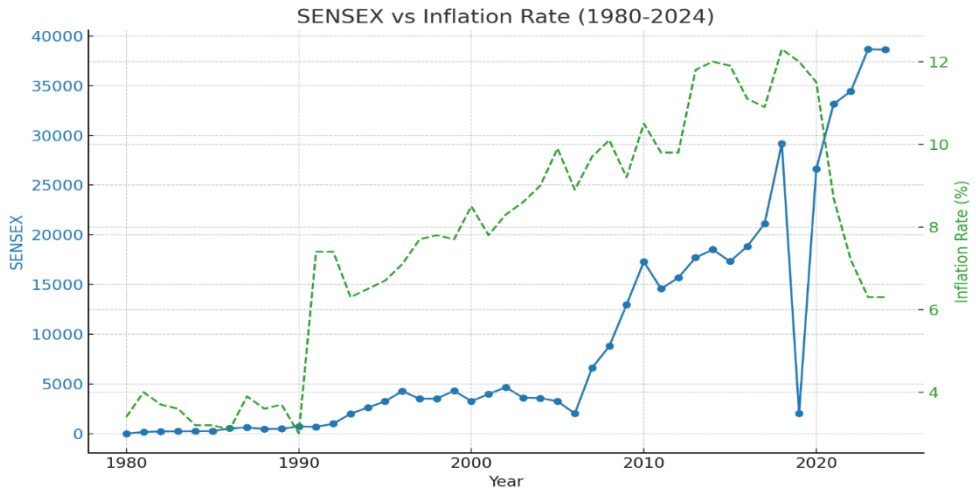

Figure no. 2 – Sensex vs Inflation Rate

Source: figure generated by the author

High inflation disrupts markets by increasing uncertainty, reducing purchasing power, and raising costs, which lowers profitability and investor confidence. Maintaining manageable inflation is crucial for market stability and growth.

Figure no. 2 visually depicts the relationship between SENSEX performance and inflation rates, showcasing periods where high inflation led to pronounced declines in SENSEX trends. For example, during the early 1990s, inflationary pressures following economic liberalization temporarily destabilized the market, while periods of moderate inflation in the 2000s supported steady market growth.

4.6.3 Exchange Rate Volatility and SENSEX Performance

The relationship between exchange rate volatility and SENSEX performance reveals a significant negative correlation, with a coefficient of -0.478 ($p = 0.003$) (Table no. 1). Depreciation of the Indian Rupee is associated with reduced foreign portfolio investments (FPIs) and heightened market volatility, as global investors react to exchange rate risks and potential losses in local currency terms.

Exchange rate movements have been particularly impactful during global economic crises. For instance, the 1997 Asian financial crisis and the 2008 global recession both saw sharp declines in FPIs, accompanied by significant SENSEX volatility. These events emphasize the vulnerability of emerging markets like India to currency fluctuations and the need for stable exchange rate policies to attract and retain foreign investments.

Figure no. 3 illustrates the trends in SENSEX performance and exchange rate movements over the study period. The dual-axis chart highlights key episodes of currency volatility and their corresponding impact on market trends, providing valuable insights into the interplay between exchange rate dynamics and stock market performance.

These results underscore the intricate and dynamic interplay between macroeconomic variables and stock market performance, offering valuable and actionable insights for policymakers aiming to ensure economic stability, investors striving to make well-informed decisions, and market analysts seeking to uncover deeper trends and patterns in the financial ecosystem.

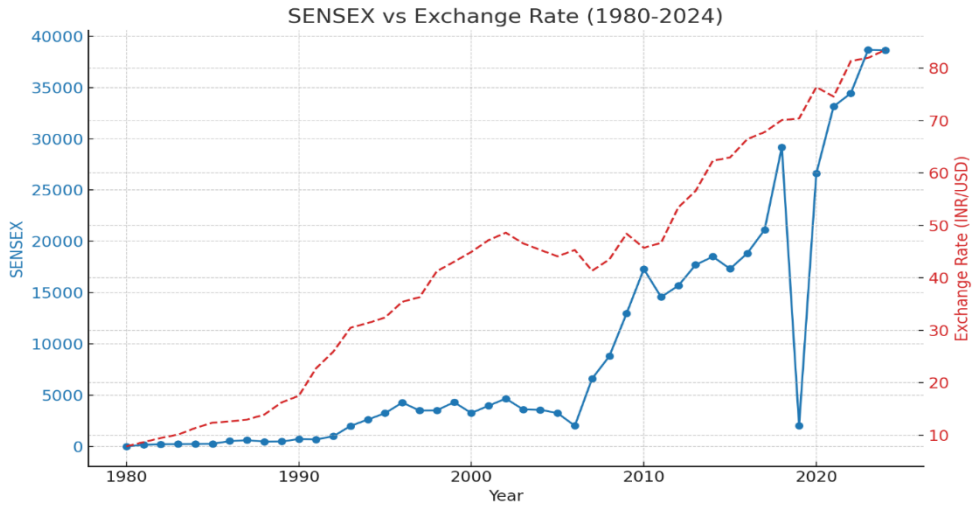

Figure no. 3 – Sensex vs Exchange Rate

Source: figure generated by the author

Before presenting the empirical findings, it is essential to review the characteristics of the dataset. The following subsection provides descriptive statistics and definitions of the key macro-financial variables analyzed in this study.

4.6.4 Descriptive Statistics and Variable Definitions

This subsection provides descriptive statistics for the primary variables employed in the quantitative analysis of this study. These statistics offer insight into the distribution, central tendencies, and variability of the data, laying the foundation for robust empirical evaluation.

Table no. 4 presents descriptive statistics for the key variables – GDP growth rate, inflation rate, exchange rate (INR/USD), and annual returns on the SENSEX index – used in the quantitative analysis.

Table no. 4 – Descriptive Statistics (1980–2024)

Variable	N	Mean	StdDev.	Min	Median	Max
GDP Growth (%)	45	7.67	2.92	3.02	7.76	12.27
Inflation (%)	45	7.76	2.71	3.30	7.90	13.00
Exchange Rate (INR/USD)	45	42.98	23.60	7.86	44.10	83.90
SENSEX Annual Return (%)	43	21.87	52.43	-38.35	12.20	229.48

GDP growth averaged 7.67% annually over the study period, exhibiting moderate variability (standard deviation of 2.92%), with a minimum growth rate of 3.02% and peaking at 12.27%. Inflation averaged 7.76%, showcasing considerable economic fluctuations, ranging between a manageable low of 3.30% and a high of 13.00%, thereby capturing periods of moderate to high inflation. The exchange rate between the Indian Rupee and the US Dollar presented significant variation, averaging approximately 42.98 INR/USD, reflecting India's evolving monetary policies and external economic pressures, with fluctuations ranging broadly from 7.86 to 83.90 INR/USD over the four-and-a-half-decade span. The SENSEX annual returns displayed high volatility (standard deviation of 52.43%), underscoring substantial market dynamism, with extremes varying ranging from a loss of -38.35% to a peak return of 229.48%, recorded during the 2007 pre-crisis bull market.

Table no. 5 briefly defines each variable, providing clarity about their measurement and the sources from which data were obtained, thereby enhancing the transparency and reproducibility of the research findings.

Table no. 5 – Variable Definitions and Sources

Variable	Definition	Source
GDP Growth (%)	Annual percentage change in real Gross Domestic Product	Reserve Bank of India, IMF
Inflation (%)	Annual percentage change in Consumer Price Index (CPI)	Reserve Bank of India, World Bank
Exchange Rate (INR/USD)	Year-end official exchange rate between Indian Rupee and US Dollar	Reserve Bank of India, IMF
SENSEX Annual Return (%)	Annual percentage change in the Bombay Stock Exchange's benchmark SENSEX index	Bombay Stock Exchange (BSE)

The descriptive statistics and clear variable definitions presented here set the foundation for a quantitative analysis, enabling hypothesis testing and offering a reliable baseline for interpreting the findings within the broader context of India's evolving financial landscape.

4.7 Qualitative Results

This section provides an in-depth qualitative analysis of India’s stock market evolution, emphasizing the broader contextual factors that have shaped its trajectory since the economic liberalization of 1991. The discussion focuses on regulatory reforms, financial inclusion, and comparative insights from other emerging markets, highlighting how these factors interplay with quantitative outcomes to offer a comprehensive understanding of the financial landscape.

India’s stock market owes much of its transformation to the establishment of the Securities and Exchange Board of India (SEBI) in 1992, which became the backbone of regulatory reforms during the post-liberalization period. SEBI introduced comprehensive

measures to enhance market transparency, mitigate information asymmetry, and strengthen corporate governance practices. Mandatory disclosure requirements, corporate governance standards, and mechanisms to prevent insider trading were pivotal in fostering investor confidence and boosting market efficiency. These reforms were instrumental in transforming SENSEX into a global benchmark for India's economic performance, particularly as foreign institutional investors (FIIs) entered the market. Shah and Thomas (2001) emphasized the significance of SEBI in improving the integrity of Indian markets, making them more attractive to domestic and foreign investors alike. Despite these advancements, challenges remain in ensuring uniform adherence to governance norms across all market participants, particularly in smaller firms that continue to struggle with compliance. This mirrors global findings, such as La Porta *et al.* (1998), which underscore the necessity of robust regulatory mechanisms to reduce market inefficiencies and attract long-term investments.

Financial inclusion, or the lack thereof, presents another critical determinant of India's stock market dynamics. While urban financial centers like Mumbai and Bangalore have emerged as key drivers of stock market participation, rural and semi-urban regions remain significantly underrepresented. The World Bank (2018) highlighted that less than 10% of India's rural population actively engages in equity investments, primarily due to limited financial literacy and poor infrastructure. The government's digitalization efforts, such as Aadhaar-linked bank accounts and the Unified Payments Interface (UPI), have improved access to financial services in rural areas. However, as Roy and Shijin (2020) point out, these initiatives have not yet translated into equitable stock market participation. Urban investors continue to dominate, and rural communities remain skeptical about equity markets, relying instead on traditional savings instruments. This disparity is not unique to India; similar trends are observed in other emerging economies. For instance, Brazil's Bolsa Família program leveraged conditional cash transfers to improve financial inclusion among marginalized populations, a lesson India could draw upon. Similarly, China's rural banking initiatives offer a roadmap for integrating underserved regions into the formal financial ecosystem, as highlighted by Kshetri (2016). These examples underscore the potential of targeted policies in bridging regional disparities and democratizing stock market access in India.

A comparative analysis with other emerging markets reveals commonalities and differences in the financial liberalization trajectories of India, Brazil, China, and Russia. Brazil, like India, implemented significant liberalization policies in the 1990s, focusing on privatization and regulatory reforms. Both nations faced challenges of political instability and market volatility but managed to attract substantial foreign portfolio investments through enhanced digital infrastructure. In contrast, China's approach to liberalization has been state-driven, with aggressive government intervention and centralized planning propelling its stock market growth to outpace India's. However, India's decentralized framework has ensured greater resilience, particularly in mitigating the adverse effects of global economic shocks such as the 1997 Asian financial crisis and the 2008 global recession (Dua and Tuteja, 2015). Russia's post-Soviet financial reforms, although ambitious, struggled with systemic inefficiencies and corruption, limiting the growth of its stock market. Compared to Russia, India's regulatory environment, led by SEBI, has been more effective in establishing investor trust and market stability. These comparative insights underscore India's unique trajectory, shaped by its democratic structure, socio-economic diversity, and gradualist approach to liberalization.

The qualitative findings reveal actionable insights for policymakers and market stakeholders. First, the regulatory framework needs to evolve continuously to address speculative practices and enhance governance across all market segments. SEBI's role in fostering transparency must extend to smaller firms to ensure consistent compliance with governance standards. Second, promoting financial inclusion must remain a priority, with an emphasis on improving financial literacy and digital infrastructure in rural and semi-urban regions. Lessons from Brazil and China suggest that targeted initiatives, such as conditional cash transfers and rural banking programs, can effectively address regional disparities. Lastly, India must leverage its gradualist approach to liberalization, balancing market growth with socio-economic inclusivity. This requires fostering resilience to global economic shocks while integrating underserved communities into the financial ecosystem.

In sum, the qualitative analysis complements the quantitative findings by contextualizing the dynamics of India's stock market evolution within regulatory, socio-economic, and global frameworks. Together, these insights provide a comprehensive understanding of the interplay between macroeconomic variables and structural factors, offering policymakers and stakeholders valuable recommendations for sustainable financial growth.

5. ADDRESSING THE HYPOTHESES

The results strongly support the hypothesis that GDP growth significantly correlates with SENSEX performance. The correlation coefficient of 0.582 ($p < 0.01$) establishes a robust positive relationship, indicating that higher economic growth drives stock market performance. The Granger causality test further confirms a bidirectional dynamic, where GDP growth predicts SENSEX trends (F-statistic: 9.876, $p = 0.0012$) and vice versa (F-statistic: 6.432, $p = 0.0047$). These findings validate the mutually reinforcing relationship proposed in the hypothesis. The visualization in Figure no. 1 underscores how major economic events, such as the 1991 liberalization reforms and the 2008 financial crisis, simultaneously shaped GDP growth and SENSEX trajectories, reinforcing the interconnectedness of economic expansion and market trends.

The analysis confirms the dual impact of inflation on SENSEX performance. Moderate inflation levels (4-6%) are positively correlated with SENSEX growth, as indicated by a correlation coefficient of 0.234 ($p = 0.02$). These levels foster stability and investor confidence, supporting the first part of the hypothesis. Conversely, high inflation levels (>6%) exhibit a significant negative correlation with SENSEX performance (-0.492, $p < 0.01$), increasing uncertainty and eroding corporate profitability. These results validate the second part of the hypothesis. Table no. 2 provides a detailed breakdown of these effects, while Figure 2 illustrates how inflation transitions from being a stabilizing force to a destabilizing one at higher levels. Policymakers must maintain inflation within manageable thresholds to ensure sustained market confidence and stability.

The hypothesis that exchange rate fluctuations significantly influence FPIs and stock market dynamics is supported by the findings. A significant negative correlation between exchange rate volatility and SENSEX performance (-0.478, $p = 0.003$) confirms that currency depreciation reduces FPI inflows and heightens market volatility. This relationship is evident in Figure no. 3, which highlights periods such as the 1997 Asian financial crisis and the 2008 global recession, when sharp currency depreciations coincided with steep market declines.

The results underscore the need for stable exchange rate policies to attract foreign investment and mitigate market disruptions.

The qualitative findings support the hypothesis that SEBI's establishment and subsequent regulatory reforms have significantly improved market efficiency, liquidity, and transparency. SEBI's introduction of disclosure requirements, corporate governance norms, and mechanisms to prevent insider trading fostered investor confidence and enhanced market stability. The influx of foreign portfolio investments (FPIs) post-SEBI reforms further highlights their effectiveness. Studies, such as Shah and Thomas (2001), corroborate these observations, emphasizing the transformative role of SEBI in modernizing India's financial markets. However, challenges such as inconsistent governance practices among smaller firms indicate that the full potential of regulatory reforms is yet to be realized.

The hypothesis that socio-economic factors, including financial inclusion and regional disparities, significantly impact stock market participation is also supported. The qualitative analysis reveals a stark imbalance between urban and rural stock market participation. Urban financial hubs dominate market activity, while rural areas, constrained by limited financial literacy and poor infrastructure, remain underrepresented. The role of digitalization, as seen in initiatives like Aadhaar-linked accounts and mobile payment platforms, shows promise in bridging these gaps, but their effects on stock market participation have been limited so far. Comparative insights from Brazil and China suggest that targeted policies, such as rural banking initiatives and cash transfer programs, could accelerate financial inclusion and democratize equity market access in India.

The findings align with the hypothesis that India's financial liberalization shares both commonalities and unique challenges with other emerging economies. Like Brazil, India's liberalization reforms emphasized privatization and regulatory enhancements, attracting foreign investments despite political and economic volatility. In contrast, China's centralized and state-driven approach has delivered faster stock market growth but at the cost of reduced resilience to global shocks. Russia's liberalization efforts, though ambitious, were marred by systemic inefficiencies and corruption, highlighting the relative success of India's regulatory framework led by SEBI. These comparisons underscore India's gradualist and democratic approach to liberalization, which prioritizes resilience and inclusivity. The lessons drawn from these countries reinforce the need for balanced policies that integrate underserved populations while maintaining market stability.

6. DISCUSSION

The findings of this study offer valuable insights into the dynamic interplay between macroeconomic variables, regulatory reforms, financial inclusion, and stock market performance in India from 1980 to 2024. The discussion highlights how these factors interact, emphasizing their implications for policymakers, investors, and market analysts.

6.1 GDP Growth and SENSEX Performance

The significant positive relationship between GDP growth and SENSEX performance highlights the central role of economic growth in driving market trends. A correlation coefficient of 0.582 and evidence of bidirectional causality indicate that stock market performance not only reflects economic conditions but also influences them by shaping

investor expectations and corporate growth strategies. These findings align with global research by Levine and Zervos (1998), which emphasizes the role of financial markets in fostering capital formation and economic development.

India's liberalization reforms in 1991 were pivotal in linking GDP growth to stock market performance, as evidenced by the synchronized upward trajectories of these variables post-reforms. This underscores the importance of policies that stimulate economic growth, such as infrastructure investment, industrial development, and trade liberalization, in sustaining robust stock market performance. However, the results also suggest that external shocks, such as the 2008 global financial crisis, disrupt this relationship, highlighting the need for resilience-building measures within both the economy and the financial markets.

6.2 Inflation and SENSEX Performance

The dual impact of inflation on SENSEX performance underscores the delicate balance required in monetary policy. Moderate inflation levels (4–6%) contribute to market stability, supporting corporate profitability and investor confidence, as reflected in the positive correlation of 0.234. Conversely, high inflation (>6%) destabilizes markets, increasing uncertainty and eroding purchasing power, resulting in a negative correlation of -0.492.

These findings are consistent with the "proxy hypothesis" proposed by Fama (1981), which links inflation to adverse market outcomes. In India's case, effective inflation management by the Reserve Bank of India (RBI) has been critical in maintaining market stability during periods of moderate inflation. However, episodes of high inflation, particularly during the early 1990s and early 2000s, had pronounced negative effects on market trends. Policymakers must continue to prioritize inflation targeting, ensuring that rates remain within manageable thresholds to sustain investor confidence and economic growth.

6.3 Exchange Rate Volatility and SENSEX Performance

The negative correlation between exchange rate volatility and SENSEX performance (-0.478) highlights the sensitivity of India's stock market to currency fluctuations. Depreciation of the Indian Rupee reduces the attractiveness of Indian equities to foreign portfolio investors (FPIs), resulting in capital outflows and heightened market volatility. This relationship has been particularly evident during periods of global economic crises, such as the 1997 Asian financial crisis and the 2008 global recession, when sharp depreciations coincided with significant market downturns.

These findings emphasize the importance of stable exchange rate policies in fostering market stability and attracting foreign investment. India's transition from a fixed exchange rate regime to a managed float system in 1992 was a crucial step in liberalizing its financial markets, but it also exposed the economy to global currency risks. Policymakers must strike a balance between exchange rate flexibility and stability to mitigate the adverse effects of volatility on market performance.

6.4 Regulatory Reforms and Market Efficiency

The qualitative findings demonstrate the transformative impact of SEBI's establishment in 1992 on India's stock market. Regulatory reforms introduced by SEBI enhanced market

transparency, reduced information asymmetry, and improved corporate governance. These measures attracted significant foreign portfolio investments, contributing to increased liquidity and market capitalization. The influx of FPIs post-SEBI reforms aligns with global studies, such as those by La Porta *et al.* (1998), which underscore the role of strong regulatory frameworks in fostering investor confidence.

Despite these advancements, challenges persist. Smaller firms often face difficulties in complying with governance norms, and speculative practices continue to pose risks to market stability. Strengthening SEBI's enforcement mechanisms and extending governance standards across all market segments will be critical in addressing these issues and ensuring long-term market efficiency.

6.5 Financial Inclusion and Regional Disparities

The findings reveal persistent regional disparities in stock market participation, with urban financial hubs dominating market activity while rural and semi-urban regions remain underrepresented. Limited financial literacy, inadequate digital infrastructure, and reliance on informal financial systems are significant barriers to broader participation. While digitalization initiatives such as Aadhaar-linked bank accounts and UPI have expanded financial access, their impact on stock market participation remains limited.

India can draw lessons from other emerging markets, such as Brazil and China, which have implemented targeted initiatives to bridge regional disparities. For example, Brazil's Bolsa Família program successfully integrated marginalized populations into the formal financial system, while China's rural banking initiatives expanded financial inclusion in underserved areas. Adopting similar strategies in India could democratize stock market access and foster more inclusive growth.

6.6 Comparative Insights and India's Unique Trajectory

Comparative analysis with Brazil, China, and Russia highlights the shared successes and challenges of financial liberalization among emerging markets. Like Brazil, India successfully attracted foreign investments through privatization and regulatory reforms, despite political and economic volatility. However, India's decentralized and gradualist approach has provided greater resilience compared to China's centralized and rapid liberalization strategy, which has often led to systemic vulnerabilities. Russia's struggles with corruption and weak regulatory enforcement further underscore the relative success of India's regulatory framework, led by SEBI, in building investor trust and market stability.

India's unique trajectory reflects its democratic framework, socio-economic diversity, and cautious approach to liberalization. While this approach has ensured stability and resilience, it has also limited the pace of financial integration compared to peers like China. Balancing inclusivity with growth and leveraging lessons from global counterparts will be critical as India continues to evolve its financial markets.

The discussion highlights the complex interplay of macroeconomic variables, regulatory reforms, and socio-economic factors in shaping India's stock market performance. The findings emphasize the need for balanced policies that promote economic growth, manage inflation and exchange rate volatility, enhance regulatory oversight, and address regional disparities in financial inclusion. Together, these measures will ensure that India's stock

market continues to serve as a robust barometer of economic health while fostering sustainable and inclusive growth.

7. DISTINCTION BETWEEN THIS STUDY AND EXISTING LITERATURE

This study contributes to the existing body of knowledge by offering a nuanced and comprehensive perspective on India's stock market evolution from 1980 to 2024. While other scholars have examined aspects of India's financial liberalization and its impact on stock markets, our research distinguishes itself in several critical ways.

7.1 Integration of Quantitative and Qualitative Approaches

Unlike many existing studies that focus solely on either quantitative or qualitative methodologies, this paper employs a dual-method approach to capture both empirical trends and contextual depth. For instance, while Shah and Thomas (2001) emphasized SEBI's role in market reforms, their work did not address the broader socio-economic factors, such as financial inclusion and regional disparities. By integrating quantitative analyses, such as Granger causality tests and regression models, with qualitative evaluations of regulatory and inclusion dynamics, our paper provides a more holistic understanding of India's financial landscape.

7.2 Longitudinal Focus Covering Pre- and Post-Liberalization Periods

Many studies, such as those by Levine and Zervos (1998) and La Porta *et al.* (1998), primarily focus on the post-liberalization period to analyze financial market trends. Our research spans a broader timeframe, from 1980 to 2024, encompassing both pre- and post-liberalization contexts. This extended scope enables us to capture the structural shifts brought about by the 1991 reforms and analyze their long-term impacts on macroeconomic variables and stock market performance. By bridging these two eras, we offer unique insights into the continuity and transformation of India's financial markets.

7.3 Focus on the Dual Impact of Inflation

While previous studies, such as Fama (1981), discuss the adverse effects of inflation on stock markets, our paper delves deeper into the dual nature of inflation's impact. By distinguishing between moderate (4–6%) and high (>6%) inflation levels, we quantify their differential effects on SENSEX performance. This granular analysis, supported by visualizations and statistical evidence, provides actionable insights for policymakers seeking to balance inflation management with market growth.

7.4 Emphasis on Exchange Rate Volatility and FPIs

The impact of exchange rate volatility on foreign portfolio investments (FPIs) and stock market dynamics has been explored in studies like Dua and Tuteja (2015). However, our paper adds value by explicitly correlating these fluctuations with SENSEX performance and highlighting their significance during global economic crises, such as the 1997 Asian financial

crisis and the 2008 global recession. This focus on crisis periods offers a deeper understanding of the vulnerabilities of emerging markets like India to external shocks.

7.5 Examination of Financial Inclusion and Regional Disparities

Existing literature often overlooks the role of financial inclusion and regional disparities in shaping stock market participation. For instance, while Roy and Shijin (2020) explore the impact of financial liberalization on volatility and information asymmetry, they do not address the socio-economic dimensions of market participation. Our study fills this gap by analyzing the urban-rural divide in stock market activity and the potential of digitalization initiatives, such as Aadhaar-linked accounts and UPI, to democratize market access. Drawing lessons from Brazil's Bolsa Família program and China's rural banking initiatives further enriches this analysis.

7.6 Comparative Analysis with Other Emerging Markets

Many studies, such as those by Kshetri (2016), focus on India's financial markets in isolation. Our paper takes a comparative approach, analyzing India's liberalization trajectory alongside Brazil, China, and Russia. By highlighting shared trends and unique challenges, we position India within the broader context of emerging market economies. For example, while China's centralized approach led to rapid market growth, India's gradualist strategy ensured greater resilience to global shocks. This comparative perspective provides policymakers with valuable insights into balancing market growth with inclusivity and stability.

7.7 Contribution to Policy Recommendations

While prior research often concludes with general observations, our study provides actionable recommendations tailored to India's unique socio-economic and financial context. For instance, we emphasize the critical need for targeted financial literacy programs, expanded digital infrastructure in rural areas, and enhanced regulatory enforcement to curb speculative practices. These recommendations are grounded in both empirical evidence and qualitative insights, offering practical pathways for fostering sustainable and inclusive financial growth.

7.8 Integration of Visualizations and Threshold Analysis

Unlike traditional studies, our research incorporates detailed visualizations and threshold analyses to make findings more accessible and impactful. For example, Figure no. 2 clearly illustrates the point at which inflation transitions from a stabilizing force to a destabilizing one, providing policymakers with a clear framework for inflation management. Similarly, dual-axis charts for GDP growth, inflation, and exchange rate trends enhance the interpretability of complex relationships.

While building on the foundational work of previous scholars, our paper extends the scope of existing literature by integrating multiple methodologies, broadening the temporal focus, and addressing underexplored factors such as financial inclusion and regional disparities. This comprehensive approach not only deepens the understanding of India's

financial liberalization but also positions it within the global context, providing unique contributions to the fields of economics and finance. The insights from this study serve as a valuable resource for policymakers, investors, and researchers aiming to navigate the complexities of emerging market economies.

8. CONCLUSIVE REMARKS

This study provides a comprehensive analysis of the evolution of India's stock market from 1980 to 2024, highlighting the interplay between macroeconomic variables, regulatory reforms, and socio-economic factors. The findings reveal significant correlations between GDP growth, inflation, and exchange rate volatility with SENSEX performance, emphasizing the critical role of economic stability in driving market trends. The transformative impact of SEBI-led reforms and the challenges of financial inclusion further underscore the complexity of India's financial landscape. Comparative insights from emerging markets like Brazil, China, and Russia highlight India's unique trajectory, shaped by its gradualist approach to liberalization. These findings offer actionable recommendations for fostering inclusive and sustainable financial growth, providing valuable guidance for policymakers, investors, and researchers navigating the complexities of India's evolving economy.

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Knowledge-Based Regional Economic Growth: The EU Perspective

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Abstract: The purpose of this paper is to address the research gaps by conducting an empirical analysis of the relationship between variables determining Knowledge-Based Economies (KBEs) and GDP growth within the regions of the European Union at the NUTS 2 level. Findings indicate that gross expenditure on research and development and employment in the knowledge-intensive sector are positively associated with gross domestic product per capita at the regional level. Additionally, this paper shows evidence that innovation does not tend to be concentrated in regions with higher student numbers, which were used as a proxy for the concentration of research and educational institutions.

Keywords: knowledge-based economy; entrepreneurship; regional development; economic growth.

JEL classification: F63; O47; P25; R11.

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1. INTRODUCTION

The global economy is undergoing a fundamental transformation towards a new phase of growth, in which knowledge is one of the most significant determinants. A country's regional development, entrepreneurial activities, innovativeness, and economic progress are all based on knowledge. Historically, nations and regions competed over material resources, but this has been displaced by a feud over non-material resources, such as knowledge of the most recent scientific findings (OECD, 1996). Nowadays, knowledge is widely recognised as the main driver of countries' economic growth (Dyker and Radosevic, 2000; Qian, 2018). At the same time, the future of countries and regions around the globe today is heavily predicated on human intelligence and scientific research, which provide novel solutions and "drive" a new form of the economic model. The above-mentioned factors explain the growing interest among researchers in Knowledge-Based Economies (KBEs) and their effect on economic growth.

One of the most prominent elements of a KBE is how knowledge has grown tremendously, evolving into a critical component of rising productivity and competitiveness, while also becoming a source of the socio-economic and financial well-being of nations (Drucker, 1998; Godin, 2006). Therefore, transitioning from an economy based on material consumption to a "new economy" based on knowledge has become the primary challenge for countries and regions in the twenty-first century.

Numerous studies have been conducted on the current state of society and economics, particularly concerning KBEs, regional development, and globalisation (Asian Development Bank, 2007; Zeibote *et al.*, 2019). Despite this, academics argue that many crucial issues, both fundamental and technical, related to KBEs and regional development remain unresolved.

Despite existing studies, a gap exists in the literature regarding the specific relationship between KBEs and GDP growth within the EU Nomenclature of Territorial Units for Statistics (or NUTS) 2 regions. While numerous studies explore the broader connection between KBEs and economic development, a deeper understanding of this relationship within the specific context of EU regions is lacking.

To address this gap, this paper conducts an empirical analysis of the relationship between KBE variables and GDP growth in EU NUTS 2 regions. The main research question is whether the development of a knowledge-based economy is associated with the value of regional gross domestic product (GDP) in the EU NUTS 2 regions.

Furthermore, this study seeks to demonstrate the importance of a KBE and its effect on long-term economic growth in the EU NUTS 2 regions. Moreover, the results of our contribution might also show that KBEs are essential for regional policies and that future policies surrounding KBEs could support GDP growth in the NUTS 2 regions.

This study aims to empirically analyse the relationships between KBEs and GDP growth in the EU regions at the NUTS 2 level. The rest of this paper is structured as follows: Section 2 provides the conceptual framework and reviews the literature related to the knowledge-based economy and regional development, while Section 3 presents the data and methodology. Section 4 provides the results and discussion, followed by Section 5 of the paper, which concludes with a summary of the findings.

2. LITERATURE REVIEW

2.1 The knowledge-based economy

The terms "knowledge economy" and "knowledge-based economy" have become increasingly synonymous in contemporary discourse. This widespread adoption has stimulated a vast and growing body of literature, reflecting the keen interest among researchers in refining and debating this key concept.

For decades, knowledge has been recognized as a key factor in scientific and innovative advancement and efficient manufacturing (OECD, 1996; Chen and Dahlman, 2005; Aparicio *et al.*, 2023). The value of knowledge has grown significantly over the twentieth century, and it has developed into one of the fundamental factors of production in different business fields (Collinge and Staines, 2009). Rapid scientific and technological advancements have further heightened the importance of knowledge, not only as a resource but also as a promoter of economic advancement and socio-political progress.

As stated before, economists have been acknowledging the role of knowledge in the economy for over a century. In his book The Theory of Economic Development, published in 1911, Joseph Schumpeter (1911) was the first to highlight the significance of knowledge in the economy. Fritz Machlup (1962), an Austrian-American economist, first presented the idea of the knowledge industry, also known as the knowledge-based economy, in his book The Production and Distribution of Knowledge in the United States in 1962. However, in 1969, Peter Drucker (1969) was one of the first who use the term “knowledge economy” in his book The Age of Discontinuity.

Leading organizations like the OECD define the knowledge-based economy as characterized by a growing reliance on knowledge, information, and high levels of ability (OECD and Eurostat, 2005). The World Bank defines knowledge economies according to four pillars: education and training, information infrastructure, economic incentives and institutional regime, and innovation systems (Chen and Dahlman, 2005). Eurostat echoes this definition, emphasizing the growing reliance on knowledge, information, and high skill levels in both commercial and public sectors (OECD and Eurostat, 2005).

Measuring a knowledge-based economy is challenging due to its reliance on intangible assets (OECD, 1999). However, the Global Knowledge Index (GKI) is an essential indicator for assessing knowledge all around the globe. The GKI, developed by Knowledge4All, has emerged as an alternative to the well-known Knowledge Economy Index, published in 2012 by the World Bank. The GKI provides access to a vast array of accurate data, which may assist governments and policymakers in better comprehending the interconnected developments and challenges so that they can respond more effectively to them.

For the GKI survey, seven sub-indices have been selected to measure progress in the cognitive and developmental processes (pre-university education, technical and vocational education, and training (TVET), higher education, research, development, and innovation (RDI), information and communications technology (ICT), economy and enabling environment) (United Natons Development Programme, 2021).

When an economy’s information intensity changes, the sectors that make up the economy tend to alter their shape, with a rise in what is known as “knowledge-based” industries. To address this, the OECD (1999) has characterized the knowledge-based economy into the following three categories:

- High-tech manufacturing
- Service sector industries
- Business services.

Recent research has shown that a knowledge economy is one in which information is continuously developed and employed, as well as being at the center of the process by which economic growth is achieved (Powell and Snellman, 2004; Aparicio *et al.*, 2023). In addition, academics define it as a type of economy in which information is acquired, produced, disseminated, and applied effectively to stimulate economic growth (Kefela, 2010; Mensah and Enu-Kwesi, 2018).

In developing countries' economies, agriculture and manufacturing are often given significant attention, while in highly developed countries, service-related sectors make up a considerable part of the economy (Johnston, 1970; Windrum and Tomlinson, 1999). These include knowledge-based economic activities, including research, technical and professional assistance, advising, and others.

Furthermore, in classic economic theories, land, labour, capital, and the entrepreneur are the four major components of production. However, a knowledge-based economy is essential for expanding the potential applications of labour beyond the production of commodities on an assembly line and towards more versatility in designing, manufacturing, and executing business concepts.

According to empirical studies, it has also been seen that Research and Development (R&D) investments are essential for innovation and the increase of available knowledge (Cameron, 2000; Miroshnychenko *et al.*, 2020). The goal of scientific research is to generate new scientific information, as well as to rectify and integrate existing knowledge when it's immediately useful or relevant. For centuries, scientists have been experimenting with new ideas and theories. During the 20th century, R&D activities became the central focus of universities and enterprises in both the public and private sectors and measuring and indicating progress in R&D became more important in the 20th century (Nelson, 1982).

In today's knowledge-based economy, Intellectual Property (IP) is a basis for innovation, investment, and development (Cowan and Harison, 2001; Foray, 2002; Tekic *et al.*, 2014). Leading-edge, knowledge-based sectors are heavily reliant on the IP system. Furthermore, economists hold that the new economy will be more successful for nations and regions when IP regimes balance the interests of various parties. Over the last several decades, IP has emerged as a significant source of competitive advantage in today's knowledge-based economy (Sagiyeva *et al.*, 2018), and modern economies have seen a fundamental shift in how value is generated, which is one of the causes of this development.

An additional critical aspect of the KBE is that it's fundamentally a learning economy, where the learning process and increasing competence are essential to the economic performance of a university-educated workforce with access to lifelong learning opportunities (Sterlacchini, 2008). This fact has significantly influenced enrolment in vocational schools and universities in both developed and developing countries.

Overall, the KBE illustrates a transformation in economic structures and how enterprises and individuals' function across all industries. However, analysing the effect of KBEs on regional economic development is crucial. Having established the importance of knowledge-based economies, we next examine how they influence regional development.

2.2 Regional development

There are various interpretations of the term "regional development", which is generally defined as the concept and plan for the economic growth of regions in both developed and developing nations. With the help of regional development, countries in economically challenged areas may realise all their resources and residents' full potential, thereby improving their well-being in all aspects of life (OECD, 2022).

Comparisons between countries' regional development are frequent, yet it's difficult to draw meaningful comparisons between small, sparsely populated regions and the largest, most populous ones. Differences among regional economies exist when certain areas within a single nation expand at a faster rate, have higher levels of economic growth, and have a better economy than other regions. Unbalanced regional economic growth is the cause of a geographical pattern of interdependence between developed and developing regions. Thus, there are many variables impacted by regional development, some of which have a direct effect and others an indirect one. Key development variables include natural and human resources, the level of technical advancement, financial resources, knowledge, a legislative and institutional framework, values, ethics, and dedication.

To provide regional data for the European Community in the early 1970s, Eurostat established the Nomenclature of Territorial Units for Statistics (NUTS) classification. According to the NUTS classification, each Member State is divided into three separate regions from large to small locations. These levels cover NUTS 1, 2, and 3 (Eurostat, 2022).

Studies on the geographical location of the knowledge-based economy in EU member states have shown indications of growing differences between metropolitan centres and peripheries (Leydesdorff and Deakin, 2010; Kim *et al.*, 2022). Therefore, the knowledge base of various regional economies differs since each region has its own base of scientific, technological, and entrepreneurial knowledge. Several countries have planned to increase their direct investment in the generation of new knowledge as a way of promoting the growth of their domestic and regional economies.

There is increasing evidence that the promotion of regional economic development is an active process involving enterprises, different public or private development agencies, and research institutions. Therefore, knowledge-based regional development should emphasise the skills and potential of regional players like enterprises, urban centres, new tech hubs, research and education institutions, and more. These strong organisational cultures highlight the interdependence of public and private activities. To better understand the circumstances in which complex development processes occur, and to show the relevance and multi-level character of skills in regional development, we might turn to the network approach of knowledge-based regional development processes (Cooke *et al.*, 2007).

The importance of regional policy processes, meanwhile, cannot be denied. At the regional level, policymaking is understood as a group process of negotiation and compromise involving many different players from different policy levels, including non-state actors, non-governmental organisations, professions, and others (Cooke and Leydesdorff, 2006; Godin, 2008; Viale and Etzkowitz, 2010).

The literature study concludes that knowledge-based regional development involves several partakers and actions. It also necessitates a well-connected set of networks comprised of various players and interconnected skills widely dispersed throughout the networks responsible for developing and enforcing regional innovation strategies.

The literature review examined the KBE and its impact on regional development, particularly within the EU. It identified knowledge, information, innovation, human capital, and R&D as key drivers of growth. However, the review also highlighted the challenge of regional disparities in knowledge and economic development, with a widening gap between metropolitan centres and peripheries in the EU. The importance of a "network approach" and the multi-level nature of skills in regional development were emphasized. Additionally, the review pointed to the potential of universities, research institutions, and new tech hubs to foster knowledge-based growth. Finally, collaboration and knowledge exchange among regional actors were identified as crucial for successful development strategies. In essence, the review laid a foundation for further research on EU regional development in the context of the KBE.

3. DATA AND METHODS

Our research began with a comprehensive review of the recent literature on the topic, which included scholarly articles, reports, and government documents. As a result of this first step, we were able to identify crucial ideas, variables, and hypotheses related to the relationship between a knowledge-based economy and GDP growth in the EU-28 NUTS 2 regions. After laying this groundwork, we moved on to the empirical part of our investigation, where we analysed relevant studies and drew insightful conclusions from the data.

While ideally, we would leverage the most recent data possible, our study focused on the 2009-2012 timeframe due to a critical consideration: data consistency across the EU-28 NUTS 2 regions. This period, according to Eurostat (2022), offered the most reliable and consistent dataset for all regions, allowing for a robust analysis of the relationship between knowledge-based economies and GDP growth. Although this limits our study to a specific period, the advantage lies in the certainty and comparability of the data across all selected regions, which is essential for drawing accurate conclusions about this complex relationship.

Our study employs a dataset that contains a variable that serves as a proxy for the development of a knowledge-based economy. This variable provides panel data for NUTS 2 regions of the EU-28, allowing us to capture regional variations in economic indicators and their relationship to the knowledge economy. We conducted a comprehensive analysis of the available data, which included 225 regions at the outset. Due to breaks in the time series, we were forced to exclude data from a number of regions, including Ireland, Slovenia, and Lithuania.

To examine the relationship between a knowledge-based economy and GDP growth, we analyzed several key indicators, including gross domestic expenditure on R&D (GERD), R&D personnel and researchers, employment in knowledge-intensive jobs, patent applications, and student participation rates. These variables provided an extensive overview of the economic development determinants in the EU-28 NUTS 2 regions and their relationship to the knowledge-based economy.

The current paper attempts to investigate the linkages between features of the knowledge-based economy and economic growth. To do so, we test the following hypothesis (*H1*) versus the alternative (*H0*):

***H1**: The value of a regional gross domestic product is associated with the development of a knowledge-based economy.*

***H0**: The value of a regional gross domestic product is not associated with the development of a knowledge-based economy.*

This hypothesis is tested on a variation of proxies. As a proxy for regional GDP, GDP per capita adjusted for purchasing power parity is used as a dependent variable for modelling. For a knowledge-based economy, we test a number of independent variables as proxies. We test Fixed Effects (FE) and Random Effects (RE) models for appropriateness, using the Hausman test (Hausman, 1978) as a criterion to opt-in for specification. In general form, the econometric specification of the model is as follows:

$$lny_i^t = \beta_0 + \sum_{j=1}^{n} \beta_j lnx_{ij}^t + \gamma_i + \delta_i + \tau_i + \varepsilon_t \quad (1)$$

where y_i^t – regional gross domestic product (PPS per inhabitant); x_{ij}^t – independent variables; γ_i – entity (region) specific fixed or random effects; δ_i – country-specific fixed or random effects; τ_i – time-specific fixed or random effects; β_0, β_j – regression coefficients; ε_t – error term.

Table no. A1 (Annexes) provides descriptive statistics for the dataset, highlighting the study's key findings. This table provides an overview of the main trends and distribution of the selected variables, offering crucial insights into various aspects of the knowledge-based economy and GDP growth across various EU NUTS 2 regions. Notably, the total number of observations ranges from 600 to 896 due to incomplete data in certain years. Therefore, the time series in our analysis was restricted to four years, highlighting the difficulties associated with conducting empirical research using publicly available datasets. Due to various specifications (sets of independent variables), the number of observations utilized in estimating empirical models differs, and it is consistently stated for each model presented.

In conclusion, our study's limited time series, driven by data availability constraints, highlights the importance of careful data selection in empirical research. We utilized a panel data approach with Fixed Effects (FE) or Random Effects (RE) models. While these models provide a robust framework for analysing regional variations, it's crucial to acknowledge limitations. The chosen knowledge-based economy proxies may not fully capture all aspects of such an economy. Further research could explore alternative proxies or even composite indices to achieve a more comprehensive picture. By acknowledging these limitations and considering alternative approaches in future studies, researchers can ensure the validity of their findings and advance our comprehension of the intricate relationship between a knowledge-based economy and GDP growth in the EU-28 NUTS 2 regions.

4. RESULTS AND DISCUSSION

In this paper, we began with an estimate of FE and RE regression analysis for the selected variables throughout the selected period so that we could thus examine the impact of individual-specific factors on the panel data set's dependent variables. Table no. A2 (Annexes) shows the results of the regression analysis (FE and RE models). Here, independent and dependent variables are employed in levels, therefore the interpretation of the coefficients cannot be considered straightforward. In order to address this issue, we estimate fixed and random effects models in log-log form, in which the interpretation of coefficient estimates is in terms of elasticities, with the difference between the models being the number of selected variables. As a result of this study, we can observe that a number of different independent variables may have a significant influence on economic growth.

The RE and FE (within) models' estimates for the Gross Domestic Expenditure on Research and Development (GERD) as the independent variable demonstrate a positive and highly significant influence on GDP per capita (constant USD) at the level of the entire sample of regions for each year. The positive and statistically significant relationship between GERD and GDP per capita in our study reinforces the established notion within the KBE literature that R&D expenditure is crucial for knowledge creation and economic growth (Cameron, 2000; Miroshnychenko *et al.*, 2020). This finding highlights the importance of expenditure in R&D for the selected regions. Several studies have addressed the significance of GERD; however, their analyses were conducted at the country level rather than the NUTS 2 region level (Veugelers and Mrak, 2009; Ejermo *et al.*, 2011; Bąk *et al.*, 2022). It is reasonable to assume that such regional outcomes will have an impact on countries' overall outcomes.

R&D personnel are statistically significant for the FE (within) model only. According to the evidence presented in this chapter, the number of R&D personnel, the percentage of employment in education, and the ratio of the proportion of students over the proportion of the population have no significant influence on regional economic performance in the chosen areas. This partially contradicts studies highlighting the importance of human capital in knowledge economies (OECD, 1996; Hassani *et al.*, 2022). We consider that the governments of the regions' economies need to enhance investments in these sectors if they are to keep up with the advanced economies.

From Table no. A2, it can be seen that employment in high-tech manufacturing and knowledge-intensive and high-technology services has a negative, though significant, and at a very low level of correlation for each model. Medium-tech manufacturing sectors are highly statistically significant for the FE and FE (within) models. Employment in the wholesale retail and trade sector is statistically significant for the FE (within) model only, while finance and insurance coefficients is statistically significant only for the FE and FE (within) models. Employment in the human health and social work activities sector has a positive and highly significant influence on GDP per capita (constant USD) at the level of the entire sample of countries for each year. This aligns with the understanding of KBEs as learning economies where a skilled workforce is essential (Sterlacchini, 2008). Additionally, this finding demonstrates how important health, and social services are for the overall economic productivity of the EU (European Commission, 2014).

As a next step, we considered analysing the RE models (model RE (patents), model RE (students), model RE (patents, students)) in order to determine whether they may help us to get more information out of our data and distribute the variation in our model more effectively. These three models test the effect of number of patents and proportion of students in population on regional GDP per capita. Table 3 (Appendix 3) shows that various variables have a statistically significant effect on economic growth. Also, regional economic development seems increasingly dependent on GERD.

According to the model, we see that patents have a statistically significant relationship with GDP per capita. Among scholars, patents are recognized as an essential driver of economic development in a knowledge-based economy, and our findings match the results obtained by other experts (Tsakalerou, 2018).

Employment in high-technology manufacturing has a statistically significant coefficient; however, it is negative. In the long run, it is reasonable to expect that increased government spending and development of the manufacturing sector in regions will boost economic growth (Naudé and Szirmai, 2012; Behun *et al.*, 2018).

From the table, we see that employment in the professional, scientific and technical activities sector has a statistically significant relationship with economic growth. Recent economic growth has clearly been affected by several important factors, such as scientific progress and changes in technology.

It should be noted that, in this model, employment in the human health and social work activities sector has a significant effect on GDP per capita, and its increase of 1% is associated with a 0.3% increase in GDP per capita. This result backs up our earlier assumption, based on the results presented in Table no. A2, that the human health and social work activities in the employment sector is a key driver of regional economic growth. Furthermore, in this model, we can also see the correlation between the ratio of the proportion of students within the population and economic growth. According to this result, we might consider the importance of employment in knowledge-intensive sectors for the selected regions' economic development.

After testing several different models and variable selection procedures, we believe that the RE model (GERD and others) and the RE (GERD and significant) model provide the most accurate representations of our data (Table no. 1). Simultaneously, the results of the estimation of the fixed effects (FE) model are also reported. The results of the Hausman test showed that the fixed effects model should be preferable, however, we opted to report the random effects model as well, as this model shows a higher fit to the dataset. It should be noted that there is no significant difference in the magnitude and direction of effects reported by either model; both models contain the same set of independent variables, and their coefficients do not differ considerably. The results suggest that the choice of a model may not have a substantial impact on the results, but it is important to consider both models to ensure the robustness of the analysis. Table 4 demonstrates that GERD, like other models, significantly affects economic growth. Within the manufacturing category, employment in high-technology manufacturing and employment in medium-high-technology manufacturing have a negative and statistically significant relationship with economic growth.

In a knowledge-based economy, services play a crucial role. We can see that, in the model, the above-mentioned hypothesis is supported by the statistically significant coefficient, which reveals a strong relationship between employment in knowledge-intensive sectors and GDP per capita. A number of other researchers have come to the same conclusion, confirming the significance of services in a KBE (Boden and Miles, 2001; Miles, 2003).

According to this model, there is a correlation between R&D personnel and economic development; however, this correlation is not nearly as significant as the correlation between other variables. If the chosen regions were to invest more resources in this field, the influence on GDP per capita might increase.

The main conclusion from this model is that employment in the knowledge-intensive services sector is highly associated with GDP per capita for European regions within the NUTS 2 level (an increase of 1% is associated with a 0.4% increase in GDP per capita), while the proportion of students is negatively associated. This means that innovation isn't likely to be commercialised and provide economic benefits in the regions with a high concentration of students, but in other regions (most likely those with higher employment in knowledge-intensive services). These findings are similar to the outcomes of other scholars' investigations (Schwartz, 2006; Bąk *et al.*, 2022). It is essential to highlight that, generally, researchers focus on the significance of knowledge-intensive industries and their significant influence on economic growth at different country levels. However, in this paper, we conducted our study on EU NUTS 2 regions. Despite this fact, we assume that it is reasonable to estimate that the importance of

knowledge-intensive service sectors and their significant effect in the various country regions might have a significant impact on the results of economic growth throughout the whole country, as shown in other scholars' studies. We believe that regional knowledge spillover and its influence on economic growth is insufficient, as shown by the differences in most knowledge economy performance-related indicators across the selected countries' regions.

Table no. 1 – Random effects models

	Model RE (GERD and others)	**Model RE (GERD and significant)**	**Model FE (GERD and others)**	**Model FE (GERD and significant)**
log(patents)				
log (GERD)	0.243***	0.191***	0.267***	0.182***
	-0.014	-0.015	-0.02	-0.02
log(rd_personnel)		0.058***		0.032
		-0.022		-0.02
log(high_tech_sectors)	0.082***		0.081***	
	-0.027		-0.027	
log(high_tech_man)	-0.051***		-0.045***	
	-0.015		-0.015	
log(med_tech_man)	-0.040**		-0.035	
	-0.02		-0.024	
log(wholesale_retail_trade)	-0.160***		-0.221***	
	-0.057		-0.058	
log(knowledge_intense_servi		0.415***		0.187*
ces)		-0.101		-0.104
log (knowledge_intense_high_tech_services)				
log(knowledge_intense_mark	0.147**		0.093***	
et_services)	-0.03		-0.03	
log(knowledge_intense_other				
_serviees)				
log(info_communication)				
log(finance_and_insurance)				
log (prof_scientifie_teeh_		0.183***		0.066**
activities)		-0.032		-0.029
log(education)				
log (human_health_social_	0.270**	0.158**	0.132***	-0.012
work)	-0.034	-0.049	-0.04	-0.049
log(proportion_students)		-0.102***		-0.033
		-0.033		-0.038
Constant	8.089***	6.721***		
	-0.217	-0.293		
Observations	528	524	528	524
R2	0.923	0.93	0.464	0.262
Adjusted R2	0.922	0.929	0.222	-0.071
F Statistic	784.931 ***	713.383**	44.905***	21.358***

Note: p<0.1*; p<0.05**; p<0.01***

Source: data was sourced from Eurostat (2022).

In addition, according to the results of our measurements using the selected indicators, we can assume that despite the attempts of national and regional governments to allocate resources proportionately, the economies of some regions will have a greater tendency than those of other regions to become knowledge based. Therefore, in order to increase regional

economic growth, regional governments should aim at strengthening their scientific institutions, invest more in the R&D sector, and develop knowledge-intensive sectors.

5. CONCLUSION

This study aims to estimate and analyse the effects of the knowledge-based economy on the economic growth process in the EU-28 for the NUTS 2 regions. The empirical findings reveal that GERD robustly enhances growth performance. In addition, the percentage of employment in knowledge-intensive services has a positive and statistically significant effect on the economic performance of regions in EU member states.

Based on the findings of this study, the research indicates that the manufacturing sector of the knowledge-based economy has a significantly less impact on the growth of GDP per capita compared to the service sectors. One possible explanation is that not all countries prioritise investing in the knowledge-based manufacturing sector. In addition, the knowledge-based manufacturing sector has a less need to be located near major urban regions along with certain space requirements. The results of this empirical study allow us to form some preliminary conclusions about the relationship between KBEs and economic growth in the EU NUTS2 regions. It thus confirms our first hypothesis (H1), which states that the value of a regional gross domestic product is associated with the development of a knowledge-based economy.

The characteristics of human capital in research and development, the dissemination of technical achievements (in both knowledge-based intensive services and knowledge-based manufacturing sectors), and the availability of financial resources all have the capability to reduce the shortfalls in this field and enhance the overall growth performance in the EU.

Regional GDP per capita is positively related to investments in the above-mentioned sectors in the selected regions. NUTS 2 regions, on the other hand, need public and private sector supportive policies implemented as a priority to improve productivity and economic performance. Though we are hampered by a relatively limited length of time (which includes only a recent few years, 2009-2012) and, therefore, the limited size of the sample, we conclude that knowledge-intensive sectors are the primary drivers of regional economic growth at the NUTS 2 level. This provides a potentially valuable clue for a successful regional policy that aims to increase GDP per capita. Furthermore, we might consider this as a potentially crucial subject that should be examined in future studies.

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ANNEXES

Table no. A1 – Descriptive statistics of the dataset

Variable	Description	N	Min	Average	Std. dev.	Max
y_i^t	GDP per capita	860	25,970.8	13,417.1	3,213.1	88,646.2
x_1^t	Patent applications to EPO	786	19.2	27.0	0.1	202.0
x_2^t	R&D personnel	600	1.6	1.1	0.2	5.9
x_3^t	Gross Domestic Expenditure on Research & Development (GERD) by sector	762	975.7	1,792.5	1.8	18,393.1
x_4^t	Employment in high-technology sectors (high-technology manufacturing and knowledge-intensive high-technology services), in % of total.	852	3.4	1.8	0.5	10.1
x_5^t	Employment in the high-technology manufacturing sector, in % of total	621	1.3	0.9	0.2	5.8
x_6^t	Employment in medium high-technology manufacturing sector, in % of total	845	4.7	3.1	0.2	17.0
x_7^t	Employment in wholesale and retail trade; accommodation and food services activities; activities of households as employers, in % of total	894	19.7	4.6	9.9	41.0
x_8^t	Employment in total knowledge-intensive services sector, in % of total	896	37.3	8.4	14.2	59.9
x_9^t	Employment in knowledge-intensive high-technology services sector, in % of total	813	2.4	1.4	0.4	7.9
x_{10}^t	Employment in knowledge-intensive market services (expect financial intermediation and high-technology services) sector, in % of total	885	5.3	2.0	1.0	15.0
x_{11}^t	Employment in other knowledge-intensive sectors, in % of total	896	27.1	6.1	10.8	46.5
x_{12}^t	Employment in information and communication sector, in % of total	827	2.5	1.4	0.5	8.6
x_{13}^t	Employment in financial and insurance activities sector, in % of total	860	2.7	1.4	0.6	12.7
x_{14}^t	Employment in professional, scientific and technical activities sector, in % of total	881	4.4	1.9	0.8	12.9
x_{15}^t	Employment in education sector, in % of total	890	7.1	1.6	2.9	12.7
x_{16}^t	Employment in human health and social work activities sector, in % of total	896	10.5	4.4	3.2	25.5
x_{17}^t	Ratio of the proportion of students (ISCED 5-6) over the proportion of the population by NUTS 2 regions	736	0.9	0.5	0.1	4.1

Source: data was sourced from Eurostat (2022).

Table no. A2 – Random and fixed effects models

Dependent variable: log(gdp_per_capita) panel linear				
	Model FE	**Model RE**	**Model FE (within)**	**Model FE (reduced)**
log(patents)	-0.007	0.002	-0.010	
	(0.023)	(0.003)	(0.009)	
log (GERD)	0.038	0.230***	0.050***	0.530
	(0.029)	(0.020)	(0.017)	
log(rd_personnel)	0.121	0.006	0.099**	0.205
	(0.075)	(0.027)	(0.039)	
log(high_tech_sectors)	0.177	0.095	0.081	
	(0.191)	(0.069)	(0.102)	
log(high_tech_man)	-0.145*	-0.046*	-0.082**	
	(0.073)	(0.027)	(0.040)	
log(med_tech_man)	0.077*	-0.007	0.061**	
	(0.042)	(0.030)	(0.024)	
log(wholesale_retail_trade)	0.111	-0.037	0.262***	
	(0.160)	(0.081)	(0.089)	
log(knowledge_intense_services)	0.374	0.675	0.028	
	(1.446)	(0.588)	(0.777)	
log(knowledge_intense_high_tech_services)	-0.428*	-0.157**	-0.274**	
	(0.251)	(0.072)	(0.126)	
log(knowledge_intense_market_services)	-0.153	0.037	-0.024	
	(0.281)	(0.105)	(0.149)	
log(knowledge_intense_other_serviees)	-0.965	-0.511	-0.569	
	(1.131)	(0.453)	(0.610)	
log(info_communication)	0.176	0.122**	0.163	-0.536
	(0.255)	(0.060)	(0.125)	
log(finance_and_insurance)	0.370***	-0.022	0.308***	
	(0.128)	(0.055)	(0.071)	
log(prof_scientifie_teeh_activities)	0.681***	0.114*	0.606***	
	(0.225)	(0.066)	(0.113)	
log(education)	0.050	-0.038	-0.039	
	(0.158)	(0.072)	(0.090)	
log(human_health_social_work)	1.052**	0.339**	0.992***	
	(0.158)	(0.072)	(0.084)	
log(proportion_students)	-0.005	-0.043	-0.016	
	(0.056)	(0.041)	(0.030)	
Constant	7.517***	6.925***		7.180
	(1.429)	(0.742)		
Observations	110	331	331	4
R2	0.919	0.960	0.899	1.000
Adjusted R2	0.904	0.958	0.893	
F Statistic	61.511*** (df =17; 92)	654.784***	162.576*** (df =17; 310)	

Note: p<0.1*; p<0.05**; p<0.01***

Source: data was sourced from Eurostat (2022).

Table no. A3 – Random effects model

	Model RE (patents)	Model RE (students)	Model RE (patents, students)	Model RE (reduced)
log(patents)	0.205***		0.203***	
	-0.011		-0.013	
log (GERD)				0.235***
				-0.014
log(md_personnel)				
log(high_tech_sectors)				
log(high_tech_man)			-0.022*	
				-0.013
log(med_tech_man)				
log(wholesale_retail_trade)				
log(knowledge_intense_services)				
log(knowledge_intense_high_tech_services)				
log(knowledge_intense_market_services)				
log(knowledge_intense_other_serviees)				
log(info_communication)			0.061	
				-0.02
log(finance_and_insurance)				
log(prof_scientifie_teeh_activities)		0.151**		
				-0.027
log(education)				
log(human_health_social_work)		0.323***		
				-0.034
log(proportion_students)	0.295***	0.126***		
		-0.049	-0.043	
Constant	9.665***	9.994***	9.676***	7.557***
	-0.027	-0.034	-0.033	-0.099
Observations	753	712	618	519
R2	0.329	0.053	0.315	0.925
Adjusted R2	0.329	0.051	0.313	0.924
F Statistic	368.910***	36.506***	282.320***	763.738***

Note: p<0.1*; p<0.05**; p<0.01***

Source: data was sourced from Eurostat (2022).