Asian Journal of Applied Economics Vol. 32 No. 2 (July-December 2025): 62–82

ISSN: 2985-1610 (Online)

Received: 3 November 2024
Received in revised form: 4 April 2025
Accepted: 24 April 2025

Impact of Financial Development on Economic Growth Volatility: Moderating Role of Innovation in Developed and Developing Economies

Mansoor Mushtaq
Department of Economics and Agricultural Economics, PMAS-Arid Agriculture University, Rawalpindi, Pakistan
Gulnaz Hameed*
Department of Economics and Agricultural Economics, PMAS-Arid Agriculture University, Rawalpindi, Pakistan
Nasir Mahmood
Department of Economics and Agricultural Economics, PMAS-Arid Agriculture University, Rawalpindi, Pakistan
Muhammad Hanif
Department of Statistics, PMAS-Arid Agriculture University, Rawalpindi, Pakistan

Abstract

While financial development has contributed to higher economic growth, it has also influenced the volatility of that growth. Numerous studies have investigated the impact of financial development on economic growth volatility, yielding ambiguous results. Additionally, innovation has emerged as a significant determinant of growth volatility. This study explores the relationship between financial development and economic growth volatility within the context of innovation, using panel data from 1996 to 2022 for both developed and developing countries. The Generalized Method of Moments (GMM) is employed as the estimation technique. The findings reveal that, when accounting for innovation, financial development negatively affects growth volatility in both developed and developing nations. Furthermore, inflation is found to increase economic growth volatility across both panels. Government spending reduces growth volatility in developed countries but exacerbates it in developing ones. Institutional quality either positively influences or has an insignificant effect on growth volatility in developing countries, whereas it contributes to reducing volatility in developed economies. The study underscores the importance of leveraging a combination of innovation and financial development to mitigate economic growth volatility.

*Corresponding Author, Address: Shamsabad, Rawalpindi, Punjab, 46000, Pakistan. Email: gulnaz.hameed@uaar.edu.pk

Keywords: innovation; financial development; institutions; growth; volatility
JEL Classification: E30; G10; G28

1. Introduction

Macroeconomic stability is essential for sustainable and steady growth. Long-term economic growth depends heavily on maintaining such stability. Economies with faster average growth are not necessarily those that thrive only during prosperous periods; rather, they tend to be more resilient to shocks and experience fewer severe recessions. An uncertain macroeconomic environment significantly reduces investment rates, thereby negatively impacting economic growth (Avom et al., 2021; Kpodar et al., 2019).

Financial development plays a critical role in both promoting economic growth and reducing economic instability. Higher output volatility, which creates uncertainty about future returns, discourages investment and hampers economic development. Financial development offers a potential explanation for mitigating growth volatility (Kpodar et al., 2019; Mulugeta, 2024). A robust financial system reduces risk, encourages investment, and channels capital towards more productive sectors of the economy. It facilitates lower transaction costs and reduces information acquisition costs. Moreover, financial development can enhance corporate governance, improve resource allocation, and address information asymmetries (Cavoli et al., 2020; Levine, 2005).

The diversification enabled by financial development helps reduce output volatility by lowering aggregate risk and ensuring a more efficient allocation of financial resources. It addresses credit market imperfections and mitigates the financial accelerator effect. Technological advancements also contribute to reducing economic uncertainty. Progress in the banking sector has improved its capacity to filter borrower information, thus reducing instability arising from asymmetric information. For developing countries, engaging in indigenous scientific and technological research can enhance long-term economic stability by increasing their absorptive capacity for new technologies (Dynan et al., 2006; Tang, 2018). Furthermore, financial development supports innovative activities by easing credit constraints and boosting research and development (R&D) funding. As economies become more complex and risks are underwritten by sophisticated financial systems, innovation and information technology—financed through these systems—can help mitigate the adverse effects of growth volatility (Fagiolo et al., 2020).

The relationship between innovation and growth volatility remains an important area of investigation. Understanding how innovation influences financial development in reducing growth volatility is a key—and novel—aspect of this study. This research contributes to the ongoing debate on financial development and growth volatility in at least three ways. First, it employs a financial sector development index, a comprehensive measure that captures overall improvements in financial systems (Sahay et al., 2015). Second, prior studies have indicated that developed and developing countries differ fundamentally in their financial market structures, suggesting that they should be analyzed separately (Oro & Alagidede, 2019). Third, this study applies various measures of financial development and innovation, thereby not only validating previous findings but also ensuring robustness.

Overall, this study aims to assist policymakers in understanding the interconnected roles of innovation, financial development, and growth volatility, enabling them to formulate policies that promote sustained economic growth.

The remainder of this paper is organized as follows: Section 2 reviews the relevant literature. Section 3 describes the methodology. Section 4 presents empirical results. Finally, Section 5 concludes the study.

2. Literature Review

2.1 Financial Development and Growth Volatility

Financial development is often associated with a reduction in production uncertainty. A well-developed financial system facilitates more efficient resource allocation, thereby dampening the impact of exogenous shocks on economic growth. Financial deepening enhances an economy's capacity to absorb and recover from shocks, contributing to a reduction in aggregate volatility (Kpodar et al., 2019). As economies grow, financial markets mature, expanding investment opportunities. This increased capacity for diversification reduces both risk and volatility, allowing borrowers and investors to spread their exposure across various markets and assets.

In bank-based financial systems, prevalent in certain countries, banks act as intermediaries by providing liquidity and absorbing external shocks, rather than amplifying them. This contrasts with market-based systems, which may be more prone to heightened volatility in response to sudden shifts in investor sentiment (Cavoli et al., 2020).

However, some studies suggest that financial development—particularly in its early stages—can contribute to economic instability. A well-established financial system may encourage excessive risk-taking by both borrowers and lenders, increasing overall economic volatility. This tendency is especially pronounced when financial markets become speculative, with investments driven by short-term gains rather than long-term sustainability (Shleifer & Vishny, 2010).

Iftikhar and Abbas (2016) examine the relationship between financial sector development and growth volatility in Pakistan, finding that instability within banking and equity markets leads to increased growth volatility. Their findings suggest that while financial sector development can stabilize high-income nations, in middle-income countries, weak financial infrastructure and poor regulatory frameworks may exacerbate volatility.

Ghosh and Adhikary (2023) further argue that both financial development and income levels influence the relationship between macroeconomic instability and financial sector growth. They note that rapid financial sector expansion has, at times, hindered economic prosperity and intensified real downturns during crises. Similarly, Ibrahim et al. (2024) highlight that financial development can aggravate macroeconomic instability when banks engage in excessive risk-taking.

2.2 Innovation and Growth Volatility

Innovation has been recognized as a key driver of economic growth since Schumpeter's (1934) seminal work, which highlighted the central role of entrepreneurial efforts driven by technological advancement in transforming economies through enhanced growth and productivity. This foundational concept has been further developed in subsequent research, emphasizing that innovation—through technological progress and creative activity—underpins economic output and long-term growth (Aghion et al., 2005).

However, nations with limited technological capabilities often face constraints in producing high value-added goods. Such economies typically rely on a narrow range of industries, making them more vulnerable to

external shocks. For instance, while a country with minimal technological expertise may experience rapid growth during positive demand shocks, it is also more susceptible to severe downturns when external conditions deteriorate, such as declines in terms of trade. In contrast, economies that prioritize technological research and innovation are better positioned to diversify their industrial base and mitigate associated risks. Public scientific and technical research serves as the foundation for technological innovation in the private sector. The increasing references to scientific and technical publications in patent applications highlight the growing contribution of research to innovation. Deploying scientific and technological research fosters high-efficiency industrial models crucial for sustained economic progress (Tang, 2018).

Countries that invest in research and development (R&D) are better equipped to overcome growth barriers, such as inefficiencies in traditional production processes. The development of new technologies and production methods enhances openness, adaptability, and competitiveness. Conversely, nations that persist with conventional practices risk falling behind in an era defined by technological advancement. As a result, technological innovation becomes a critical pillar for nations aiming to achieve sustainable and robust growth (Abdelaoui & Abdelaoui, 2020; Mohamed et al., 2022).

The interaction between financial sector development and innovation has been shown to positively influence economic growth. The growing integration of information technology within the financial industry has led to the creation of increasingly sophisticated financial products and services. As information technology and financial development become more interconnected, these financial offerings are expected to advance in complexity, usability, and value creation. This evolution can enhance financial inclusion by extending benefits to a broader segment of the population, thereby supporting more resilient economic growth (Verma et al., 2023).

The diffusion of technology—particularly financial technologies (fintech)—is increasingly recognized for its role in reducing economic growth volatility. The integration of digital platforms and fintech innovations lowers transaction costs, improves access to finance, and significantly boosts the efficiency of financial services. These advancements strengthen financial systems by enabling real-time payments and promoting greater financial inclusion, especially in developing economies where traditional banking infrastructure is limited. Improved financial accessibility helps smooth economic fluctuations and enhances resilience to external shocks, thereby reducing growth volatility.

Moreover, fintech innovations improve risk assessment capabilities, enabling financial institutions to better evaluate creditworthiness and manage financial risks. This leads to more efficient capital allocation and reduces information asymmetry, a common source of volatility in underdeveloped markets. By fostering financial stability and optimizing resource distribution, fintech plays a vital role in minimizing growth volatility, particularly in economies vulnerable to both external and internal shocks (Gopalan & Rajan, 2022; Nguyen et al., 2022; Verma et al., 2023).

Based on this discussion, the following hypothesis is proposed:

H1: Innovation moderates the impact of financial development in reducing growth volatility.

3. Methodology and Data

The estimating model employed in this analysis is defined by the following equations, with specifications drawn from the works of Mulugeta (2024), Kapingura et al. (2022), and Tang and Abosedra (2020):

$$\mathrm{EVOL} = \mathrm{f}\,(\mathrm{FD} * \mathrm{INNOV}, \mathrm{GE}, \mathrm{INF}, \mathrm{IQ})$$

In econometric form, the model is expressed as:

$$\mathrm{EVOL} = \beta_0 + \beta_1 \mathrm{FD} * \mathrm{INNOV} + \beta_2 \mathrm{GE} + \beta_3 \mathrm{INF} + \beta_4 \mathrm{IQ} + \varepsilon$$

Where:

EVOL represents economic growth volatility,

FD denotes financial development,

INNOV captures innovation,

GE refers to government expenditure,

INF is inflation,

IQ stands for institutional quality,

ε is the error term.

Data for all variables, except where noted, are sourced from the World Development Indicators (WDI). The financial development index is obtained from the International Monetary Fund (IMF), while institutional quality data comes from the Worldwide Governance Indicators (WGI).

The panel dataset comprises 32 developed and 46 developing countries, covering the period from 1996 to 2022. The selection of the sample size and timeframe ensures adequate data availability and captures long-term trends relevant to the study. Country classifications follow the IMF's categorization, facilitating comparative analysis between advanced and developing economies. This dual focus provides a comprehensive framework to investigate the dynamics between innovation, financial development, and growth volatility across varying levels of economic maturity.

However, country selection was constrained by data availability for all relevant variables, which may introduce sample selection bias. The exclusion of countries with incomplete data could limit the generalizability of the findings.

The financial development index ranges from 0 to 1, where a value of 0 indicates a severely underdeveloped financial system characterized by inefficiency, low depth, and limited access, while a value of 1 represents a highly advanced, efficient, and widely accessible financial system (Sahay et al., 2015).

This study employs two measures of financial development:

FD1: Financial sector development index

FD2: Credit to the private sector as a percentage of GDP

Similarly, two measures of innovation are used:

INNOV1: Number of patents

INNOV2: Scientific and technical research publications

The use of multiple indicators for financial development and innovation serves to test the robustness of the findings. Details regarding variable descriptions and data sources are presented in Table 1.

Table 1: Description of variables

Variable	Definition	Source	Literature
EVOL	Economic growth volatility measured by standard deviation of growth rate of GDP per capita	WDI	Economic growth volatility has been used by Abanikanda and Dada (2024) as well as Mulugeta (2024).
FD1	Financial development index	IMF	The financial development index has been employed by Mulugeta (2024) and Avom et al. (2021).
FD2	Credit to private sector as percentage of GDP	WDI	This indicator is discussed by Kapingura et al. (2022).
INNOV1	Innovation measured by number of patents	WDI	Tang (2018) has used patent counts as a proxy for innovation.
INNOV2	Scientific and technical research publications	WDI	Tang (2018) employed this variable to measure innovation.
GE	General government final consumption expenditure as a percentage of GDP	WDI	Government expenditure has been employed by Kapingura et al. (2022).
INF	Inflation rate in percentage	WDI	Inflation rate has been analyzed by Awan et al. (2021) and Tang and Abosedra (2020).
IQ	Institutional quality has six measures (VA = Voice and accountability; PS = Political stability; GE = Government effectiveness; RQ = Regularity quality; RL = Rule of law; CC = Control of corruption)	WGI	Institutional quality is a central theme in the works of Acemoglu et al. (2005) and Ehigiamusoe and Samsurijan (2021).

Source: Authors' data compilation from IMF, WDI and WGI.

4.Results and Discussion

4.1 Descriptive statistics

This section presents the descriptive statistics of the variables for both developed and developing countries. Tables 2 and 3 summarize key statistics, including the mean, standard deviation, minimum, and maximum values for each variable. These statistics provide an overview of the central tendencies and variability within the dataset, highlighting differences between advanced and developing economies in terms of financial development, innovation, institutional quality, government expenditure, inflation, and economic growth volatility.

Table 2: Descriptive statistics for developed countries

Variables	Mean	Std.	Min.	Max.
EVOL	2.263	1.825	0.130	11.321
FD1	0.634	0.205	0.093	1.000
FD2	4.528	0.481	3.162	6.262
INNOV1	7.800	2.367	1.386	13.339
INNOV2	9.171	1.872	3.704	13.029
GE	19.469	3.995	8.043	28.154
INF	2.403	2.696	-4.009	24.625

Variables	Mean	Std.	Min.	Max.
IQ_VA	1.375	0.737	-0.586	2.459
IQ_PS	1.390	0.527	0.038	2.469
IQ_GE	0.852	0.546	-1.625	1.758
IQ_RQ	1.355	0.435	-0.171	2.252
IQ_RL	1.350	0.535	-0.634	2.124
IQ_CC	1.160	0.414	-0.406	1.800

Source: Authors' own calculations

Table 3: Descriptive statistics for developing countries

Variables	Mean	Std.	Min.	Max.
EVOL	2.855	2.293	0.156	25.129
FD1	0.304	0.150	0.026	0.737
FD2	3.495	0.713	0.153	5.222
INNOV1	7.194	3.737	1.807	14.279
INNOV2	7.510	2.014	2.870	13.414
GE	14.023	4.191	4.727	29.321
INF	8.342	10.697	-8.525	96.096
IQ_VA	-0.358	0.587	-1.597	1.610
IQ_PS	-0.153	0.511	-1.705	1.337
IQ_GE	-0.430	0.774	-2.810	1.260
IQ_RQ	-0.108	0.616	-1.709	1.542
IQ_RL	-0.310	0.565	-1.708	1.348
IQ_CC	-0.270	0.787	-1.907	1.307

Source: Authors' own calculations

4.2. Correlation Matrix

This section presents the correlation matrices for the variables used in the analysis for both developed and developing countries. The correlation coefficients provide an initial understanding of the relationships between financial development, innovation, institutional quality, and macroeconomic variables, as well as their association with economic growth volatility.

Table 4: Correlation matrix for developed countries

EVOL	1			
FD1*INNOV1	-0.318	1		
FD1*INNOV2	-0.296	0.877	1	
FD2*INNOV1	-0.302	0.982	0.846	1

FD2*INNOV2	-0.274	0.845	0.975	0.854	1								
INF	0.168	-0.209	-0.232	-0.192	-0.213	1							
GE	-0.001	-0.145	-0.043	-0.119	-0.002	0.117	1						
IQ_VA	-0.235	0.414	0.315	0.387	0.272	-0.177	-0.612	1					
IQ_PS	-0.221	0.419	0.333	0.378	0.274	-0.222	-0.147	0.933	1				
IQ_GE	-0.044	-0.104	-0.190	-0.116	-0.213	-0.078	-0.181	0.474	0.458	1			
IQ_RQ	-0.183	0.353	0.272	0.311	0.213	-0.145	-0.199	0.858	0.836	0.416	1		
IQ_RL	-0.238	0.388	0.312	0.338	0.244	-0.192	-0.065	0.937	0.914	0.495	0.850	1	
IQ_CC	-0.270	0.129	0.167	0.082	0.115	-0.081	0.318	0.604	0.508	0.434	0.484	0.675	1

Source: Authors' own calculations

Table 5: Correlation matrix for developing countries

EVOL	1												
FD1*INNOV1	-0.110	1											
FD1*INNOV2	-0.081	0.867	1										
FD2*INNOV1	-0.149	0.975	0.847	1									
FD2*INNOV2	-0.116	0.841	0.979	0.867	1								
INF	0.195	-0.104	-0.145	-0.154	-0.190	1							
GE	0.223	0.069	0.199	0.070	0.199	-0.117	1						
IQ_VA	-0.244	0.161	0.202	0.192	0.230	-0.149	0.298	1					
IQ_PS	-0.065	0.344	0.373	0.371	0.397	-0.253	0.212	0.805	1				
IQ_GE	0.068	-0.042	-0.061	-0.012	-0.033	-0.107	0.279	0.582	0.496	1			
IQ_RQ	0.014	0.120	0.140	0.129	0.148	-0.234	0.236	0.729	0.782	0.491	1		
IQ_RL	-0.037	0.199	0.284	0.232	0.313	-0.211	0.262	0.864	0.820	0.574	0.779	1	
IQ_CC	-0.0005	-0.001	0.001	-0.034	-0.027	-0.014	0.108	0.592	0.508	0.433	0.642	0.592	1

Source: Authors' own calculations

The System Generalized Method of Moments (GMM) is employed in this empirical study to address potential endogeneity and reverse causality issues between financial development and growth volatility. The GMM estimator used in this analysis satisfies key diagnostic tests, including the Sargan and Hansen tests for over-identifying restrictions to verify instrument validity, as well as the AR(1) and AR(2) tests for first- and second-order serial correlation. The diagnostic results indicate that all model specifications perform effectively, confirming the

robustness of the estimations.

In applying the GMM estimator, all explanatory variables are treated as potentially endogenous. The system GMM approach utilizes both the level and differenced equations: the level equation instruments the explanatory variables using their first differences, while the differenced equation employs the second or third lags of the explanatory variables as instruments. The number of instruments is controlled by using collapsed instruments, following the guidance of Roodman (2009), to prevent instrument proliferation and ensure the validity of the estimation.

4.3. Findings for Developed Economies

The results presented in Tables 6 to 9 illustrate the impact of financial development on economic growth volatility through the channel of innovation in developed countries, using the system-GMM estimator. In these tables, IV refers to independent variables and DV denotes the dependent variable.

Table 6: System-GMM results for developed economies

IV	DV= EVOL					
LAG_EVOL	0.7293*	0.7288*	0.7279*	0.7295*	0.7267*	0.7014*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FD1*INNOV1	-0.0173**	-0.0156***	-0.0325*	-0.0214*	-0.0142***	-0.0101***
	(0.044)	(0.073)	(0.000)	(0.007)	(0.093)	(0.089)
GE	-0.5966*	-0.5621*	-0.5284**	-0.5884*	-0.6162*	-1.1845*
	(0.001)	(0.002)	(0.032)	(0.001)	(0.001)	(0.000)
INF	0.0771*	0.0761*	0.0791*	0.0767*	0.0736*	0.0740*
	(0.002)	(0.002)	(0.001)	(0.002)	(0.003)	(0.002)
IQ_VA	-0.1020**					
	(0.040)					
IQ_PS		-0.1587**				
		(0.023)				
IQ_GE			-0.1248***			
			(0.079)			
IQ_RQ				-0.1251***		
				(0.106)		
IQ_RL					-0.1873*	
					(0.005)	
IQ_CC						-0.6160
						(0.000)
Cons	-1.3900*	-1.2183**	-1.1119***	-1.3071**	-1.3523*	-2.5715*
	(0.013)	(0.034)	(0.074)	(0.026)	(0.015)	(0.000)
AR(1) p-value	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*
AR(2) p-value	0.120	0.119	0.122	0.131	0.125	0.138
Sargan p-value	0.914	0.975	0.949	0.833	0.957	0.823
Hansen p-value	1.000	1.000	0.108	1.000	1.000	0.859

Source: Authors' own calculations.***, ** and * show level of significance at 10%, 5% and 1%, respectively. | LAG_EVOL stands for lagged dependent variable.

Table 7: Robustness results 1 for developed economies

IV	DV= EVOL					
LAG_EVOL	0.7277*	0.7274*	0.7251*	0.7291*	0.7255*	0.7009*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FD1*INNOV2	-0.0201**	-0.0183**	-0.0386*	-0.0240*	-0.0169***	-0.0118***
	(0.028)	(0.049)	(0.000)	(0.006)	(0.065)	(0.066)
GE	-0.6717*	-0.6308*	-0.6608*	-0.6854*	-0.6804*	-1.2301*
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
INF	0.0757*	0.0749*	0.0771*	0.0758*	0.0725*	0.0734*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)
IQ_VA	-0.1058**					
	(0.027)					
IQ_PS		-0.1613*				
		(0.016)				
IQ_GE			-0.1488**			
			(0.042)			
IQ_RQ				-0.1281***		
				(0.104)		
IQ_RL					-0.1881*	
					(0.003)	
IQ_CC						-0.6148
						(0.000)
Cons	-1.5574*	-1.3719*	-1.3847*	-1.5382**	-1.4978*	-2.6791*
	(0.005)	(0.016)	(0.018)	(0.008)	(0.006)	(0.000)
AR(1) p-value	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*
AR(2) p-value	0.122	0.121	0.127	0.131	0.125	0.138
Sargan p-value	0.888	0.984	0.771	0.985	0.919	0.856
Hansen p-value	1.000	1.000	0.344	0.690	1.000	1.000

Source: Authors' own calculations. ***, ** and * show level of significance at 10%, 5% and 1%, respectively.

Table 8: Robustness results 2 for developed economies

IV	DV= EVOL					
LAG_EVOL	0.7322*	0.7314*	0.7340*	0.7329*	0.7292*	0.7027*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FD2*INNOV1	-0.0150*	-0.0133***	-0.0322*	-0.0200**	-0.0122***	-0.0095**
	(0.010)	(0.062)	(0.000)	(0.024)	(0.084)	(0.059)
GE	-0.6028*	-0.5641*	-0.5496*	-0.5930*	-0.6243*	-1.1996*
	(0.001)	(0.002)	(0.004)	(0.001)	(0.000)	(0.000)
INF	0.0786*	0.0774*	0.0815*	0.0784*	0.0747*	0.0748*
	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)
IQ_VA	-0.1143**					
	(0.020)					

IV	DV= EVOL					
IQ_PS		-0.1764*				
		(0.010)				
IQ_GE			-0.1130***			
			(0.105)			
IQ_RQ				-0.1410***		
				(0.084)		
IQ_RL					-0.2020*	
					(0.002)	
IQ_CC						-0.6274*
						(0.000)
Cons	-1.3336**	-1.1510**	-1.0295***	-1.2112**	-1.3101**	-2.5598*
	(0.021)	(0.051)	(0.107)	(0.044)	(0.022)	(0.000)
AR(1) p-value	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*
AR(2) p-value	0.118	0.117	0.120	0.131	0.125	0.138
Sargan p-value	0.572	0.508	0.425	0.611	0.607	0.916
Hansen p-value	1.000	1.000	1.000	1.000	1.000	0.859

Source: Authors' own calculations. ***, ** and * show level of significance at 10%, 5% and 1%, respectively.

Table 9: Robustness results 3 for developed economies

IV	DV= EVOL					
LAG_EVOL	0.7307*	0.7302*	0.7316*	0.7327*	0.7281*	0.7023*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FD2*INNOV2	-0.0181***	-0.0162*	-0.0387*	-0.0224**	-0.0150***	-0.0113**
	(0.075)	(0.017)	(0.000)	(0.023)	(0.107)	(0.034)
GE	-0.6687*	-0.6232*	-0.6818*	-0.6835*	-0.6799*	-1.2436*
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
INF	0.0773*	0.0762*	0.0798*	0.0776*	0.0736*	0.0742*
	(0.002)	(0.002)	(0.001)	(0.002)	(0.003)	(0.002)
IQ_VA	-0.1174*					
	(0.013)					
IQ_PS		-0.1785*				
		(0.007)				
IQ_GE			-0.1369***			
			(0.065)			
IQ_RQ				-0.1448***		
				(0.073)		
IQ_RL					-0.2029*	
					(0.001)	
IQ_CC						-0.6272*
						(0.000)
Cons	-1.4606*	-1.2641**	-1.2648**	-1.4127*	-1.4182*	-2.6530*
	(0.009)	(0.028)	(0.040)	(0.015)	(0.010)	(0.000)

IV	DV= EVOL					
AR(1) p-value	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*
AR(2) p-value	0.119	0.118	0.124	0.132	0.125	0.138
Sargan p-value	0.665	0.605	0.337	0.985	0.697	0.910
Hansen p-value	1.000	0.138	0.913	1.000	1.000	0.981

Source: Authors' own calculations. ***, ** and * show level of significance at 10%, 5% and 1%, respectively.

According to the findings in Table 6, the interaction term FD1*INNOV1 exhibits a consistently significant negative effect on growth volatility across all model specifications. Specifically, each percentage increase in FD1*INNOV1 reduces economic growth volatility by 0.0173%, 0.0156%, 0.0325%, 0.0214%, 0.0142%, and 0.0101%, respectively.

To test the robustness of these findings, alternative measures of financial development and innovation were employed. The financial development index (FD1) was replaced by credit to the private sector as a percentage of GDP (FD2), while the number of patents (INNOV1) was substituted with the number of scientific and technical research publications (INNOV2). The robustness results, reported in Tables 7 to 9, confirm that the negative relationship between financial development, innovation, and growth volatility remains consistent across all alternative specifications. The interaction terms FD1*INNOV2, FD2*INNOV1, and FD2*INNOV2 all display significant negative effects on growth volatility, supporting previous studies by Arcand et al. (2015) and Fagiolo et al. (2020).

A well-developed financial sector enhances access to investment and finance through bond and stock markets, reducing liquidity risks and promoting sustainable production growth (Levine, 2005). Robust financial institutions mitigate financial frictions caused by information asymmetry, improving data collection, loan screening, and supervision. This reduces adverse selection, moral hazard, and the financial accelerator effect, thereby smoothing business cycles and lowering volatility (Kapingura et al., 2022; Bezooijen & Bikker, 2017).

The synergy between innovation and financial development strengthens the financial system's capacity to assess risks and ease financial constraints for households and firms. During economic downturns, improved access to credit helps stabilize consumption and investment, reducing economic instability (Dynan et al., 2006). Financial intermediation, when aligned with technological advancement, can either promote or hinder economic progress depending on how it supports innovation (Fagiolo et al., 2020). As financial services evolve with technology, they become more accessible and efficient, contributing to more inclusive and resilient economic growth (Verma et al., 2023). Furthermore, technology-driven financial intermediation enhances transparency, reduces information costs, and improves resource allocation, which collectively mitigate market inefficiencies and reduce volatility (Beck et al., 2014; Nguyen et al., 2022; Tang, 2018).

Global shocks, such as the 2008 financial crisis and the COVID-19 pandemic, have highlighted the importance of resilient financial systems and adaptive institutions. While financial development has cushioned some negative impacts through emergency mechanisms, uneven innovation diffusion has led to sectoral and regional disparities (Kaffenberger, 2020; Stiglitz, 2015). These events underscore the need for balanced policy responses

that promote both innovation and financial stability, including investments in digital infrastructure and human capital development.

Government spending consistently demonstrates a significant negative impact on growth volatility across all specifications in Table 6, with each percentage increase in government expenditure reducing volatility by values ranging from 0.5284% to 1.1845%. This stabilizing effect of fiscal policy is confirmed in the robustness checks (Tables 7 to 9), aligning with the view that active fiscal policies can dampen business cycle fluctuations in developed economies (Tang, 2018).

Inflation, by contrast, shows a positive and significant relationship with growth volatility. A 1% increase in inflation raises volatility by approximately 0.0736% to 0.0791% across specifications in Table 6, with consistent results in the robustness analyses. Higher inflation is associated with macroeconomic instability, which disrupts financial markets, increases uncertainty, and amplifies output volatility (Awan et al., 2021).

All measures of institutional quality exhibit a negative impact on growth volatility, reinforcing the critical role of strong institutions in fostering stable economic environments. High-quality institutions that uphold property rights, the rule of law, and governance standards promote technological investment and productivity growth, which are essential for sustainable development (Acemoglu et al., 2005). Enhancing institutional quality, particularly in emerging contexts, is vital for boosting total factor productivity and reducing economic fluctuations.

4.4. Findings for Developing Economies

The results presented in Tables 10 to 13 examine the impact of financial development on growth volatility through the innovation channel in developing countries, using the system-GMM estimator.

Table 10: System-GMM results for developing economies

IV	DV= EVOL					
LAG_EVOL	0.7341*	0.7307*	0.7215*	0.7249*	0.7327*	0.7297*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FD1*INNOV1	-0.0045**	-0.0127***	-0.0031***	-0.0066**	-0.0067**	-0.0054**
	(0.034)	(0.105)	(0.065)	(0.034)	(0.035)	(0.034)
GE	0.4391*	0.3796*	0.2849*	0.3760*	0.3924*	0.3849*
	(0.001)	(0.001)	(0.018)	(0.001)	(0.000)	(0.001)
INF	0.0627**	0.0725**	0.0696**	0.0785*	0.0629**	0.0614**
	(0.041)	(0.021)	(0.023)	(0.013)	(0.041)	(0.045)
IQ_VA	-0.0484					
	(0.572)					
IQ_PS		0.1216				
		(0.150)				
IQ_GE			0.1328**			
			(0.021)			
IQ_RQ				0.1228**		
				(0.028)		
IQ_RL					0.0347	
					(0.698)	

IV			DV= EVOL			
IQ_CC						0.0341
						(0.416)
Cons	-1.0275*	-0.8065*	-0.6026***	-0.8436*	-0.8661*	-0.8510*
	(0.005)	(0.008)	(0.063)	(0.005)	(0.006)	(0.005)
AR(1) p-value	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*
AR(2) p-value	0.356	0.319	0.322	0.351	0.351	0.349
Sargan p-value	0.250	0.462	0.350	0.323	0.268	0.289
Hansen p-value	1.000	1.000	1.000	1.000	1.000	0.349

Source: Authors' own calculations. ***, ** and * show level of significance at 10%, 5% and 1%, respectively.

Table 11: Robustness results 1 for developing economies

IV			DV= EVOL			
LAG_EVOL	0.7372*	0.7335*	0.7240*	0.7281*	0.7356*	0.7323*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FD1*INNOV2	-0.0704**	-0.0369***	-0.0095***	-0.0706**	-0.0631***	-0.0141**
	(0.035)	(0.098)	(0.089)	(0.040)	(0.062)	(0.045)
GE	0.4540*	0.3927*	0.2559**	0.3780*	0.4005*	0.3845*
	(0.000)	(0.000)	(0.036)	(0.001)	(0.000)	(0.001)
INF	0.0686**	0.0743*	0.0772*	0.0850*	0.0682**	0.0677**
	(0.026)	(0.019)	(0.012)	(0.007)	(0.027)	(0.028)
IQ_VA	-0.0679					
	(0.424)					
IQ_PS		0.0733				
		(0.376)				
IQ_GE			0.1581*			
			(0.006)			
IQ_RQ				0.1196**		
				(0.033)		
IQ_RL					0.0108	
					(0.904)	
IQ_CC						0.0362
						(0.392)
Cons	-1.1191*	-0.9023*	-0.5723***	-0.9004*	-0.9414*	-0.8971*
	(0.002)	(0.003)	(0.080)	(0.002)	(0.003)	(0.003)
AR(1) p-value	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*
AR(2) p-value	0.357	0.328	0.315	0.350	0.351	0.348
Sargan p-value	0.250	0.462	0.109	0.375	0.477	0.090
Hansen p-value	1.000	1.000	0.406	1.000	0.328	1.000

Source: Authors' own calculations. ***, ** and * show level of significance at 10%, 5% and 1%, respectively.

Table 12: Robustness results 2 for developing economies

IV	DV= EVOL					
LAG_EVOL	0.7347*	0.7309*	0.7219*	0.7254*	0.7332*	0.7303*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FD2*INNOV1	-0.0031***	-0.0115***	-0.0049**	-0.0054**	-0.0053**	-0.0039**
	(0.068)	(0.108)	(0.045)	(0.054)	(0.048)	(0.048)
GE	0.4436*	0.3818*	0.2798**	0.3768*	0.3944*	0.3856*
	(0.001)	(0.001)	(0.020)	(0.001)	(0.000)	(0.001)
INF	0.0642**	0.0729**	0.0714**	0.0798*	0.0641**	0.0630**
	(0.037)	(0.021)	(0.020)	(0.011)	(0.037)	(0.040)
IQ_VA	-0.0537					
	(0.530)					
IQ_PS		0.1149				
		(0.180)				
IQ_GE			0.1385*			
			(0.016)			
IQ_RQ				0.1221**		
				(0.029)		
IQ_RL					0.0299	
					(0.740)	
IQ_CC						0.0337
						(0.422)
Cons	-1.0378*	-0.7659*	-0.6250**	-0.8297*	-0.8571*	-0.8460*
	(0.006)	(0.017)	(0.055)	(0.007)	(0.009)	(0.007)
AR(1) p-value	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*
AR(2) p-value	0.355	0.320	0.319	0.350	0.350	0.348
Sargan p-value	0.160	0.286	0.262	0.201	0.167	0.169
Hansen p-value	1.000	1.000	1.000	1.000	1.000	1.000

Source: Authors' own calculations. ***, ** and * show level of significance at 10%, 5% and 1%, respectively.

Table 13: Robustness results 3 for developing economies

IV	DV= EVOL					
LAG_EVOL	0.7384*	0.7347*	0.7250*	0.7292*	0.7368*	0.7334*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
FD2*INNOV2	-0.0588**	-0.0154***	-0.0112***	-0.0466**	-0.0623***	-0.0132**
	(0.028)	(0.072)	(0.105)	(0.021)	(0.109)	(0.025)
GE	0.4564*	0.3936*	0.2498**	0.3770*	0.4014*	0.3824*
	(0.000)	(0.000)	(0.041)	(0.001)	(0.000)	(0.001)
INF	0.0703**	0.0750*	0.0790*	0.0867*	0.0697**	0.0696**
	(0.023)	(0.018)	(0.011)	(0.006)	(0.024)	(0.024)
IQ_VA	-0.0726					
	(0.393)					

IV	DV= EVOL					
IQ_PS		0.0631				
		(0.450)				
IQ_GE			0.1628*			
			(0.005)			
IQ_RQ				0.1198**		
				(0.033)		
IQ_RL					0.0039	
					(0.966)	
IQ_CC						0.0380
						(0.372)
Cons	-1.1528*	-0.9081*	-0.6230**	-0.9164*	-0.9637*	-0.9155*
	(0.002)	(0.004)	(0.056)	(0.003)	(0.003)	(0.003)
AR(1) p-value	0.000*	0.000*	0.000*	0.000*	0.000*	0.000*
AR(2) p-value	0.356	0.329	0.311	0.348	0.349	0.346
Sargan p-value	0.090	0.101	0.201	0.342	0.472	0.070
Hansen p-value	1.000	0.140	1.000	1.000	0.713	0.508

Source: Authors' own calculations. ***, ** and * show level of significance at 10%, 5% and 1%, respectively.

According to the findings in Table 10, the interaction term FD1*INNOV1 demonstrates a consistently negative effect on growth volatility across all specifications. Specifically, each percentage increase in FD1*INNOV1 reduces growth volatility by 0.0045%, 0.0127%, 0.0031%, 0.0066%, 0.0067%, and 0.0054%, respectively. The robustness checks, reported in Tables 11 to 13, confirm that this negative relationship persists when alternative measures of financial development and innovation are applied (FD1*INNOV2, FD2*INNOV1, and FD2*INNOV2). These findings are consistent with previous studies by Tang (2018) and Verma et al. (2023), highlighting the stabilizing role of financial development and innovation in reducing growth volatility within developing economies.

Deeper financial systems can mitigate growth volatility by alleviating corporate liquidity constraints and fostering long-term investments (Iwasaki et al., 2022; Levine & Warusawitharana, 2021). Financial development enhances risk-sharing mechanisms, improves resilience to shocks, and facilitates consumption smoothing, particularly in low-income economies where credit constraints are more binding (Kpodar et al., 2019; Abanikanda & Dada, 2024). When coupled with technological progress, advanced financial systems help reduce issues of asymmetric information by improving the capacity of financial institutions to assess risk and identify potentially failing projects (Tang, 2018). Access to credit supports technological innovation and diffusion, encouraging enterprises to balance research efforts with practical application, thereby promoting sustainable economic growth (Arcand et al., 2015; Levine et al., 2017).

Technological innovation enhances financial intermediation by improving transparency, efficiency, and risk management. Fintech solutions facilitate easier access to credit, especially in underdeveloped markets, while reducing transaction costs and improving service delivery. These advancements contribute to stabilizing economic growth by directing investments toward productive and sustainable ventures, thus reducing the likelihood of

financial crises (Gopalan & Rajan, 2022; Nguyen et al., 2022).

However, global shocks—such as the 2008 financial crisis and the COVID-19 pandemic—have exposed vulnerabilities in developing financial systems, including over-leverage, speculative behavior, and inadequate risk management. While innovation can act as both a stabilizer and a source of volatility, these crises highlighted its dual role: offering new opportunities while simultaneously disrupting traditional sectors (Penzin et al., 2025). Financial sector development generally complements innovation by financing R&D, startups, and business expansion (Levine, 2005), but resilience also depends on regulatory frameworks and institutional adaptability.

The analysis further reveals that government spending has a positive and significant impact on growth volatility across all specifications. Each percentage point increase in government expenditure raises volatility by values ranging from 0.2849% to 0.4540%, as shown in Table 10, with consistent results in the robustness checks (Tables 11 to 13). This pro-cyclicality of government spending in developing countries is attributed to weak fiscal frameworks, limited automatic stabilizers, and destabilizing mechanisms within social security systems, leading to heightened macroeconomic volatility (Galeano et al., 2021).

Inflation also exhibits a positive and significant relationship with growth volatility. A 1% increase in inflation raises volatility by approximately 0.0614% to 0.0785% across specifications in Table 10, with robustness confirmed in subsequent tables. High inflation environments are associated with macroeconomic instability, amplifying fluctuations in economic growth (Tang & Abosedra, 2020).

Regarding institutional quality, the results indicate either insignificant or positive impacts on growth volatility in developing economies. These outcomes are consistent across robustness checks. Weak institutions are linked to lower investment efficiency, slower productivity growth, and greater economic instability (Acemoglu et al., 2005; Ajide et al., 2015; Hall & Jones, 1999). In environments where political and institutional constraints are weak, economic agents may respond to uncertainty by withdrawing capital quickly, thereby exacerbating volatility and undermining long-term growth prospects.

5. Conclusion

Understanding the role of financial sector development is critical at a time when global policy efforts increasingly emphasize enhancing economic resilience. Despite its importance, research on the relationship between financial development and economic growth volatility remains limited and yields inconsistent findings. The question of how financial development influences growth volatility—particularly in conjunction with innovation—remains unresolved, especially for countries lagging in both financial sector maturity and economic growth.

This study investigates how innovation moderates the relationship between financial development and economic growth volatility across 32 developed and 46 developing countries, using annual data from 1996 to 2022. The analysis employs six models, with growth volatility as the dependent variable and the interaction between financial development and innovation as the key explanatory variable.

The findings reveal that, in both developed and developing economies, financial sector growth reduces economic growth volatility—provided that a sufficient level of innovation is present. Additionally, inflation consistently increases growth volatility across both groups of countries. Government spending, however, has

divergent effects: it reduces volatility in developed economies but increases it in developing ones. Similarly, institutional quality contributes to reducing growth volatility in advanced economies, while its impact in developing countries is either insignificant or positive.

5.1. Policy Implications

Innovation emerges as a critical moderating factor in reducing economic growth volatility through financial development. Policymakers in both developed and developing countries should prioritize fostering innovation by investing in research and development (R&D), education, and technology infrastructure. For example, South Korea's strategic emphasis on technological innovation in the late 20th century transformed its economy into a stable, high-growth model despite external shocks.

Given the pro-cyclical nature of government spending in developing countries, it is recommended that these nations adopt counter-cyclical fiscal policies—increasing spending during recessions and reducing it during expansions—to stabilize economic fluctuations, as practiced in advanced economies like the United States during the global financial crisis.

To mitigate the adverse effects of inflation, governments should implement effective monetary and fiscal policies aimed at stabilizing price levels and reducing macroeconomic uncertainty.

Improving institutional quality is essential for developing countries to enhance economic stability. This involves strengthening governance frameworks by promoting transparency, combating corruption, ensuring effective law enforcement, and reinforcing property rights. Measures such as adopting digital governance systems, establishing independent anti-corruption bodies, and enhancing judicial efficiency can foster a more stable business environment conducive to growth.

Additionally, promoting innovation requires targeted investments in education—particularly in science and technology—establishing innovation hubs, offering R&D tax incentives, and fostering collaborations between academia, industry, and government. Expanding access to digital infrastructure and financing will further support a dynamic environment that encourages creativity and technological advancement.

5.2. Future Research

While this study provides robust findings, it has certain limitations. The analysis covers only 78 countries, which may limit generalizability, particularly in regions with data scarcity. Expanding the dataset to include more countries would enhance the representativeness of future research.

A deeper exploration of the moderating role of institutional quality is warranted, given this study's finding that its impact on growth volatility differs between developed and developing economies. Future research could provide valuable insights into how strong institutions interact with financial development and innovation to stabilize economies.

Sector-specific analyses—examining how innovation in manufacturing, services, or agriculture affects GDP volatility—could help identify which types of innovation contribute most to economic stability. This would offer policymakers clearer guidance on where to direct innovation efforts for sustainable growth.

Another promising avenue is investigating how political stability influences the relationship between financial development, innovation, and growth volatility. Incorporating political factors could clarify how governance

environments enable or hinder the stabilizing effects of financial and technological advancements, particularly in politically unstable countries.

Future studies might also examine additional moderating factors, such as trade openness and human capital. Openness to trade can shape how economies integrate into global markets and manage volatility, while education and skilled labor play crucial roles in enhancing the effectiveness of financial innovations and stabilizing growth.

Incorporating these dimensions would provide a more comprehensive understanding of the complex dynamics driving economic stability across diverse economic contexts.

References

Abanikanda, E. O., & Dada, J. T. (2024). External shocks and macroeconomic volatility in Nigeria: Does financial development moderate the effect? *PSU Research Review, 8*(3), 828–844.

Abdelaoui, T. M. L., & Abdelaoui, O. (2020). The impact of innovation on economic development in Arab countries: The case of selected Arab countries from 2007 to 2016. *Journal of African Economies, 16,* 33–54.

Acemoglu, D., Johnson S., & Robinson, J. A. (2005). Institutions as a fundamental cause of growth. In P. Aghion & S. N. Durlauf (Eds.), *Handbook of economic growth* (Vol. 1, pp. 386–454). North-Holland.

Aghion, P., Bloom, N., Blundell, R., Griffith, R., & Howitt, P. (2005). Competition and innovation: An inverted-U relationship. *The Quarterly Journal of Economics*, *120*(2), 701–728.

Ajide, K. B., Raheem, I. D., & Adeniyi, O. (2015). Output growth volatility, remittances and institutions. *International Journal of Development Issues*, *14*(3), 190–203.

Arcand, J. L., Berkes, E., & Panizza, U. (2015). Too much finance? *Journal of Economic Growth*, *20*, 105–148.

Avom, D., Kamguia, B., Ngameni, J. P., & Njangang, H. (2021). How does terms of trade volatility affect macroeconomic volatility? The roles of financial development and institutions. *International Economics*, *168*, 98–114.

Awan, A., Asghar, N., & Rehman, H. U. (2021). The impact of financial globalization on output volatility: Panel data evidence for Asian countries. *Pakistan Journal of Commerce and Social Sciences (PJCSS)*, *15*(1), 213–239.

Beck, T., Degryse, H., & Kneer, C. (2014). Is more finance better? Disentangling intermediation and size effects of financial systems. *Journal of Financial Stability, 10,* 50–64.

Bezooijen, E., & Bikker, J. A. (2017). *Financial structure and macroeconomic volatility: A panel data analysis* [DNB Working Paper No. 568]. Utrecht: Utrecht University and Amsterdam: De Nederlandsche Bank.

Cavoli, T., Gopalan, S., & Rajan, R. S. (2020). Does financial inclusion amplify output volatility in emerging and developing economies? *Open Economies Review*, *31*(4), 901–930.

Dynan, K. E., Elmendorf, D. W., & Sichel, D. E. (2006). Can financial innovation help to explain the reduced volatility of economic activity? *Journal of Monetary Economics*, *53*(1), 123–150.

Ehigiamusoe, K. U., & Samsurijan, M. S. (2021). What matters for finance-growth nexus? A critical survey of

macroeconomic stability, institutions, financial and economic development. *International Journal of Finance & Economics*, *26*(4), 5302–5320.

Fagiolo, G., Giachini, D., & Roventini, A. (2020). Innovation, finance, and economic growth: An agent-based approach. *Journal of Economic Interaction and Coordination*, *15*, 703–736.

Galeano, L., Izquierdo, A., Puig, J. P., Vegh, C. A., & Vuletin, G. (2021). *Can automatic government spending be procyclical?* [NBER Working Paper No. 28521]. Cambridge, MA: National Bureau of Economic Research.

Ghosh, P., & Adhikary, M. (2023). Dynamicity and nonlinearity in the association between different facets of financial development and macroeconomic volatility: Evidence from the world economy. *International Review of Applied Economics, 37(6),*745-766.

Gopalan, S., & Rajan, R. S. (2022). Does digital financial inclusion moderate or exacerbate output volatility? *Applied Economics Letters, 29(19),* 1804–1809.

Hall, R. E., & Jones, C. I. (1999). Why do some countries produce so much more output per worker than others? *The Quarterly Journal of Economics*, *114*(1), 83–116.

Ibrahim, M. H., Law, S. H., & Sukmana, R. (2024). Finance and output volatility during the global financial crisis. *Muslim Business and Economics Review, 3(1),* 1–31.

Iftikhar, S. F., & Abbas, W. (2016). Does financial development volatility affect growth volatility of industries in Pakistan? *Econometrics Letters, 3(2),* 15–27.

Iwasaki, I., Kočenda, E., & Shida, Y. (2022). Institutions, financial development, and small business survival: Evidence from European emerging markets. *Small Business Economics, 58,* 1261–1283.

Kaffenberger, M. (2020). Modelling the long-run learning impact of the Covid-19 learning shock: Actions to (more than) mitigate loss. *International Journal of Educational Development, 81,* 102326.

Kapingura, F. M., Mkosana, N., & Kusairi, S. (2022). Financial sector development and macroeconomic volatility: Case of the Southern African Development Community region. *Cogent Economics & Finance*, *10*(1), 2038861.

Kpodar, K. R., Le Goff, M., & Singh, R. J. (2019). *Financial deepening, terms of trade shocks and growth in low-income countries* (IMF Working Paper No. 2019/068). International Monetary Fund.

Levine, O., & Warusawitharana, M. (2021). Finance and productivity growth: Firm-level evidence. *Journal of Monetary Economics*, *117*, 91–107.

Levine, R. (2005). Finance and growth: Theory and evidence. *Handbook of Economic Growth, 1*, 865–934.

Levine, R., Lin, C., & Wei, L. (2017). Insider trading and innovation. *The Journal of Law and Economics*, *60*(4), 749–800.

Mohamed, M. M. A., Liu, P., & Nie, G. (2022). Causality between technological innovation and economic growth: Evidence from the economies of developing countries. *Sustainability*, *14*(6), 3586.

Mulugeta, E. T. (2024). Output growth volatility, remittances, and financial development in the Common Market for Eastern and Southern Africa Region: A system generalized method of moments approach. *Journal of the Knowledge Economy, 5,* 1–17.

Nguyen, T. P., Dinh, T. T. H., Tran Ngoc, T., & Duong Thi Thuy, T. (2022). Impact of ICT diffusion on the

interaction of growth and its volatility: Evidence from cross-country analysis. *Cogent Business & Management*, *9*(1), 2054530.

Oro, O. U., & Alagidede, I. P. (2019). The non-linear relationship between financial development, economic growth and growth volatility: Evidence from Nigeria. *African Review of Economics and Finance, 11(2),* 67–97.

Penzin, D. J., Isah, K. O., & Salisu, A. A. (2025). Climate change-stock return volatility nexus in advanced economies: The role of technology shocks. *Journal of Economic Studies, 52(1),* 119–135.

Roodman, D. (2009). How to do xtabond2: An introduction to difference and system GMM in Stata. *The Stata Journal*, *9*(1), 86–136.

Sahay, R., Čihák, M., N'Diaye, P., Barajas, A., Bi, R., Ayala, D., ... & Yousefi, S. R. (2015). Rethinking financial deepening: Stability and growth in emerging markets. *Revista de Economía Institucional, 17(33),* 73–107.

Schumpeter, J. A. (1934). *The theory of economic development: An inquiry into profits, capital, credit, interest, and the business cycle* (R. Opie, Trans.). Cambridge, MA: Harvard University Press. (Original work published 1911)

Shleifer, A., & Vishny, R. W. (2010). Unstable banking. *Journal of Financial Economics*, *97*(3), 306–318.

Stiglitz, J. E. (2015). Macroeconomic fluctuations, inequality, and human development. In D. Nayyar (Ed.), *Macroeconomics and human development* (pp. 31–58). Routledge.

Tang, C. F., & Abosedra, S. (2020). Does financial development moderate the effects on growth volatility? The experience of Malaysia. *Margin: The Journal of Applied Economic Research, 14*(4), 361–381.

Tang, S. H. K. (2018). Does scientific and technical research reduce macroeconomic volatility? *Bulletin of Economic Research*, *70(1),* 68–88.

Verma, A., Dandgawhal, P. S., & Giri, A. K. (2023). Impact of ICT diffusion and financial development on economic growth in developing countries. *Journal of Economics, Finance and Administrative Science, 28(55),* 27–43.

Appendix 1

List of developed countries

Australia, Austria, Belgium, Canada, Croatia, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong, Iceland, Israel, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Portugal, Singapore, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom, United States

List of developing countries

Algeria, Argentina, Armenia, Azerbaijan, Bangladesh, Belarus, Brazil, Bulgaria, Chile, China, Colombia, Costa Rica, Dominican Republic, Ecuador, Egypt, Georgia, Guatemala, Hungary, India, Indonesia, Iran, Jamaica, Jordan, Kazakhstan, Kenya, Kyrgyz Republic, Malaysia, Mexico, Moldova, Mongolia, Morocco, Pakistan, Peru, Philippines, Poland, Romania, Russia, Saudi Arabia, South Africa, Sri Lanka, Sudan, Thailand, Tunisia, Türkiye, Uruguay, Viet Nam