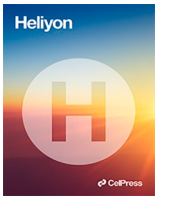
Heliyon 9 (2023) e20265

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon



The complexity of financial development and economic growth nexus in Syria: A nonlinear modelling approach with artificial neural networks and NARDL model

Abdullah Mohammad Ghazi Al khatib

Department of Banking and Insurance, Faculty of Economics, Damascus University, Damascus, Syrian Arab Republic

ARTICLE INFO

JEL classification:
C45
C32
E44
O16
O53

Keywords:
Artificial neural network VAR model
Nonlinear causality test
Financial development
Economic growth
NARDL model
Cumulative dynamic multiplier

ABSTRACT

This study investigates the complex interaction between financial development (FD) and economic growth (EG) in Syria from 1980 to 2018 using advanced nonlinear modeling techniques including artificial neural network VAR models, nonlinear causality tests, and nonlinear autoregressive distributed lag (NARDL) models. The results indicate that linear models are inadequate to capture the data patterns, necessitating nonlinear approaches. The artificial neural network VAR model reveals a nonlinear connection between FD and EG. The nonlinear causality test confirms that FD causes EG in a nonlinear manner. The NARDL (1, 1, 0, 1, 1) model is selected based on Akaike information criterion and diagnostics. The findings show a long-run equilibrium and short-run dynamics between FD and EG in Syria. Moreover, positive changes in FD have stronger, more persistent effects on EG compared to negative changes, implying asymmetry. Additionally, the impact of FD on EG is nonlinear, varying with FD levels. These results support recent studies suggesting a nonlinear nexus between FD and EG. They also lend support to the finance-led growth theory while opposing the "too much finance harms growth" hypothesis. The study offers policy implications for Syria to create conditions conducive to positive FD shocks and adopt a long-term perspective regarding FD-EG policies.

1. Introduction

The relationship between financial development (FD) and economic growth (EG) is intricate and fascinating. FD enhances the efficiency and stability of the financial system, enabling resource mobilization and allocation for productive activities. EG denotes the sustained increase in a country's output and income over time. Many empirical studies have identified various determinants of EG Ref. [1].

FD can promote EG by providing better financial services, reducing information asymmetry and transaction costs, stimulating innovation and entrepreneurship, and mitigating macroeconomic fluctuations. However, empirical evidence on the causal link between FD and EG remains ambiguous and context-specific, varying across countries, time periods, and methodologies. For instance Ref. [2], find bidirectional causality between FD-EG in Western, Central, Eastern, and Southern African countries and unidirectional causality in Northern Africa [3]. find mutual causality between FD and EG in Pakistan.

[4] explored the association between FD, EG, foreign direct investment and trade openness in four South Asian countries over three decades using Granger causality tests, VECM, VDA and IRF. The results showed different unidirectional causalities but no bidirectional

E-mail address: abdullah1991.alkhatib@damascusuniversity.edu.sy.

https://doi.org/10.1016/j.heliyon.2023.e20265
Received 29 March 2023; Received in revised form 1 September 2023; Accepted 18 September 2023
Available online 22 September 2023

causality. The study suggested policies to boost trade, finance and investment for long-term growth in these countries.

Recent studies indicate that the impact of FD on EG is asymmetric and nonlinear. Positive shocks from FD enhance EG while negative shocks hinder it [5]. Different finance indicators like capital markets, money markets, internet finance, and rural finance have varying short and long-run effects on EG depending on context and period [6–8]. However, excessive or inefficient FD can negatively impact EG beyond a threshold by misallocating capital or diverting resources to unproductive uses [9–11]. Therefore, the functional form of the finance-growth relationship is crucial to understand its nature and implications, as linear models may not capture regime-switching behaviors [12]. Some studies have found U-shaped or inverted U-shaped nonlinear relationships, implying an optimal FD level that maximizes EG Refs. [13–15]. Policymakers need to consider the threshold when regulating financial expansion, and reliably measuring the nonlinearity is essential for addressing specific issues and monitoring financial intermediaries' activities.

The FD-EG nexus in Syria has received little attention in the literature despite the country's recent political and economic turmoil. Only two time series studies have examined this nexus using linear models [16,17]. Regarding panel data studies, only two have examined this nexus using linear models [18,19]. Therefore, this study aims to fill this gap by analyzing the nonlinear nexus between FD and EG in Syria over 1980–2018 using artificial neural network VAR, nonlinear causality tests and NARDL models to capture the temporal dynamics and causality. Moreover, it examines how other determinants like government spending, exchange rates, and institutions affect this nexus.

This research will augment the knowledge on the intricacies and causality of the FD-EG nexus in Syria and provide insights to aid policymaking [20]. suggest examining nonlinear relationships that may escape linear models like ARDL. Next, the paper describes the data and methods used, including the data sources and variables analyzed. The results are then presented, showing a positive yet nonlinear nexus between FD and EG in Syria, along with nonlinear causality from FD to EG. Additionally, government spending, exchange rates, and institutions are found to significantly influence Syria's EG.

Finally, implications of the results for Syrian policymaking are concluded. A comprehensive approach is necessary to fully understand the FD-EG relationship in Syria, and policymakers should account for the nonlinear, dynamic nature of this nexus in policy design.

There are five key contributions: First, advanced nonlinear models examine the complex FD-EG relationship in Syria. Second, empirical evidence of nonlinear causality from FD to EG and long-term equilibrium is provided. Third, positive FD changes have stronger, more persistent EG effects than negative changes, indicating asymmetry. Fourth, the nonlinear impact of FD on EG depending on FD levels is revealed. Fifth, the finance-led growth theory is supported while the "too much finance" hypothesis is opposed.

1.1. Background of Syria

Syria is a low-income country suffering from prolonged armed conflict since 2011, resulting in massive human and economic losses, widespread displacement and humanitarian crises. The conflict has also severely disrupted the country's FD [21], and EG as well as its trade, investment, and fiscal policies.

According to Ref. [22], "Syria was among the countries that suffered the most from economic decline since 2008, along with Greece and Libya, which were also devastated by war. Syria's brutal war has lasted for years and is still unresolved." The conflict has significantly impacted Syria's financial sector and EG:

- The conflict has caused declining economic activity, with businesses closing and job losses.
- The financial sector has been severely affected, with banks and institutions closing or destroyed.
- Foreign investment and tourism have decreased, further damaging the economy.
- Government resources have been diverted from economic development to the war effort, slowing EG.
- Exports have decreased and imports have increased, hurting the trade balance.

Despite these challenges, some studies suggest FD remains necessary for EG in Syria [16,17]. However, financial reforms and improved financial system efficiency are required to stimulate savings and investment for Syria's long-term EG Refs. [16,18].

Overall, the ongoing Syrian conflict has significantly and negatively impacted the financial sector and EG. It has also damaged the country's physical and institutional infrastructure, eroded human capital, and undermined social cohesion and trust. Before the conflict, Syria had a relatively diversified economy based on agriculture, industry, services, and oil exports. It had also embarked on gradual economic liberalization and FD reforms since the early 2000s involving banking sector opening to private and foreign participation, stock market development, exchange rate reforms, and improved regulation and supervision. These reforms helped enhance the financial system's efficiency, stability, access and depth, which supported EG by mobilizing savings, allocating resources, diversifying risks, and enabling innovation [23]. However, the conflict onset reversed these positive trends and exposed the fragility and vulnerability of Syria's financial system and economy. Currency depreciation, economic sanctions, trade and investment disruptions, deteriorating fiscal and monetary policies, and foreign exchange reserve depletion have all contributed to worsening the macroeconomic situation and triggering hyperinflation.

The financial system has also suffered from reduced liquidity, increased non-performing loans, limited credit access, and weakened governance and oversight [16]. These factors have adversely affected the FD-EG nexus in Syria and increased its complexity and dynamics.

Given this context, it is vital to assess how FD and EG interact intricately over time in Syria, especially considering the recent political and economic shocks. Moreover, examining how this interaction varies across different aspects of FD (financial institutions and markets) and EG indicators (like GDP per capita) is essential. Furthermore, nonlinear modeling approaches are needed that can

capture the asymmetric and dynamic FD-EG relationship in Syria and account for other influencing macroeconomic factors. These are the main objectives and motivations for this study.

1.2. Research gap and contribution

Despite the importance and intricacy of the FD-EG nexus in Syria, empirical studies examining it using nonlinear modeling approaches to capture its dynamic and asymmetric nature remain scarce. Most existing Syria studies utilize linear models that assume a symmetric and stable FD-EG relationship, which may not reflect the reality in a nonstationary, conflict-affected country like Syria. Moreover, most existing studies use aggregate FD and EG measures, which may not capture their multidimensional aspects and interactions. For instance, some studies use broad money supply or credit to the private sector as FD indicators, while others use GDP per capita or GDP growth for EG Ref. [17]. However, these indicators may not reflect the diversity and depth of financial services and products, or the quality and structure of economic output and performance. Therefore, this study aims to address this gap in the literature by employing nonlinear modeling approaches to account for the dynamic and asymmetric FD-EG relationship in Syria over time. Specifically, artificial neural network VAR, nonlinear causality tests, and nonlinear autoregressive distributed lag (NARDL) models are applied to examine the FD-EG nexus in Syria from 1980 to 2018.

Artificial neural networks are flexible, powerful tools that can approximate any nonlinear function without imposing assumptions or restrictions on the data or model. NARDL models are useful for testing asymmetric cointegration between variables with structural breaks. Using these methods enables capturing the nonlinearities, asymmetries, and dynamics of the Syria FD-EG nexus under different scenarios and shocks. Furthermore, the study contributes to the literature by using different FD and EG dimensions and indicators to analyze their nexus in Syria. The IMF multidimensional FD index is used, covering financial institutions, financial markets, and three sub-dimensions (depth, access and efficiency). The IMF index enables a more comprehensive, nuanced analysis of the Syria FD-EG nexus compared to previous studies.

The study also provides relevant policy recommendations for enhancing FD and EG in Syria and other developing countries facing similar challenges and opportunities. By identifying the key mechanisms and channels of the complex FD-EG interaction in Syria, appropriate interventions that foster a virtuous cycle of FD-EG to support sustainable development and social welfare can be suggested. Moreover, by analyzing the impact of different shocks and scenarios on the Syria FD-EG nexus, the study offers policy guidance on coping with uncertainty and volatility in conflict-affected countries like Syria.

1.3. Theoretical framework

The theoretical literature has proposed various channels and mechanisms through which FD can impact EG and vice versa [23–25].

According to neoclassical growth theory, EG is driven by key factor inputs like capital, labor, natural resources, and technological progress. Capital accumulation plays a pivotal role in propelling growth, as higher capital investment boosts productivity and output through various mechanisms. Specifically, increased capital enables the adoption of more advanced machinery and equipment, facilitates innovation, augments human capital via training, and expands infrastructure development. This in turn enhances labor productivity and total factor productivity - two crucial determinants of economic growth. By spurring capital deepening and permitting fuller utilization of resources, greater capital formation allows economies to operate closer to their production possibility frontiers. The endogenous growth model further endogenizes technological change and human capital, explaining how capital accumulation enables innovation and skills upgrading, generating long-run growth rather than diminishing returns. Therefore, from a neoclassical perspective, capital formation is a fundamental driver of EG through its impacts on factor productivity, technological

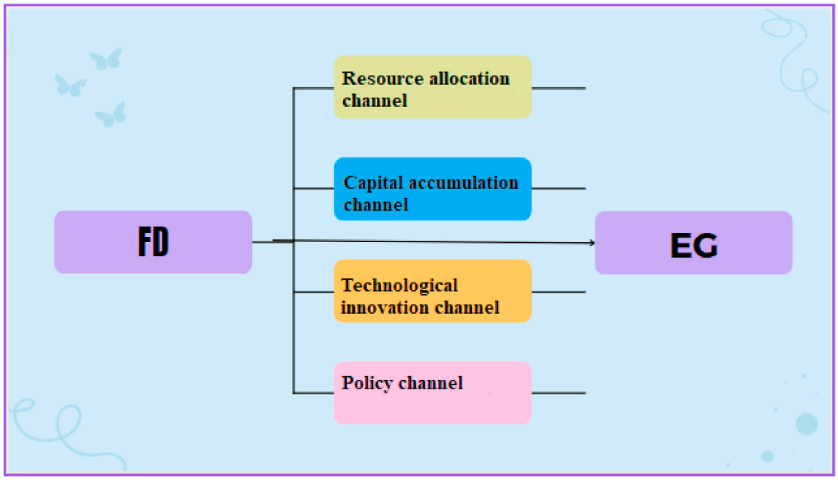


Fig. 1. Theoretical channels of interaction between FD and EG.

progress, and overcoming diminishing marginal returns. Policies that encourage capital investment and efficiency are thus important for sustaining growth [1].

A well-developed financial system can promote economic growth through several key mechanisms. First, by offering a wide array of attractive savings products and services, a robust financial system encourages higher savings rates in the economy. Greater pool of savings then provides funding for productive investments that expand the capital stock and increase productive capacity.

Second, an efficient financial system matches savings to the most promising investment opportunities, ensuring capital is allocated to its most productive uses that yield the highest returns. Superior information processing and risk management by financial institutions improves resource allocation.

Third, diverse financial instruments and markets allow improved risk sharing and diversification. This results in increased risk-taking behavior and entrepreneurship, further stimulating productive investment and innovation.

Fourth, well-functioning financial markets provide price signals that coordinate decentralized economic decisions and incentivize long-term investments. This mobilizes capital for projects with positive net present values.

Fifth, financial institutions and markets reduce information, transaction and agency costs, facilitating business activities and economic transactions. This expands economic output and productivity.

Therefore, through encouraging savings, enabling efficient capital allocation, facilitating risk management, providing price signals, and reducing transaction costs, a well-developed financial system can stimulate investment and accelerate economic growth [26].

As depicted in Fig. 1, the main channels linking FD and EG can be summarized as follows:

- **Resource allocation channel:** FD can improve resource allocation efficiency by reducing information asymmetry, transaction costs, and agency problems. It can also facilitate risk management, innovation, and diversification. This enhances investment project productivity and profitability, increasing EG Ref. [23].
- **Capital accumulation channel:** FD can raise the capital accumulation rate by mobilizing savings, lowering borrowing costs, and expanding credit access. This stimulates investment in physical and human capital, boosting EG Ref. [24].
- **Technological innovation channel:** FD can foster technological innovation by providing R&D funding and incentives, enabling knowledge spillovers, and facilitating creative destruction. This increases total factor productivity levels and growth, raising EG Ref. [25].
- **Policy channel:** FD can influence EG through its impact on macroeconomic policies and institutions. For instance, FD can enhance monetary policy effectiveness and promote fiscal discipline. Moreover, it can strengthen legal systems, governance, and regulation by improving transparency, accountability, and enforcement [27].

Several theories explain the FD-EG relationship. The supply-leading theory suggests FD spurs EG by mobilizing savings, efficiently allocating resources, diversifying risks and facilitating transactions and innovation [28,29]. The demand-following theory argues EG stimulates demand for financial services, leading to FD [30]. The feedback effect theory posits FD and EG mutually reinforce each other in a virtuous cycle [31]. The neutrality theory argues FD and EG are independent with no causal relationship [32].

As depicted in Fig. 2, our theoretical framework combines these theories and identifies the main FD-EG interaction channels. First, greater financial service access, more active and liquid markets, and more efficient institutions can mobilize more savings and allocate more resources to productive investments, boosting EG. Second, higher incomes and a larger middle class increase demand for financial services, spurring financial innovation and broadening access. Third, lower risk and uncertainty encourages savings/investment and using financial instruments to hedge risk, creating a virtuous cycle between financial deepening and economic prosperity.

However, the FD-EG nexus may exhibit threshold effects and asymmetries. Excessive finance can potentially harm growth by

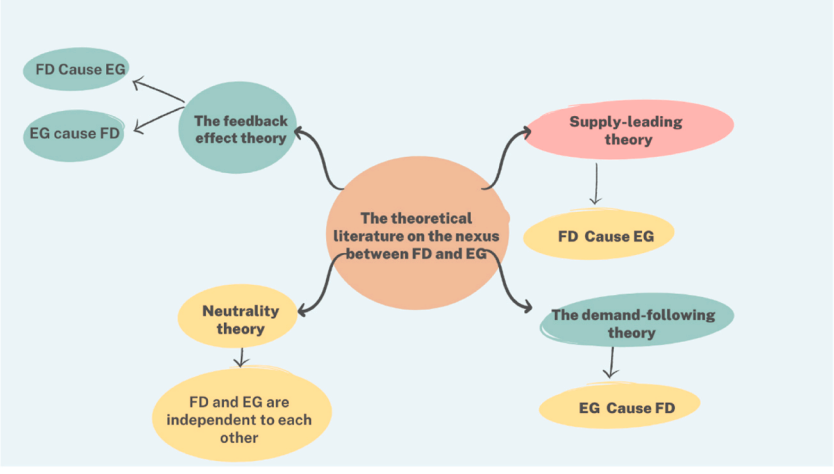


Fig. 2. Theoretical framework of finance-growth nexus.

misallocating resources, creating asset bubbles and instability. Positive and negative FD changes may also have differential EG effects. Furthermore, the nexus depends on country-specific conditions related to institutions, human capital, openness, and macroeconomic stability.

Our framework posits a mutually reinforcing yet complex, nonlinear FD-EG relationship contingent on various mediating factors. By examining this relationship in Syria using advanced nonlinear models, we aim to gain novel insights into the intricacies of finance-growth interactions, especially in a developing country facing political and economic shocks.

[33]categorized the main strands of literature on the finance-growth nexus into four key areas:

1. Banking sector development and economic growth (EG) nexus
2. Stock market development and EG nexus
3. Bond market development and EG nexus
4. Insurance market development and EG nexus

[33]highlighted four main hypotheses proposed regarding the causal finance-growth relationship:

1. Supply-leading hypothesis (SLH): Unidirectional causality from financial development (FD) to EG.
2. Demand-following hypothesis (DFH): Unidirectional causality from EG to FD.
3. Feedback hypothesis (FBH): Bidirectional causality between FD and EG.
4. Neutrality hypothesis (NEH): No causality between FD and EG.

The study found cointegration between banking sector development, stock market development, bond market development, insurance market development and EG for a panel of ASEAN countries over 1991–2011. The results supported the supply-leading, demand-following and feedback hypotheses depending on the financial sector [33]. concluded that developing the banking sector, stock market, bond market and insurance market contributes to long-run EG. The short-run causal relationships exhibited greater variation. As discussed by Ref. [34], the insurance sector can influence EG through various channels:

1. Promoting financial stability and reducing volatility
2. Providing an alternative to government programs
3. Facilitating trade and commerce
4. Mobilizing savings
5. Enabling more efficient risk management
6. Encouraging loss mitigation
7. Improving capital allocation efficiency

An active insurance sector may also help develop the banking sector and stock markets. Similarly, higher EG can increase demand for insurance services.

Our framework incorporates the potential bidirectional relationship between insurance sector development and EG outlined by Ref. [34]. We posit that greater insurance access and depth can stabilize the economy, mobilize savings, facilitate risk-taking and trade, improving resource allocation and capital accumulation. However, excessive or unregulated insurance may also create moral hazard. Meanwhile, higher growth and incomes can increase insurance uptake.

As discussed by Ref. [35], stock market development can influence EG through various channels:

1. Improving capital allocation efficiency
2. Mobilizing and pooling savings

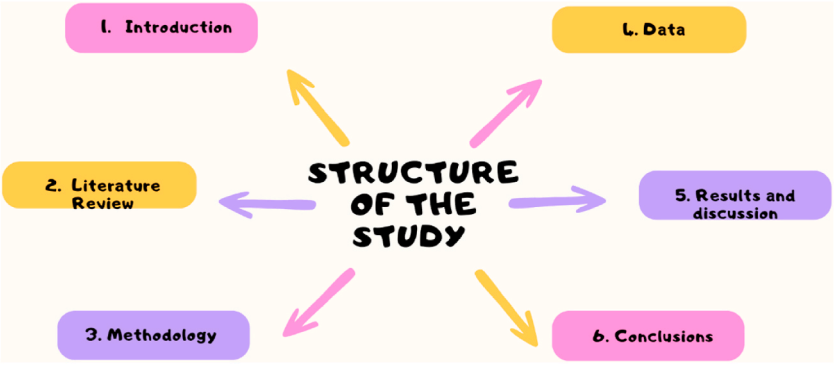


Fig. 3. Flow chart of article structure.

3. Providing financing for productive investments
4. Facilitating risk diversification
5. Enabling price discovery

More liquid and active stock markets can also enhance the transmission of monetary policy. Meanwhile, higher EG generates greater demand for equities and other securities.

Our framework incorporates the potential bidirectional relationship between stock market development and EG outlined by Ref. [35]. We posit that more advanced stock markets can mobilize savings, improve resource allocation, and provide growth capital, boosting productivity and output. However, excessive speculation may create volatility and misallocation. Meanwhile, rising incomes increase demand for equities and other securities.

The article structure is shown in Fig. 3.

2. Literature review

The literature on the FD-EG nexus exhibits heterogeneous findings. Some studies have found a positive association while others detected no association or even a negative one. This section summarizes the salient findings.

2.1. Studies finding a positive relationship

Utilizing linear econometric techniques [36], revealed inflation, EG, exchange rate, and trade openness jointly affect FD in Egypt. Employing UECM and ARDL bounds testing [16], found a positive, statistically significant linear FD impact on Syria's EG Ref. [37]. showed no FD threshold beyond which EG is negatively affected [38]. found positive FD effects on developing country EG Ref. [39]. found a linear finance-growth nexus when accounting for nonlinearity between initial per capita income, human capital, and EG Ref. [40]. found a positive but varying FD impact on growth using different indicators, estimation methods, data frequencies, and functional forms [23]. argued that most logic and evidence support a direct, positive FD-EG linkage [41]. found financial intermediation positively influences EG Ref. [42]. found a positive degree of FD influence on EG, although negative when using Latin American panel data.

2.2. Studies finding a negative relationship

Some studies find the FD effect on EG remains unclear [43]. suggested FD negatively affects EG in developed countries [44]. proposed a negative FD effect on China's EG.

2.3. Studies finding a nonlinear relationship

Different studies have applied the NARDL model to examine asymmetric FD and other factor effects on EG Ref. [5]. found asymmetric FD and remittance impacts on EG, with growth increasing during positive shocks but slowing during negative ones [6]. analyzed asymmetric China finance indicator effects using NARDL, showing capital and money markets differently affect short and long-run EG Ref. [7]. revealed nonlinear FD-EG relationships in African economies [8]. showed Chinese rural EG is contributed to by internet finance and rural finance [9]. proposed a "too much finance effect" while [13] suggested a nonlinear FD-EG relationship.

2.4. Studies suggesting growth leads to financial development

[36] showed Egyptian FD is jointly influenced by inflation, EG, exchange rate, and trade openness [45,46]. and others supported the demand-following hypothesis whereby EG leads to FD.

2.5. Studies suggesting financial development leads to growth

Supporting Patrick's supply-leading hypothesis [47], examples include [16]: found FD leads to Syrian EG Ref. [48]. found FD causes linear EG in top remittance-receiving economies. Zhang et al. (2012) [49] found positive China FD-EG links [50]. used multi-economy data over 1975–2011 and typically found larger finance impacts on developed economy growth. Other positive FD-EG studies include [26,51,52].

[53] examined the causal relationships between insurance market development, FD, and EG for 34 OECD countries over 1988–2012.

The study tested insurance market development using six measures: life insurance density, non-life insurance density, total insurance density, life insurance penetration, non-life insurance penetration, and total insurance penetration. The study concluded that insurance market development specifically, and FD overall, are significant drivers of long-run EG in OECD countries.

2.6. Studies finding a bidirectional relationship

To account for potential endogeneity between financial development (FD) and economic growth (EG) [26], employed three-stage

least squares methodology to analyze data for Ghana over the 1971–2018 period.

By applying this technique, they detected feedback effects between FD and EG in Ghana. Their findings provide empirical evidence supporting both the supply-leading and demand-following hypotheses regarding the finance-growth nexus.

Specifically, the results indicate bi-directional causality, with FD fostering EG in line with the supply-leading hypothesis. Meanwhile, EG also spurs demand for financial services, consistent with the demand-following hypothesis.

Therefore, by addressing endogeneity concerns through appropriate econometric modeling, this study on Ghana enriches understanding of the nuanced and interdependent bidirectional relationship between financial sector development and economic growth.

The evidence on feedback effects highlights the need for policy approaches that simultaneously strengthen financial systems and promote productive investment and growth.

Using dynamic common correlated estimation and panel Granger causality tests on 1980–2020 emerging market data [54], challenged previous static panel study conclusions and confirmed positive, linear FD effects on EG along with strong bidirectional Granger causality between them across all FD proxies.

[55] examined the causal relationships between inflation (INFLR), EG (PCGDP), and stock market development for 34 OECD countries over 1960–2012. Three indicators of stock market development were used: market capitalization (MARCC), turnover ratio (TURNR), and value of traded stocks (TRADS). The results supported the FBH, finding bidirectional causality between stock market development and EG in the short-run.

2.7. Studies finding No relationship

Some studies found no FD-EG relationship evidence, implying neither hypothesis validity. For instance, using a frequency-domain spectral causality method [56], analyzed 47 African countries over 1980–2016 and found strong neutrality hypothesis evidence that FD and EG do not influence each other at most time levels.

2.8. Studies on Syria

As mentioned earlier, studies on the Syria FD-EG nexus are scarce, especially using nonlinear modeling approaches. To our knowledge, only two time series studies have examined this nexus using linear models [16,17]. For panel data, only two studies have examined this nexus using linear models [18,19]. Therefore, this study aims to address these limitations by employing nonlinear techniques to analyze the dynamic, asymmetric FD-EG relationship in Syria over 1980–2018, specifically through artificial neural network VAR and NARDL models. Contributions include using a more comprehensive FD measure based on multiple dimensions and examining how determinants like government spending, exchange rates and institutions affect the finance-growth nexus in Syria. By gaining deeper understanding, more relevant policy recommendations and insights can be provided for Syria and other developing countries facing economic and political volatility.

In summary, extensive research exists on the finance-growth nexus but the relationship remains controversial and complex. Recent studies highlight the need to examine asymmetries, nonlinearities and threshold effects using nonlinear models, especially in developing contexts, to which this study aims to contribute by analyzing the finance-growth nexus in Syria.

3. Methodology

Annual 1980–2018 Syrian time series data is used to examine the FD-EG relationship. Eviews 12 and RStudio are utilized for analysis including unit root testing with structural break, followed by nonlinear causality testing to determine relationship linearity and directionality. After establishing one-way nonlinear causality from FD to EG, cointegration is tested using the Nonlinear Autoregressive Distributed Lag (NARDL) model to examine FD and control variable impacts on Syrian EG. An unrestricted error correction model (UECM) also analyzes the short-run dynamics. Neural Network (NN) is a flexible and powerful technique that can capture the non-linear relationship between FD and EG without imposing any prior functional form or distributional assumptions. Machine learning techniques like neural networks can detect complex hidden nonlinear patterns that economic modeling cannot.

NARDL is a novel technique that can account for the asymmetric effects of FD on EG in different regimes of economic activity.

Justification for Using Multiple Nonlinear Techniques.

- Expand on the limitations of individual techniques to justify a multi-pronged approach:

1. NARDL models can estimate asymmetric effects but assume a linear functional form. Nonlinearity tests indicate this may be inaccurate.
2. Nonlinear causality tests have lower power in small samples. A combination of tests can validate results.
3. Machine learning methods like neural networks have challenges with interpretability. Using them alongside econometric models provides explanatory power.
4. Each technique has strengths and weaknesses. Using multiple complementary methods provides rigor and addresses limitations.

- Note how applying an array of nonlinear data-driven and econometric techniques provides deeper, more robust insights on the complex finance-growth nexus.

Advantages of this methodology include using unit root tests accounting for structural breaks, given Syria's turmoil, along with nonlinear causality and cointegration tests to capture the asymmetric, complex FD-EG relationship. Relevant control variables are also

included to minimize omitted variable bias. The methodology accounts for the nonlinear, asymmetric FD-EG relationship and FD's multidimensional nature requiring diverse indicators. Nonlinear causality and cointegration tests capture potential asymmetries and nonlinearities. Additionally, the IMF FD indicator reflecting financial system depth, efficiency and access is used [57].

3.1. Unit root tests

Unit roots in the time series were tested by applying tests with an endogenous structural break [58]. [59] developed a unit root test accounting for structural breaks like the ZA test. The Perron-Vogelsang (PV) test is based on the model:

$$y_t = c + \Phi 1 yt-1 + \Phi 2 yt-2 + + \Phi p yt-p + \sum i = 1r\ \gamma i Di,t + \varepsilon t$$

where y_t is the timeseries at time t, c is a constant term, Φ1, Φ2, …, Φp are lagged time series values, Di,t is a dummy variable that takes the value of 1 if the time series has a structural break at time i, γi is the coefficient associated with the dummy variable, and ϵt is the error term. If the null hypothesis of a unit root is true, then the coefficient Φ1 should be significantly different from zero.

To perform the PV test, the values of p (number of lagged time series values included) and r (number of structural breaks) need to be specified. The model parameters are then estimated using least squares regression and the coefficients are used to test the null hypothesis of a unit root. Rejection implies the series is stationary without a unit root.

3.2. Nonlinear granger causality test and neural network VAR model

[60] created the NlinTS R package for nonlinear time series analysis and causality detection using feedforward neural networks, which extend Granger testing and handle nonlinear dependencies between series. It also implements transfer entropy using the Kraskov approximation. Additionally, NlinTS provides VARNN models along with discrete/continuous entropy and mutual information. It employs two multilayer perceptron networks, with the second incorporating both time series, to assess causality strength using the Granger causality index and F-test. This statistical framework explores causal relationships in nonlinear systems.

3.3. Cointegration analysis using NARDL model

The NARDL model statistically analyzes the long-run variable relationship [61]. First, the Wald test examines cointegration by testing the null hypothesis of no cointegration against the alternative of cointegration. Rejection implies cointegration. Appropriate variable lags are determined via Akaike, Schwarz or Hannan-Quinn information criterion tests. The long-run relationship is then estimated using the cointegrating model. Here, a NARDL (1, 1, 0, 1, 1) model was optimal based on Akaike Information Criterion (AIC), with a maximum lag order of "2″ for the annual data.

3.4. Stability and diagnostic tests

Diagnostic and stability coefficient tests are conducted to ensure correct model specification for forecasting.

3.5. Robustness check with cumulative dynamic multiplier

The NARDL model uses the cumulative dynamic multiplier (CDM) to assess the explanatory variable change impact on the dependent variable over time [61]. The CDM can be positive or negative based on a positive/negative change and also capture asymmetric effects. For instance, if a positive X change has a larger Y impact than a negative change of the same size, the CDM will be bigger for positive than negative adjustments. The CDM is computed by summing the NARDL model lagged term coefficients for X.

Table 1
Variables and data sources.

Variables	Data-source
FD: measured by The FD Index (FD)	The FD database issued by the International Monetary Fund. (IMF FD Database)
The exchange rate (XR): measured by the logarithm of real exchange rate	Penn World Table version 10.0 Database
Total Government Expenditure: Measured by the logarithm of final total government spending at current prices	(WDI) database, Central Bank-of-Syria and the-Central-Bureau-of-Statistics
EG represented by logarithm of GDPPerCapita_at current prices	(WDI) database, Central-Bank-of Syria and the-Central Bureau of-Statistics
Dummy Variable: The legal system is measured using a dummy variable D, which has been used in several studies, including [62]. It is a control variable	Researcher calculations based on Perron & Vogelsang Unit Root with Break Test

Source: Prepared by the researcher

4. Data

The secondary data was obtained from the World Bank World Development Indicators, IMF Financial Development database, Penn World Table version 10.0, the Central Bank of Syria, the Central Bureau of Statistics, and researcher calculations. The variables and data sources are presented in Table 1.

5. Empirical results and analysis

5.1. Linearity analysis of GDP per capita and financial development

The GDP Per Capita and FD descriptive statistics are presented in Table 2.

The variables are non-normal based on the Jarque-Bera (J-B) test. Table 2 also provides skewness and kurtosis information.

Table 3 shows the linear trend test results for FD and GDP Per Capita, including R-squared, F-test, degrees of freedom (Df), constant, and beta coefficients (β).

Visualization for power linear trend in the variables is shown in Fig. 4.

Fig. 4 visually represents the linear trends, which do not fit most of the data.

5.2. Artificial neural network VAR model verifying nonlinear relationship

The VARNN model uses previous values of multiple variables as inputs to a neural network to forecast a target variable. Advantages include flexibility, integration of new data without assumptions, handling multivariate time series without variable relationship restrictions, and capturing nonlinearities and interactions via neural networks.

Artificial neural network VAR model is shown in Fig. 5.

Fig. 5 shows the artificial neural network VAR model output after training, predicting the production variable based on the inputs. This proves a nonlinear link between the two variables.

5.3. Nonlinear causality analysis

The nonlinear Granger causality test in the NlinTS package uses two MLP networks, with the second incorporating both time series, to examine causal relationship strength using the Granger causality index and F-test.

Table 4 shows the nonlinear Granger causality test results, indicating a nonlinear causality from FD to EG.

5.4. Unit root tests

Ignoring structural breaks in time series could lead to false outcomes [63]. Hence, the Perron-Vogelsang test for unit root with structural break is used. Table 5 shows the results:

5.5. NARDL model estimation

The NARDL model statistically analyzes the long-run variable relationship [61]. Cointegration is first tested using the Wald test, testing no cointegration against the alternative of cointegration. Rejection means cointegration exists. Appropriate lags are determined via information criterion tests. The long-run relationship is then estimated using the cointegrating model. Here, a NARDL (1, 1, 0, 1, 1) model was optimal based on the Akaike Information Criterion (AIC), with a maximum lag order of "2″ for the annual data.

Table 6 presents the long-term F Bounds test and T Bounds test.

Table 7 presents the NARDL (1, 1, 0, 1, 1) long-run levels equation estimation.

The empirical analysis reveals that all independent variables, except for negative FD (FD_NEG) shocks, significantly influence EG in the long run at the 5% level.

Specifically, positive FD shocks exhibit a positive impact on long-run EG. A 1% increase in positive FD shocks is estimated to raise long-run EG by 8.54%, holding other factors constant. This indicates financial deepening supports Syria's long-term growth prospects.

On the other hand, negative FD shocks have a statistically insignificant negative effect on long-run EG. This implies adverse financial fluctuations do not meaningfully hamper Syria's growth in the long run.

Additionally, government spending and exchange rates have statistically significant positive effects on long-run EG at the 1%

Table 2
Descriptive-statistics-for (GDP per capita –FD).

Variables	Normality J-B (Prob)	Skewness	Kurtosis
GDP Per Capita	No	−1.577	6.32
FD	No	0.194	4.814

Source: Prepared by the researcher using Eviews 12

Table 3
Power linear trend in variables.

Variables	R-Square	F	Df1	Df2	constant	β
FD	0.124	5.239	1	37	−0.410	000
GDP	0.118	4.932	1	37	526.8	−0.263

Source: Prepared by the researcher using Eviews 12

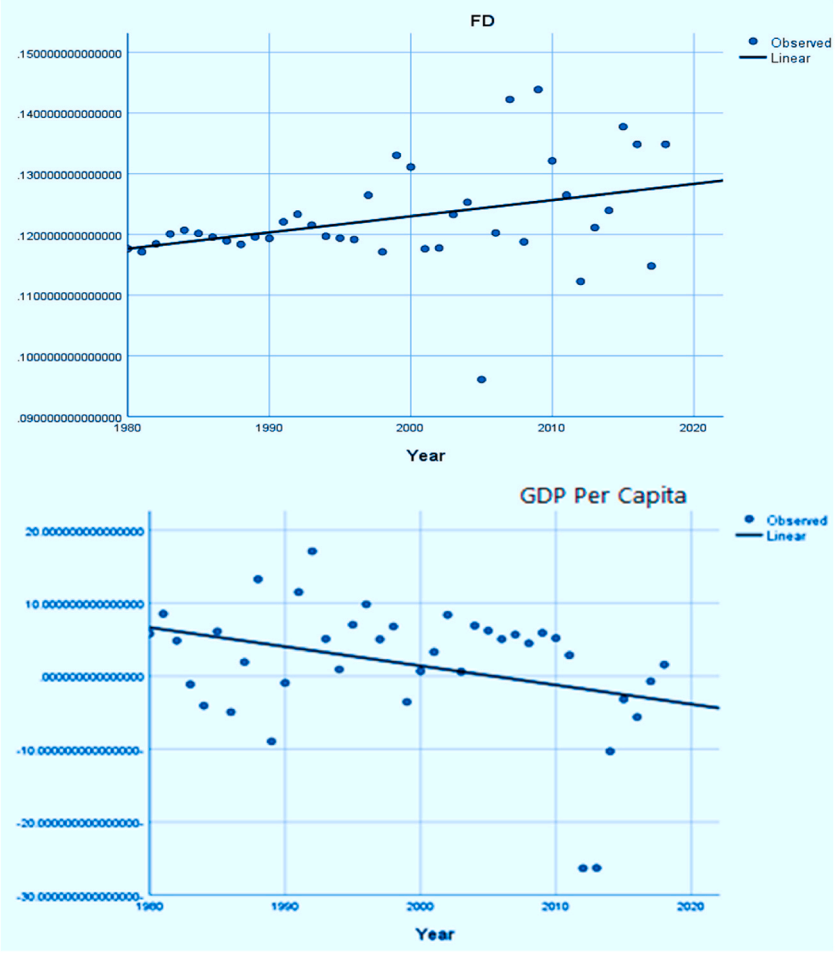


Fig. 4. Visualization for power linear trend in the variables.

significance level.

A 1% rise in government expenditures is found to increase long-run EG by 0.52%, ceteris paribus. This suggests higher fiscal spending on productive investments may facilitate Syria's growth performance.

The findings provide important long-run EG factor insights. Increased government spending can develop infrastructure and stimulate private investment, aligning with Keynesian perspectives. Private investment is also positively influenced by government spending, particularly in low-income countries [64]. Furthermore [65], found a positive long-run exchange rate effect on Malaysia's 1971–2009 EG.

5.6. Short-run relationship estimation

After verifying cointegration, the NARDL model short-run relationship is estimated using the unrestricted error correction model (UECM) in Table 8. The UECM approach utilizes bounds testing but does not restrict the short-run relationship, incorporating both long-run/short-run information through the error correction term and lagged differences [66]. It differs from the traditional ECM, which only considers the long run. The NARDL general equation is linearly transformed to obtain the short-run relationship.

Table 8 presents the NARDL unconditional error correction regression results.

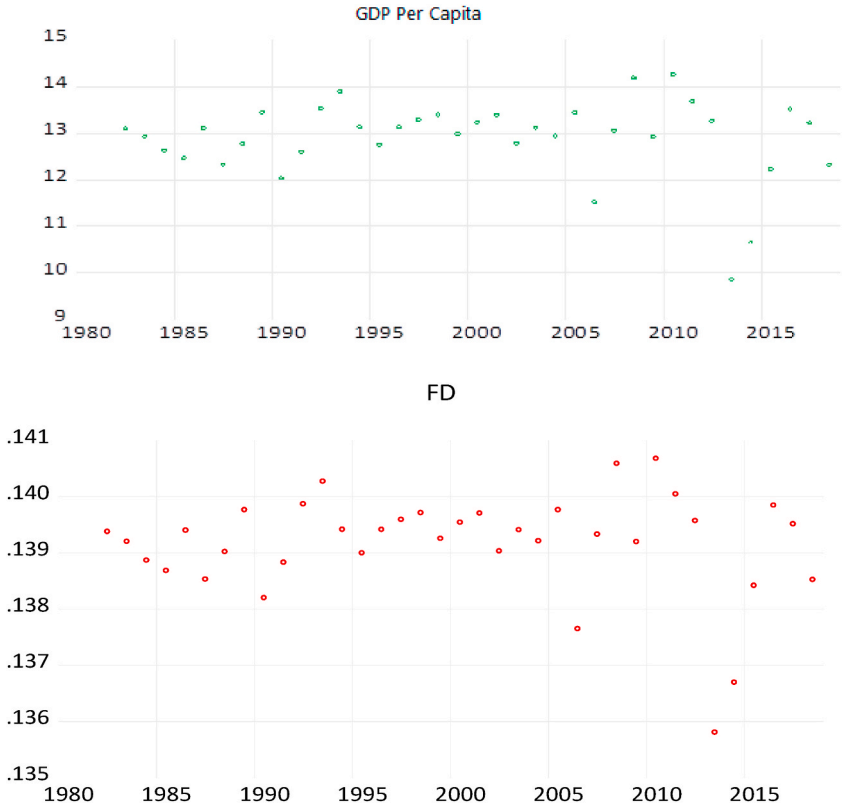


Fig. 5. Artificial neural network VAR model predicting nonlinear relationship.

Table 4
Nonlinear granger causality test.

Methods: Nonlinear Granger Causality					
Pair of variables	**Hypothesis**	**F-Test**	**GCI**	**Lag**	**Layers**
FD and GDP per Capita	FD does not cause EG	9.286***	0.494	1	2,2
	EG does not cause FD	−3.015	0	1	2,2

Source: the researcher findings based on R Studio (NlinTS package)

The estimation was performed using Eviews 12 software by the researcher.

The error-correction coefficient is significant at 1% and negative, indicating cointegration long-run relationship existence between the independent and dependent variables. The EG variable adjustment speed to its long-run equilibrium is estimated as 1.34 years, with an imbalance rate of around −0.745 each period. Negative FD and exchange rate shocks do not significantly impact short-run EG. However, a 1% government expenditure increase raises short-run EG by 0.74%, ceteris paribus. Moreover, the legal regulation dummy has a positive, significant short-run EG effect. Importantly, the long-run relationship is not spurious.

The NARDL results confirm the nonlinear Granger test findings in both the short and long term, supporting the hypothesis that FD plays a leading EG role as suggested by Ref. [47]. This shows FD leads to and generates more EG, aligning with the idea that "more financing leads to more growth" [67]. FD is a necessary, prerequisite EG condition, consistent with the "finance-led growth" theory. These results agree with previous studies [16,18,52] that found evidence for the supply-leading hypothesis whereby financial system development drives EG.

5.7. Diagnostic tests

Table 9 presents diagnostic tests for the NARDL model residuals to assess normality, serial correlation, heteroscedasticity, and omitted variable bias.

The Jarque-Bera test p-value of 0.73 indicates normally distributed residuals [68]. The Breusch-Godfrey p-value of 0.66 implies no serial correlation [69]. The ARCH test p-value of 0.42 indicates no heteroscedasticity [70]. The Ramsey RESET p-value of 0.42 implies no omitted variable bias [71]. After NARDL error correction equation estimation, CUSUM and CUSUMSQ tests assessed structural stability of the short and long-term parameters [72].

Table 5
Results of Perron & Vogelsang test (break selection min DF t-statistic).

Variables	Level						
	AO	**C**	**break**	**IO**	**C, T**	**break**	**result**
XR		−4.06 (3)	2006		−6.95 (3) ***	2015	Non- stationary
FD		−11.4 (9) ***	1997		−7.22 (0) ***	2005	stationary
Total Government Expenditure		−1.35 (0)	1989		−4.1 (0)	1985	Non- stationary
GDP per Capita		−1.29 (0)	1989		−3.74 (2)	2017	Non- stationary
First Differences							
Variables	**AO**	**C**	**break**	**IO**	**C, T**	**break**	**result**
Δ(XR)		−6.97 (9) ***	2006		−4.78 (5) *	2015	stationary
Δ (FD)		−11.2 (0) ***	2007		−10.91 (0) ***	2007	stationary
Δ (Total Government Expenditure)		−7.82 (0) ***	1990		−11.02 (8) ***	2006	stationary
Δ (GDP per Capita)		−9.26 (0) ***	1990		−9.5 (0) ***	1990	stationary

Notes.
1. ***, **, * indicate significance at the 1%,5%,and 10%level, respectively.
2. The numbers in parentheses for the ADF statistics show the lag length of the dependent variables used to obtain white noise residuals.
3. The lag length was chosen by Schwarz information criterion.
4. AO (Additive Outlier), IO (Innovation Outlier).
The test shows no I (2) stationarity. The dependent variable (GDP per capita) is I(1) stationary with a 1990 structural break. The independent variables exhibit I(0) and I(1) stationarity, meeting NARDL model requirements.
Source: the researcher findings based on Eviews 12

Table 6
Long-term F bounds test and T bounds test.

Null Hypothesis: No levels-relationship				F-Bounds Test
I (1)	I (0)	Signif.	Value	Test Statistic
	Finite Sample: n = 35			
3.89	2.69	10%	8.48	**F-statistic**
4.63	3.27	5%	4	**k**
6.36	4.59	1%		
37				**Actual Sample Size**
Null Hypothesis: No levels-relationship			**t-Bounds Test**	
I(1)	**I(0)**	**Signif.**	**Value**	**Test Statistic**
−3.66	−2.57	10%	−5.59	**t-statistic**
−3.99	−2.86	5%		
−4.26	−3.13	2.5%		
−4.6	−3.43	1%		

The results were obtained using Eviews 12 software.
The F-Bounds Test value of 8.48 indicates a long-term relationship between the independent and dependent variables at the 1% significance level. The T-Bounds Test value of −5.59 indicates a long-term relationship between the dependent variable and its lagged value at the 1% significance level.

Table 7
NARDL model long-run levels equation estimation.

Levels Equation				
Case 3: Unrestricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Total government Expenditure	0.52	0.07	6.92	0.00***
FD_POS	8.54	3.50	2.43	0.02**
FD_NEG	5.57	4.23	1.31	0.1995
XR	0.23	0.04	4.97	0.00***

Note: ***, ** representing significance at 1% and 5%, respectively.Prepared by the researcher using Eviews 12.

CUSUM and CUSUM-SQ tests are shown in Fig. 6.

Fig. 6 shows the tests remained within critical lines at 5% significance, indicating coefficient stability over time, except for brief 2006–2011 CUSUM-SQ instability corresponding to economic shocks in Syria. Overall, the model exhibits no econometric issues, making it suitable for further analysis.

Table 8
NARDL unconditional error correction regression.

NARDL Unconditional Error Correction Regression				
Case 3: Unrestricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	−2.98	0.42	−6.95	0.00***
Δ (Total government Expenditure)	0.74	0.06	11.1	0.00***
Δ (FD_NEG)	−1.13	2.01	−0.56	0.57
Δ (XR)	−0.06	0.07	−0.86	0.39
Dummy	0.14	0.04	3.32	0.00***
CointEq(-1)*	−0.745	0.10	−6.98	0.00***

Note: ***, ** representing significance at 1% and 5%, respectively.

Table 9
NARDL model diagnostic tests.

Normality test (Jarque-Bera)	X^2	0.62	Prob.	0.73
Breusch-Godfrey Serial Correlation (LM test)	**F-statistic**	0.41	**Prob. F(2,25)**	0.66
	Obs*R-squared	1.19	**Prob.ChiSquare(2)**	0.54
ARCH (heteroskedasticity test)	**F-statistic**	0.88	**Prob. F(2,32)**	0.42
	Obs*R-squared	1.82	**Prob.ChiSquare(2)**	0.40
Ramsey RESET test	**F-statistic**	0.65	**Probability**	0.42
	t-statistic	0.80	**Probability**	0.42

Prepared by the researcher using Eviews 12 software.

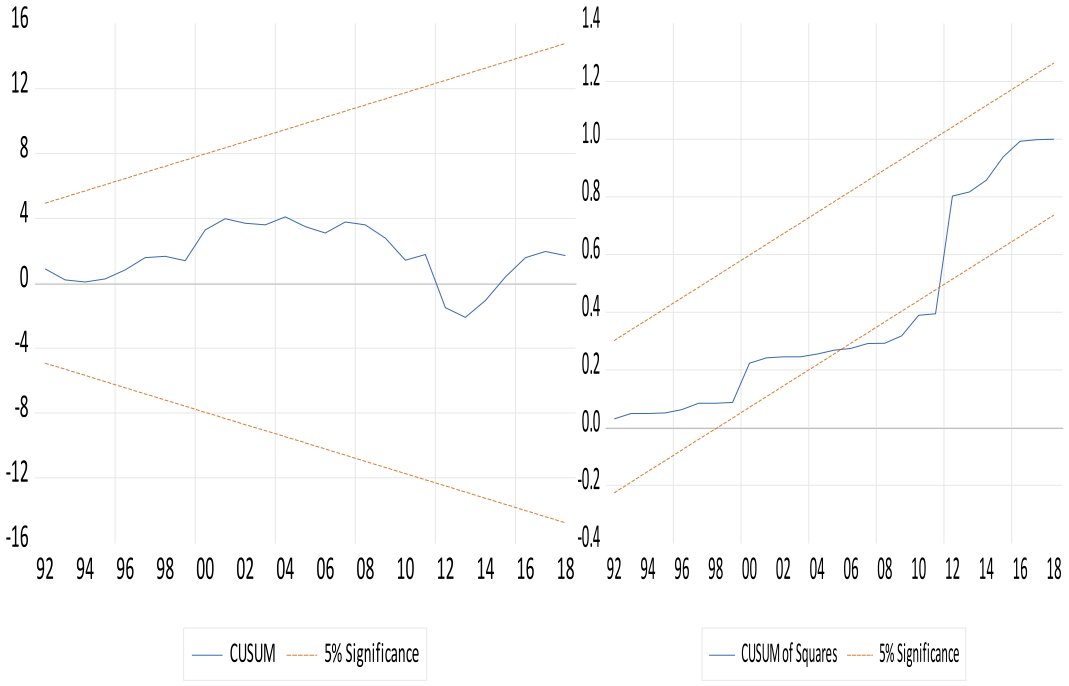


Fig. 6. CUSUM and CUSUM-SQ tests. Source: Authors' computations.

5.8. Robustness check with cumulative dynamic multiplier

Fig. 7 illustrates the NARDL model FD variable cumulative dynamic multipliers, measuring the EG impact of a one-unit FD+ and FD-shock over 15 years. Examining the adjustment path and imbalance duration after a positive/negative shock provides asymmetry pattern insights. The multipliers were estimated using the optimal NARDL model per the Akaike criterion.

Fig. 7 shows the positive FD changes with the top thick solid line and negative changes with the bottom thick dashed line. The middle thick dotted red line represents the asymmetry line, the difference between positive and negative shock multiplier effects on EG

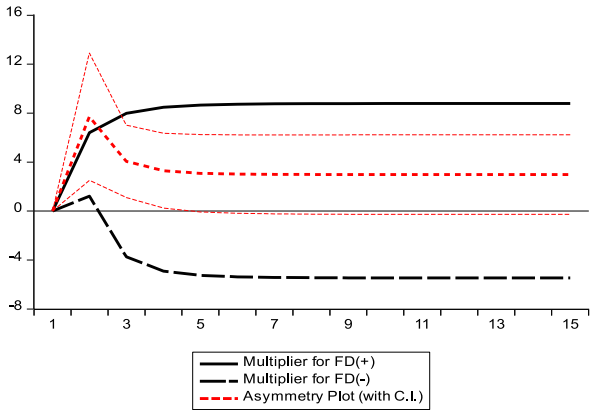


Fig. 7. The cumulative dynamic multipliers.

over 15 years. The upper and lower thin dashed red lines indicate the 95% confidence level providing statistical significance for asymmetry. If the zero line is between the intervals, asymmetry is insignificant at 5%.

The chart confirms stronger positive than negative FD shock impacts on EG throughout the period in both the short and long term, lying above zero. The positive shock impact is positive throughout, while the negative impact is initially positive but turns negative from year three onwards until the period end. The imbalance corrects in around four years. Therefore, the figure indicates short and long-term asymmetry in the FD impact on EG, with EG responding more to positive than negative FD shocks. This agrees with findings of nonlinear FD-EG relationships [9,13].

According to Ref. [61], "the dynamic multiplier can still capture asymmetry in the adjustment path even if no short-term asymmetry evidence is found, since the path is determined by long-term parameters, error correction coefficients and model dynamics". There is clear asymmetry in the Syria FD-EG impact.

[73] found a development-varying causal FD-EG relationship, with FD leading EG in developing countries while EG drives FD in developed ones [74]. confirmed these results. As the IMF FD Index measures Syria's financial system development, understanding the FD-EG relationship is essential for assessing FD shock impacts on Syria.

[16] analyzed the 1980–2018 Syrian FD-EG impact using dynamic linear models, finding a favorable, statistically significant FD effect on Syria's short and long-term EG. FD was found to be a necessary prerequisite for Syrian EG. Another study by Ref. [18] on six MENA countries including Syria found finance leads to growth, and suggested Syria accelerate financial reforms to stimulate savings and investment for long-term growth. Furthermore [19], found positive, significant FD impacts on MENA country growth by stimulating savings and optimizing resource allocation.

Recent evidence indicates the relationship between (FD) and (EG) is complex and depends on country-specific conditions.

A US study found a bilateral FD-EG relationship, with significant negative FD and insignificant positive EG effects [75]. Another study on emerging economies found considerable FD impacts on EG Ref. [76].

[77] examined the impact of environmental regulations and FD on carbon emissions in BRICS countries from 1995 to 2016 using the common correlated effect means group approach. They found FD increases emissions, while regulations also perversely raise emissions, highlighting the unintended consequences of policy measures. This underscores the need for nuanced, evidence-based policies tailored to country contexts.

Similarly [78], analyzed the nexus between FD, EG, energy innovation and environmental quality in OECD countries over 1990–2017 using the Pooled Mean Group ARDL method. Their results showed FD promotes energy innovation and improves environment, and globalization relates to innovation and lower emissions. This again indicates country-specific heterogeneity in the multifaceted finance-environment-growth relationship.

While no specific nonlinear Syria study exists yet, insights from this cross-country evidence suggest the need for a nuanced approach in evaluating the asymmetric effects of positive/negative FD shocks on Syrian EG, though the relationship may depend on factors like trade openness, inflation, capital formation, and debt servicing [79].

The differential economy-wide responses to each shock type imply policies should recognize this asymmetry. Furthermore, the nonlinear causal association indicates complexity necessitating tailored interventions that account for nonlinear dynamics.

Overall, these studies underscore the need for evidence-based, customized policymaking that promotes Syria's EG and stability through appropriate financial sector development while considering associated environmental impacts. A long-term, adaptive approach is prudent given the complex; asymmetric nature of finance-environment-growth interactions revealed across countries facing varied challenges. Further Syria-specific research can provide additional insights to support its economic reconstruction and environmental sustainability.

The finding of asymmetric positive/negative FD shock EG impacts in Syria is significant, implying differential Syrian economy responses to both shock types that policymakers should consider in economic planning and strategies. Additionally, the nonlinear causal FD-EG relationship highlights this nexus' complexity in Syria, necessitating nuanced policy approaches accounting for nonlinearities.

Overall, the findings underscore informed Syrian policymaking to promote EG and stability by recognizing the asymmetric impacts and nonlinear finance-growth relationship.

6. Conclusions

This study analyzed the intricate 1980–2018 Syrian FD-EG nexus using advanced nonlinear models like neural network VAR, nonlinear causality tests and NARDL models to capture dynamics and causality. It also examined the asymmetric long and short-run impacts of FD and other variables on Syria's EG via NARDL models.

This study significantly enhances scholarly understanding of the nonlinear, asymmetric mechanisms linking financial sector development and EG over time in Syria's turbulent setting. The rigorous empirical approach establishes the value of applying suitable nonlinear models to uncover the inherent complexities and dynamics of economic relationships in developing countries facing volatility. By generating novel evidence and tailored policy perspectives, the research makes multifaceted contributions to knowledge, methodology and practice regarding the nuanced finance-growth nexus and its implications for unstable contexts.

6.1. Key findings

- The advanced nonlinear models used such as neural network VAR and NARDL enabled the capture of intricate dynamics and asymmetries in the Syrian finance-growth nexus that linear models cannot detect. This allowed new insights into this relationship.
- Testing for both short and long-run impacts provided a comprehensive perspective on how FD affects EG over different time horizons.
- Examining the differential effects of positive and negative FD shocks shed light on potential asymmetric effects not explored before.
- Considering the nonlinear impact of FD level on growth provided evidence that higher FD has a disproportionately positive effect.
- Positive FD shocks have stronger, more persistent short and long-term EG effects than negative shocks, indicating asymmetry.
- The FD effect on EG is nonlinear, depending on the FD level, with higher FD having larger positive EG impacts than lower FD.
- Financial system development drives Syria's EG, agreeing with the finance-led growth theory given the positive, significant short and long-run FD effects on EG.
- No evidence was found for a negative or inverted U-shaped FD-EG relationship in Syria. Higher FD levels have larger positive EG impacts, indicating a nonlinear relationship.
- FD has an asymmetric effect on Syria's EG with positive shocks having stronger, more persistent impacts than negative ones.
- Long-run Syrian EG is significantly, positively impacted by FD, government spending, legal systems and exchange rates.

6.2. Policy implications

These results support supply-leading theory while opposing the "too much finance harms growth" view. The study provides implications for Syrian policymakers to create conditions conducive to positive FD shocks and take a long-term perspective regarding FD-EG policies.

- The findings highlight the need for policies tailored to the unique conditions and challenges in Syria rather than a one-size-fits-all approach.
- Fostering positive financial developments may be more impactful than mitigating negative shocks due to asymmetry. Regulators should focus on enabling upside potential.
- Gradual approaches taking a long-term view on financial reform may be prudent given the persistent long-run impacts found.
- Multidimensional policies simultaneously targeting financial, legal, governmental and trade factors may synergistically promote sustainable growth.
- The findings highlight the need to strengthen Syria's institutional quality and governance for finance to positively impact growth. Legal and regulatory reforms should accompany financial liberalization.
- Exchange rate policy also matters for growth - maintaining currency stability and competitiveness should be prioritized.
- Fiscal policy and public spending have a significant growth impact suggesting a balanced, supportive approach is required.
- A policy mix simultaneously targeting financial, legal, governmental and trade factors may effectively promote sustainable growth.

6.3. Limitations

One limitation of this study is the lack of data on other macroeconomic factors, such as institutional quality, human capital, and so on, that may influence the relationship between FD and EG in Syria. Another limitation is the narrow scope of focusing only on Syria. Future research could address these limitations by conducting a cross-country study that incorporates more variables.

6.4. Further research

Future research could explore the specific mechanisms linking Syria's FD and EG, test for nonlinearities in other FD/EG dimensions, compare results to countries with different financial/economic characteristics, or incorporate more recent data capturing conflict and pandemic effects.

The study contributes to the literature on the intricate, causal FD-EG nexus by applying an innovative methodology capturing the nonlinear, asymmetric features of this relationship and providing valuable Syria-specific insights. It also offers recommendations to promote sustainable Syrian EG through FD, such as fostering positive financial sector developments, considering asymmetries in policy design, mitigating impediments to the finance-growth nexus, and adopting a multi-dimensional financial/economic development approach.

In summary, this study makes important contributions regarding the intrinsic complexity and policy implications of the nonlinear finance-growth nexus in Syria, while opening up avenues for further research on this relationship in developing countries facing turbulence. The nuanced modeling and analysis provide valuable insights to support Syria's economic revival and prosperity.

Author contribution statement

Abdullah Mohammad Ghazi Al khatib: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

Data will be made available on request.

Additional information

No additional information is available for this paper.

Funding statement

This research is funded by Damascus University - funder No. 501100020595.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] P.A. Kwakwa, W. Adzawla, H. Alhassan, A. Achaamah, Natural resources and economic growth: does political regime matter for Tunisia? J. Publ. Aff. 22 (2022), e2707 https://doi.org/10.1002/pa.2707.
[2] C. Haibo, E.K. Manu, M. Somuah, Examining Finance-Growth Nexus: Empirical Evidence from the Sub-regional Economies of Africa, vol. 13, SAGE Open, 2023, https://doi.org/10.1177/21582440231153117.
[3] K. Nawaz, A. Lahiani, D. Roubaud, Natural resources as blessings and finance-growth nexus: a bootstrap ARDL approach in an emerging economy, Resour Policy 60 (2019) 277–287, https://doi.org/10.1016/j.resourpol.2019.01.007.
[4] G. Mustafa, The Dynamic Relationship between Financial Development Economic Growth Foreign Direct Investment and Trade Openness: Evidence from South Asian Countries, Millennial Asia, 2023, https://doi.org/10.1177/09763996221138465.
[5] U. Golder, N. Rumaly, M.K. Hossain, M. Nigar, Financial progress inward remittances and economic growth in Bangladesh: is the nexus asymmetric? Heliyon 23 (2023) https://doi.org/10.1016/j.heliyon.2023.e14454.
[6] M.N. Azimi, Assessing the asymmetric effects of capital and money markets on economic growth in China, Heliyon 8 (2022), e08794, https://doi.org/10.1016/j.heliyon.2022.e08794.
[7] L.T. Zungu, Nonlinear dynamics of the financial–growth nexus in African Emerging Economies: the case of a macroprudential policy regime, Economies 10 (2022) 90, https://doi.org/10.3390/economies10040090.
[8] B. Mei, A.A. Khan, S.U. Khan, M.A.S. Ali, J. Luo, Complementarity or substitution: a study of the impacts of internet finance and rural financial development on agricultural economic growth, Agriculture 12 (2022) 1786, https://doi.org/10.3390/agriculture12111786.
[9] J.L. Arcand, E. Berkes, U. Panizza, Too much finance? J. Econ. Growth 20 (2015) 105–148.
[10] L. Ductor, D. Grechyna, Financial development technological progress and economic growth, SSRN Available at: 1997526, https://doi.org/10.2139/ssrn.1997526, 2013.
[11] S.H. Law, A.M. Kutan, N.A.M. Naseem, The Role of Institutions in Finance Curse: Evidence from International Data, Journal of Comparative Economics 46 (2018) 174–191, https://doi.org/10.1016/j.jce.2017.04.001.
[12] J.B. Ang, Are financial sector policies effective in deepening the MALAYSIAN financial system? Contemp Econ Policy 26 (2008) 623–635, https://doi.org/10.1111/j.1465-7287.2008.00110.x.
[13] K.V. Krinichanskii, The Relationship between Financial Development and Economic Growth: the Issue of Nonlinearity, Finance Credit, 2022, https://doi.org/10.24891/fc.28.6.1212.
[14] E.N. Bahri, A.H. Nor, T. Sarmidi, N.H. Nor, Nonlinear Relationship between Financial Development and Economic Growth: Evidence from Post Global Financial Crisis Panel Data, 2018, https://doi.org/10.17576/jem-2018-5201-2.
[15] E.N. Bahri, A.H. Nor, T. Sarmidi, N.H. Nor, The Role of Financial Development in the Relationship between Foreign Direct Investment and Economic Growth: A Nonlinear Approach, Rev Pac Basin Financ Mark Policies, 2019, https://doi.org/10.1142/s0219091519500097.
[16] A.M.G. Al khatib, B.M. Alshaib, P. Mishra, R.K. Narvariya, S. Yadav, S. Ray, A. Kanaan, Modeling and analyzing the dynamic impact of financial development on economic growth in Syria, Econ. Aff. 67 (2022) 855–897, https://doi.org/10.46852/0424-2513.5.2022.24.
[17] L. Hammoud, Financial Development and Economic Growth an Empirical Analysis for Syria, SSRN Available at: 3569798, 2020, https://doi.org/10.2139/ssrn.3569798. Available at SSRN.
[18] S. Abu-Bader, A.S. Abu-Qarn, Financial Development and Economic Growth: Empirical Evidence from Six Mena Countries, Econometric & Statistical Methods - General eJournal, Econometrics, 2008, https://doi.org/10.1111/j.1467-9361.2008.00427.x.

[19] S. Matallah, N. Ghazi, C. Bounoua, How the triptych" economic freedom-financial development-FDI" can affect the MENA region's economic growth? Int J Innov Appl Stud 13 (2015) 50.
[20] C.F. Wu, S.C. Huang, T. Chang, C.C. Chiou, H.P. Hsueh, The nexus of financial development and economic growth across major Asian economies: evidence from bootstrap ARDL testing and machine learning approach, J. Comput. Appl. Math. 372 (2020), 112660.
[21] I. Alnafrah, R. Sultan, R. Aldoumani, S. Mouselli, The impact of ICT on financial development, An Empirical Evidence from Syria 2 (2021) 1–11, https://doi.org/10.33168/SISD.2021.0101.
[22] Z. Klarić, Challenges of Sustainable Tourism Development in the Mediterranean, IEMed Mediterranean yearbook, 2017, pp. 261–269.
[23] R. Levine, Financial development and economic growth: views and agenda, J. Econ. Lit. 35 (1997) 688–726. http://www.jstor.org/stable/2729790.
[24] M. Pagano, Financial markets and growth: an overview, Eur. Econ. Rev. 37 (1993) 613–622, https://doi.org/10.1016/0014-2921(93)90051-B.
[25] R.G. King, R. Levine, Finance entrepreneurship and growth, J. Monetary Econ. 32 (1993) 513–542, https://doi.org/10.1016/0304-3932(93)90028-E.
[26] H. Alhassan, P.A. Kwakwa, S.A. Donkoh, The interrelationships among financial development, economic growth and environmental sustainability: evidence from Ghana, Environ. Sci. Pollut. Res. Int. 29 (24) (2022) 37057–37070, https://doi.org/10.1007/s11356-021-17963-9.
[27] P. Arestis, P.O. Demetriades, K.B. Luintel, Financial development and economic growth: the role of stock markets, J. Money Credit Bank. 33 (2001) 16–41, https://doi.org/10.2307/2673870.
[28] J.A. Schumpeter, The Theory of Economic Development, Harvard University Press, Cambridge Mass, 1911.
[29] R. McKinnon, Money and Capital in Economic Development, Brookings Institution, Washington, 1973.
[30] J. Robinson, The generalization of the general theory.", in: The Rate of Interest and Other Essays, Macmillan Press, London, 1952.
[31] W.A. Lewis, The theory of economic growth, Economica 26 (1955) 171.
[32] R. E Lucas Jr., On the mechanics of economic development, J. Monetary Econ. 22 (1988) 3–42, https://doi.org/10.1016/0304-3932(88)90168-7.
[33] R.P. Pradhan, M.B. Arvin, S. Bahmani, J.H. Hall, N.R. Norman, Finance and growth: evidence from the ARF countries, Q. Rev. Econ. Finance 66 (2017) 136–148, https://doi.org/10.1016/j.qref.2017.01.011.
[34] R.P. Pradhan, B.M. Arvin, N.R. Norman, M. Nair, J.H. Hall, Insurance penetration and economic growth nexus: cross-country evidence from ASEAN, Res. Int. Bus. Finance 36 (2016) 447–458, https://doi.org/10.1016/j.ribaf.2015.09.036.
[35] R.P. Pradhan, M.B. Arvin, N.R. Norman, Insurance development and the finance-growth nexus: evidence from 34 OECD countries, J. Multinatl. Financ. Manag. 31 (2015) 1–22, https://doi.org/10.1016/j.mulfin.2015.02.001.
[36] A.M.G. Al khatib, V. Pawariya, P. Lal, S. Ray, P. Mishra, L. Kumar, A. Kanaan, The relationship between financial development and inflation rate in Egypt, Indian J. Econ. Dev. 19 (2023), https://doi.org/10.35716/IJED/22298.
[37] J. Botev, B. Égert, F. Jawadi, The nonlinear relationship between economic growth and financial development: evidence from developing, emerging and advanced economies, Int. Econ. 160 (2019) 3–13.
[38] M.D. Doran, M.M. Poenaru, A.L. Zaharia, S. Vătavu, O.R. Lobonț, Fiscal policy, growth, financial development and renewable energy in Romania: an autoregressive distributed lag model with evidence for growth hypothesis, Energies 16 (2023), https://doi.org/10.3390/en16010070.
[39] Thanasis Stengos, Andreas Savvides, Theofanis Mamuneas, Elena Ketteni, Is the Financial Development and Economic Growth Relationship Nonlinear? Economics Bulletin, AccessEcon 15 (14) (2007) 1–12.
[40] M.S. Khan, A.S. Senhadji, Financial development and economic growth: a review and new evidence, J. Afr. Econ. 12 (2003) ii89–ii110.
[41] J. Greenwood, B. Jovanovic, Financial development growth and the distribution of income, J. Polit. Econ. 98 (1990) 1076–1107.
[42] J. De Gregorio, P.E. Guidotti, Financial development and economic growth, World Dev. 23 (1995) 433–448.
[43] C.Y. Cheng, M.S. Chien, C.C. Lee, ICT diffusion financial development and economic growth: an international cross-country analysis, Econ Model 94 (2021) 662–671.
[44] Y. Ouyang, P. Li, On the nexus of financial development economic growth and energy consumption in China: new perspective from a GMM panel VAR approach, Energy Econ. 71 (2018) 238–252.
[45] J. Gurley, E. Shaw, Financial structure and economic development, Econ. Dev. Cult. Change 15 (1967) 257–268, https://doi.org/10.1086/450226.
[46] R.W. Goldsmith, Financial Structure and Development, Yale University Press, New Haven, CT, 1969.
[47] H.T. Patrick, Financial development and economic growth in underdeveloped countries, Econ. Dev. Cult. Change 14 (1966) 174–189.
[48] M.S. Islam, I.A. Alhamad, Impact of financial development and institutional quality on remittance-growth nexus: evidence from the topmost remittance-earning economies, Heliyon 8 (2022), e11860, https://doi.org/10.1016/j.heliyon.2022.e11860.
[49] J. Zhang, L. Wang, S. Wang, Financial development and economic growth: recent evidence from China, J. Comp. Econ. 40 (2012) 393–412, https://doi.org/10.1016/j.jce.2012.01.001.
[50] H. Herwartz, Y.M. Walle, Determinants of the link between financial and economic development: evidence from a functional coefficient model, Econ Model 37 (2014) 417–427, https://doi.org/10.1016/j.econmod.2013.11.029.
[51] A. Musabeh, K. Alrifai, M. Kalloub, Financial development economic growth and welfare: evidence from emerging countries, J Bus Econ Finance 9 (2020) 2, https://doi.org/10.17261/Pressacademia.2020.1218.
[52] R. Levine, N. Loayza, T. Beck, Financial intermediation and growth: causality and causes, J. Monetary Econ. 46 (2000) 31–77.
[53] R.P. Pradhan, M.B. Arvin, S. Bahmani, Causal nexus between economic growth, inflation, and stock market development: the case of OECD countries, Glob. Financ. J. 27 (2015) 98–111, https://doi.org/10.1016/j.gfj.2015.04.006.
[54] H.M. Nguyen, Q.T.T. Le, C.M. Ho, T.C. Nguyen, D.H. Vo, Does financial development matter for economic growth in the emerging markets? Borsa Istanbul Rev 22 (2022) 688–698, https://doi.org/10.1016/j.bir.2021.10.004.
[55] R.P. Pradhan, M.B. Arvin, A. Ghoshray, The dynamics of economic growth, oil prices, stock market depth, and other macroeconomic variables: evidence from the G-20 countries, Int. Rev. Financ. Analys. 39 (2015) 84–95, https://doi.org/10.1016/j.irfa.2015.03.006.
[56] E.E.O. Opoku, M. Ibrahim, Y.A. Sare, The causal relationship between financial development and economic growth in Africa, Int. Rev. Appl. Econ. 33 (2019) 789–812, https://doi.org/10.1080/02692171.2019.1607264.
[57] K. Svirydzenka, Introducing a new broad-based index of financial development, in: IMF Working Paper No. 16/5, International Monetary Fund, 2016. https://www.imf.org/en/Publications/WP/Issues/2016/12/31/Introducing-a-New-Broad-based-Index-of-Financial-Development-43621.
[58] E. Zivot, D.W.K. Andrews, Further evidence on the great crash the oil-price shock and the unit-root hypothesis, J. Bus. Econ. Stat. 20 (2002) 25–44.
[59] P. Perron, T.J. Vogelsang, Nonstationarity and level shifts with an application to purchasing power parity, J. Bus. Econ. Stat. 10 (1992) 301–320.
[60] Y. Hmamouche, NlinTS: an R package for causality detection in time series, R J 12 (2020) 21.
[61] Y. Shin, B. Yu, M. Greenwood-Nimmo, Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework, in: Festschrift in Honor of Peter Schmidt, Econometric methods and applications, 2014, pp. 281–314.
[62] S.B. Naceur, S. Ghazouani, Stock markets banks and economic growth: empirical evidence from the MENA region, Res. Int. Bus. Finance 21 (2007) 297–315.
[63] C. Amsler, J. Lee, An LM test for a unit root in the presence of a structural change, Econ Theory 11 (1995) 359–368.
[64] R. Ram, Government size and economic growth: a new framework and some evidence from cross-section and time-series data, Am. Econ. Rev. 76 (1986) 191–203.
[65] M. Kogid, R. Asid, J. Lily, D. Mulok, N. Loganathan, The effect of exchange rates on economic growth: empirical testing on nominal versus real, IUP J Financ Econ 10 (2012). https://EconPapers.repec.org/RePEc:icf:icfjfe:v:10:y:2012:i:1:p:7-17.
[66] M.H. Pesaran, Y. Shin, R.J. Smith, Bounds testing approaches to the analysis of level relationships, J. Appl. Econ. 16 (2001) 289–326.
[67] R. Levine, More on finance and growth: more finance more growth? Rev-Fed Reserve Bank St Louis 85 (2003) 31–46.
[68] A.K. Bera, C.M. Jarque, Efficient tests for normality homoscedasticity and serial independence of regression residuals: Monte Carlo evidence, Econ. Lett. 7 (1981) 313–318, https://doi.org/10.1016/0165-1765(80)90024-5.
[69] T.S. Breusch, Testing for autocorrelation in dynamic linear models, Aust. Econ. Pap. 17 (1978) 334–355, https://doi.org/10.1111/j.1467-8454.1978.tb00635.x.

[70] R.F. Engle, Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation, Econometrica 50 (1982) 987–1007, https://doi.org/10.2307/1912773.
[71] J.B. Ramsey, Tests for specification errors in classical linear least-squares regression analysis, J. Roy. Stat. Soc. B 31 (1969) 350–371, https://doi.org/10.1111/j.2517-6161.1969.tb00796.x.
[72] R.L. Brown, J. Durbin, J.M. Evans, Techniques for testing the constancy of regression relationships over time, J. Roy. Stat. Soc. B 37 (1975) 149–163.
[73] C. Calderon, L. Liu, The direction of causality between financial development and economic growth, J. Dev. Econ. 72 (2003) 321–334.
[74] L. Blanco, The finance-growth link in Latin America, South. Econ. J. 76 (2009) 224–248.
[75] L.O. Oyelami, P. Olomola, R. Ajisafe, Economic interdependence and macro-economic shocks synchronization in west african monetary zone member countries, Int Econ Stud 46 (2016) 69–84, https://doi.org/10.22108/ies.2019.113208.1043.
[76] V.C. Ehiedu, A.C. Onuorah, F.C. Osakwe, Financial deepening and small and medium scale enterprises (SMEs) output in Nigeria, J Econ Financ Manag Stud (2022), https://doi.org/10.47191/jefms/v5-i10-11.
[77] M.A. Baloch, Danish, CO2 emissions in BRICS countries: what role can environmental regulation and financial development play? Clim. Change 172 (2022) 9, https://doi.org/10.1007/s10584-022-03362-7.
[78] M.A. Baloch, I. Ozturk, F.V. Bekun, D. Khan, Modeling the dynamic linkage between financial development, energy innovation, and environmental quality: does globalization matter? Bus. Strateg. Environ. bse. 2615 (2020) https://doi.org/10.1002/bse.2615.
[79] A.A. Shah, R. Younas, K.M. Junaid, M. Iqbal, Attaining economic growth through financial development and external debts: evidence from emerging economies, Res J Soc Issues (2023), https://doi.org/10.56976/rjsi.v5i1.58.