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Long-Run Cointegration and Sectoral Elasticities of Economic Growth in Ghana: An ARDL and Cointegration Analysis (1990–2023)

Samuel Asuamah Yeboah
Faculty of Business and Management Studies, Sunyani Technical University, Ghana.
E-mail: nelkonsegal@yahoo.com

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Abstract

The paper analyses the correlation between structural transformation and economic growth in Ghana from 1990 to 2023, utilising annual World Development Indicators data. Applying the ARDL model with long-run estimators including FMOLS, DOLS, and VECM, it investigates how agriculture, industry, and services contribute to GDP growth. Results show that industrialisation, services expansion, and investment positively and significantly influence growth, while inflation and trade openness exhibit mixed short-run and long-run effects. Findings indicate that transformation is progressing but remains incomplete, driven largely by service sector expansion with limited industrial productivity spillovers. Grounded in the Lewis dual sector framework, the Kuznets structural shift hypothesis, and Romer's endogenous growth theory, the study integrates sectoral dynamics, innovation, and human capital into a unified analytical model. Policy implications highlight the need for industrial diversification, agricultural modernisation, human capital development, macroeconomic stability, and institutional reforms to achieve sustainable, productivity-led, and inclusive long-term transformation.

Keywords: Structural transformation; Sectoral contribution; Industrialisation; Services sector; Agriculture

Jel Classification Codes: O55; E60; Q16

I. Background to The Study

Ghana's post-independence economic evolution shows a gradual but uneven structural transformation, marked by the reallocation of resources from agriculture to industry

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and services. Structural transformation promotes productivity, employment, and diversification (Lewis, 1954; Loizou *et al.*, 2019). Historically agrarian, Ghana relied heavily on agriculture, which contributed over half of GDP and absorbed most labour (Awunyo-Vitor & Sackey, 2018). Economic reforms, including the 1980s Economic Recovery Programme and subsequent liberalisation, aimed to promote industrialisation and export diversification (Rahaman *et al.*, 2023). From 1990 to 2023, the labour movement from agriculture to higher-productivity sectors reflected Lewis's dual-sector model. Agriculture's GDP share declined from over 45% to below 20%, while services rose to nearly 38% (World Bank, 2024). Industrial growth remained volatile due to inconsistent investment, infrastructure deficits, and high costs (Ogbuabor *et al.*, 2025). Despite diversification, Ghana increasingly exhibits a services-led transformation trap where service expansion surpasses industrial productivity (Dorosh & Thurlow, 2018).

Ghana's growth trajectory aligns with the structural transformation, endogenous growth, and Kuznets hypotheses. Lewis (1954) emphasises shifting surplus labour from agriculture to modern industry as a driver of growth, while Romer (1990) highlights innovation, human capital, and technological progress as internal engines of sustained expansion. The Kuznets hypothesis explains agriculture's declining share as economies industrialise (Kuznets, 1973; Bilenko, 2022). Empirical evidence shows that investment in education, technology, and research enhances productivity and industrial upgrading, supporting long-run growth in emerging economies (Sarwar *et al.*, 2021; Amir *et al.*, 2025).

Ghana's transformation mirrors trends in developing economies where industrialisation and trade openness drive long-run growth, while inflation and volatility hinder investment and transformation. Evidence shows that labour and services aid short-term growth, but weak industry and agriculture constrain long-run productivity. Ghana's transformation remains dominated by low-value services. Achieving Vision 2057 and the SDGs requires productivity-driven industrialisation, modernised agriculture, and innovation-led services. Stronger human capital, technology adoption, and institutional quality are essential for inclusive growth, while macroeconomic stability through controlled inflation, improved trade facilitation, and effective financial intermediation is vital to sustain Ghana's structural transformation and long-term competitiveness.

Against this background, the present study, *Structural Transformation and Economic Growth in Ghana: Evidence from World Development Indicators (1990–2023)*, seeks to analyse the sectoral contributions of agriculture, industry, and services to overall GDP growth. It examines whether shifts in sectoral output shares have significantly influenced long-run growth and derives policy implications for fostering inclusive and

sustainable transformation. By employing rigorous econometric techniques such as ARDL and cointegration analysis, the study contributes to the empirical literature by providing new evidence on Ghana's transformation dynamics and offering insights for achieving productivity-based and equitable economic progress.

Ghana's economy shows a persistent gap between growth and productivity, with most labour in low-productivity agriculture and informal services, while industry contributes only a quarter of GDP and under 15% of jobs. Macroeconomic instability and infrastructure deficits hinder industrial competitiveness. Existing studies are fragmented and static. This study applies ARDL, VECM, FMOLS, DOLS, and CCR to analyse Ghana's structural transformation (1990–2023) using WDI, ILO, and GSS data. Integrating Lewis, Romer, and Kuznets frameworks, it examines sectoral composition, investment, trade, inflation, and labour participation, distinguishing short- and long-run dynamics to offer a comprehensive understanding of Ghana's transformation trajectory.

The purpose of the study is to examine how structural transformation influences long-term economic growth in Ghana by analysing sectoral reallocation among agriculture, industry, and services, and determining whether these shifts reflect productivity-driven development. It evaluates the contributions of each sector to GDP, the long-run effects of changes in output shares, and the sustainability of recent growth patterns. The inquiry is structured around four key research questions that interrogate the nature of the relationship between structural transformation and growth, sectoral contributions to GDP, the impact of changing output shares, and the policy measures needed to promote inclusive, productivity-led, and sustainable development.

The study examines Ghana's economy from 1990–2023, focusing on GDP, industry, agriculture, services, trade, investment, labour, and inflation. Despite limitations such as secondary data reliance, informal sector exclusion, and unmodelled shocks, it provides new empirical insights linking macroeconomic performance to structural change, guiding Ghana's transition toward a diversified, innovation-driven, and resilient development path.

II. Literature Review

1. Theoretical Review

1.1 Structural Transformation Theory

The structural transformation theory, integrating Lewis, Kuznets, and Romer as outlined by Yeboah (2023), explains development as the movement of surplus labour from low-

productivity agriculture to higher-productivity industry. Rooted in Lewis's (1954) dual-sector model, it highlights industrialisation and agricultural modernisation as key to diversification and poverty reduction. Empirical studies (Ansari & Khan, 2018; Loizou *et al.*, 2019; Nyamekye *et al.*, 2021) support this, while Ghana's policies promoting industrial expansion and agricultural upgrading align with these principles (Ableeva *et al.*, 2019; Rahaman *et al.*, 2023). Evidence from Nigeria and Indonesia (Bashir *et al.*, 2019; Afriyanti *et al.*, 2023) further validates the industry's role in employment and productivity growth.

1.2. Endogenous Growth Theory

The endogenous growth theory, as presented by Romer (1990), views innovation, human capital, and knowledge accumulation as internal engines of long-run growth. Empirical studies show that investment and human capital formation strongly influence the growth paths of emerging economies (Sarwar *et al.*, 2021; Ogbuabor *et al.*, 2025). In Ghana, these mechanisms operate through investment in industrial capacity, ICT infrastructure, and the expansion of knowledge-intensive services, consistent with evidence that technology-driven sectors and improvements in service productivity generate significant multiplier effects on GDP (Pradhan *et al.*, 2018; Lee & McKibbin, 2018).

1.3. Sectoral Linkages and Interdependence Theory

The intersectoral linkage theory argues that agriculture, industry, and services function as mutually reinforcing drivers of economic growth (Varkey & Panda, 2018; Bashir *et al.*, 2019). Expanding agricultural output supports industry through input provision and labour sustenance, while industrial growth supplies technology and infrastructure that enhance agricultural productivity (Dorosh & Thurlow, 2018; Evangelista *et al.*, 2022). Evidence from Ethiopia and Tanzania confirms that these complementarities strengthen supply chains and promote sustainable growth and employment (Tekilu *et al.*, 2018; Miku *et al.*, 2023). For Ghana, this framework implies that industrialisation gains depend on coordinated progress in agriculture and services.

1.4. Classical and Neoclassical Growth Models

The classical and neoclassical growth models, originating from Solow and Swan, explain growth through capital accumulation, labour participation, and technological progress, with long-run expansion driven by innovation and productivity due to diminishing returns to capital (Bhatti *et al.*, 2024; Amir *et al.*, 2025). Empirical evidence shows

that labour participation and demographic dividends support growth when linked to industrial development (Jafrin *et al.*, 2021; Degu, 2019). In Ghana, labour market responses to industrial and service expansion reflect neoclassical expectations of efficient factor reallocation.

1.5. Trade Openness and Comparative Advantage Theory

Trade openness theory, rooted in Ricardo's comparative advantage and the Heckscher–Ohlin emphasis on factor endowments, argues that liberalised trade enhances efficiency, technology diffusion, and growth. Empirical evidence shows that openness boosts GDP through expanded markets and foreign investment (Abinabo & Abubakar, 2023; Ajayi *et al.*, 2024). Studies across Asia and Africa confirm its role in driving industrialisation and productivity (Akhter *et al.*, 2022; Deryag & Khalifa, 2024; Miku *et al.*, 2021). In Ghana, openness supports industrial policy by widening export opportunities and attracting capital.

1.6. Agricultural Transformation and the Kuznets Hypothesis

The Kuznets (1973) hypothesis suggests that agriculture's GDP share declines as industry and services expand, yet agriculture remains vital in early development for employment, food security, and exports (Bilenko, 2022; Loizou *et al.*, 2019). Evidence from Bangladesh, Nigeria, and Indonesia shows agriculture drives growth through rural incomes and industrial inputs (Chowhan *et al.*, 2023; Awunyo-Vitor & Sackey, 2018; Poudel *et al.*, 2021). Ghana must strengthen value chains and agro-industrial linkages.

1.7. Inflation and Investment Theories

Monetarist theory argues that stable inflation supports investment and productivity, whereas high inflation disrupts resource allocation (Raghutla, 2020; Bashir & Rashid, 2019). Evidence from Nigeria and Pakistan shows controlled inflation boosts capital formation and GDP (Bhattarai, 2025; Khan, 2021). For Ghana, single-digit inflation is essential for sustaining long-run growth.

1.8. Summary of Theoretical Nexus

The synthesis of these theories underscores that economic growth is a multidimensional process driven by structural reallocation, innovation, and trade integration. The structural transformation theory explains the sectoral shift from agriculture to industry and services, while the endogenous growth theory captures the internal mechanisms of

innovation and capital formation. Trade openness theory complements both by linking external competitiveness to domestic productivity gains. Together, these theoretical perspectives provide the analytical foundation for examining Ghana's structural transformation and justify the econometric specification used in this study.

III. Methodology

1. Research Design

This study employs a quantitative longitudinal design within the positivist paradigm to objectively analyse Ghana's structural transformation from 1990 to 2023. Using econometric techniques, it examines short- and long-run dynamics between GDP, industrialisation, inflation, investment, labour, services, trade, and agriculture. Unit root tests (ADF, PP) confirmed mixed integration, validating the ARDL approach. Baseline OLS preceded ARDL modelling, supported by diagnostic checks. The ARDL Bound Test confirmed long-run equilibrium, with a significant negative error correction term (−1.037, $p < .001$) indicating rapid adjustment. Robustness tests using FMOLS, DOLS, and CCR estimators yielded consistent long-run coefficients, reinforcing model stability and reliability.

Although the stationarity tests indicate a mix of I(0) and I(1) variables, the Johansen cointegration test is employed as a supplementary robustness check to validate the long-run relationships established through the ARDL bounds testing approach. The ARDL model remains the primary technique due to its suitability for mixed integration orders. Nonetheless, empirical literature supports using Johansen's test as a confirmatory tool when variables are not I(2). This dual approach strengthens result credibility by triangulating evidence from independent methods, ensuring that conclusions on long-run equilibrium and sectoral growth linkages are not dependent on a single estimation framework.

2. Data Description and Sources

The study uses annual time series data from 1990 to 2023, covering thirty-four observations that reflect Ghana's major structural transformation phases. The dependent variable is real GDP growth, while the independent variables include industrialisation (IND), inflation, investment (INF), labour participation LAB, services output (SER), trade openness (TRD), and agricultural output (AGR), selected for their theoretical and empirical relevance (Romer, 1990; Lewis, 1954; Kuznets, 1973). The variables capture

Ghana's shift toward industry-driven growth: industrialisation reflects structural change, inflation indicates macroeconomic stability, and investment represents capital accumulation. Labour participation and services denote human capital and tertiary expansion, while trade openness measures global integration and agriculture the traditional sector. Data verification ensured reliability and ARDL suitability.

3. Model Specification and Variable Description

This section outlines the functional, econometric, and log-linear model specifications used to examine Ghana's structural transformation and economic growth (1990–2023). Both static and dynamic frameworks capture short- and long-run sectoral dynamics, following Yeboah's (2023) integrated transformation framework that emphasises sectoral interactions and macroeconomic drivers.

Functional Form of the Model: The functional representation of the model is expressed as in equation (1):

$$GDP_t = f(IND_t, INF_t, INV_t, LAB_t, SER_t, TRD_t, AGR_t) \quad (1)$$

where GDP_t represents economic growth at time t, and IND_t, INF_t, INV_t, LAB_t, SER_t, TRD_t, and AGR_t denote industrial output, inflation rate, investment, labour participation, service sector output, trade openness, and agricultural output, respectively.

Econometric (*Linear*) *Specification:* To empirically estimate the relationship, the model is specified in linear form as in equation (2):

$$GDP_t = \beta_0 + \beta_1 IND_t + \beta_2 INF_t + \beta_3 INV^t + \beta_4 LAB_t + \beta_5 SER_t + \beta_6 TRD_t + \beta_7 AGR_t + \varepsilon_t \quad (2)$$

where β_0 is the intercept, β_1–β_7 are slope coefficients measuring the marginal effect of each variable on GDP, and ε_t is the stochastic error term assumed to have zero mean and constant variance.

Log-Linear Transformation: Given the macroeconomic nature of the data, the model is expressed in log-linear form to interpret coefficients as elasticities and stabilise variance as in equation (3):

$$\ln(GDP_t) = \alpha_0 + \alpha_1 \ln(IND_t) + \alpha_2 \ln(INF_t) + \alpha_3 \ln(INV_t) + \alpha_4 \ln(LAB_t) + \alpha_5 \ln(SER_t) + \alpha_6 \ln(TRD_t) + \alpha_7 \ln(AGR_t) + \mu_t \quad (3)$$

This form implies that a 1% change in any explanatory variable leads to an α_i% change in GDP, holding other factors constant. It also reduces heteroskedasticity and improves comparability of sectoral elasticities.

4. Short-Run ARDL Error-Correction Representation

For dynamic estimation, the short-run ARDL error-correction model (ECM) is expressed as in equation (4):

$$\Delta\ln(GDP_t) = \varphi_0 + \Sigma\varphi_{1_i}\Delta\ln(GDP_{\_\{t-i\}}) + \Sigma\varphi_{2_i}\Delta\ln(IND_{\_\{t-i\}}) + \ldots + \Sigma\varphi_{8_i}\Delta\ln(AGR_{\_\{t-i\}}) + \lambda ECT_{\_\{t-1\}} + \varepsilon_t \quad (4)$$

where λ represents the speed of adjustment toward long-run equilibrium, and $ECT_{\_\{t-1\}}$ denotes the previous period's deviation from equilibrium.

5. Hypotheses Formulation

This section presents the hypotheses formulated to empirically examine the relationship between economic growth (GDP) and key macroeconomic indicators, including industrialisation (IND), inflation (INF), investment (INV), labour force participation (LAB), services sector output (SER), trade openness (TRD), and agricultural output (AGR) in Ghana. The hypotheses are derived from the structural transformation and endogenous growth frameworks, and they are tested using OLS, ARDL, Johansen cointegration, VECM, FMOLS, DOLS, CCR, and Granger causality estimators (Romer, 1990; Lewis, 1954).

Hypotheses on Individual Variable Effects

(a) Industrialisation

H_{01}: Industrialisation has no statistically significant effect on economic growth in Ghana.

H_{11}: Industrialisation has a statistically significant positive effect on economic growth in Ghana.

(b) Inflation

H_{02}: Inflation has no statistically significant effect on economic growth in Ghana.

H_{12}: Inflation has a statistically significant negative effect on economic growth in Ghana.

(c) Investment

H_{03}: Investment has no statistically significant effect on economic growth in Ghana.

H_{13}: Investment has a statistically significant positive effect on economic growth in Ghana.

(d) Labour Force

H_{04}: Labour force participation has no statistically significant effect on economic growth in Ghana.
H_{14}: Labour force participation has a statistically significant positive effect on economic growth in Ghana.

(e) Services Sector

H_{05}: Services sector output has no statistically significant effect on economic growth in Ghana.
H_{15}: Services sector output has a statistically significant positive effect on economic growth in Ghana.

(f) Trade Openness

H_{06}: Trade openness has no statistically significant effect on economic growth in Ghana.
H_{16}: Trade openness has a statistically significant positive effect on economic growth in Ghana.

(g) Agriculture

H_{07}: Agricultural output has no statistically significant effect on economic growth in Ghana.
H_{17}: Agricultural output has a statistically significant positive effect on economic growth in Ghana.

(h) Long-Run Cointegration Hypothesis

H_{08}: There is no long-run cointegrating relationship among GDP, industrialisation, inflation, investment, labour, services, trade, and agriculture in Ghana.
H_{18}: There exists a long-run cointegrating relationship among GDP, industrialisation, inflation, investment, labour, services, trade, and agriculture in Ghana.

(i) Adjustment and Error-Correction Hypothesis

H_{09}: The error-correction term does not significantly adjust short-run disequilibrium toward long-run equilibrium.
H_{19}: The error-correction term significantly adjusts short-run disequilibrium toward long-run equilibrium.

(j) Robustness and Consistency Hypotheses

H_{010}: The estimated coefficients are inconsistent across cointegration estimators (VECM, FMOLS, DOLS, CCR).
H_{110}: The estimated coefficients are consistent across alternative long-run estimators (VECM, FMOLS, DOLS, CCR).

6. Stationarity and Unit Root Tests

Stationarity was assessed using Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests to determine each variable's order of integration, critical for avoiding spurious regression (Gujarati & Porter, 2009). The ADF addressed serial correlation via lagged differences, while the PP corrected for heteroskedasticity and autocorrelation, providing robustness. Tests revealed a mix of I(0) and I(1) variables, justifying the ARDL bounds approach, which accommodates such combinations but excludes I(2) variables. Confirming unit roots ensured stable statistical properties, supporting valid regression and cointegration inference. Using both tests mitigated individual limitations, reflecting best macroeconomic practice and enhancing the credibility of the modelling framework for analysing Ghana's structural transformation.

7. Preliminary Estimation: OLS Approach

The study first used OLS to examine relationships between structural transformation variables and GDP growth, providing a simple benchmark to assess relevance, signs, multicollinearity, and fit. While OLS assumes stationarity and ignores long-run dynamics, its exploratory results guided ARDL specification, enabling robust modelling of short- and long-run relationships in Ghana's structural transformation.

8. Lag Length Selection Criteria

Optimal lag length for ARDL and VECM was determined using AIC, SC, and HQ criteria (Lütkepohl, 2005) to capture dynamics and avoid over-parameterisation. A lag of one, minimising AIC, was applied to both models, ensuring stable, efficient estimation and accurately reflecting sectoral interactions with GDP growth, enhancing robustness and validity.

9. Dynamic Estimation: ARDL Model

After confirming integration orders and optimal lags, the study applied the ARDL Bounds Testing procedure to examine long-run cointegration between GDP and structural

transformation variables. ARDL accommodates mixed I(0) and I(1) variables while excluding I(2), offering greater flexibility than Engle–Granger or Johansen methods (Pesaran, Shin, & Smith, 2001). Implemented via an unrestricted error correction model, it captures short-run adjustments and long-run equilibrium. The F statistic tests joint significance of lagged levels; exceeding the upper bound indicates cointegration. With F = 8.09 surpassing the 1% upper bound, a stable long-run relationship is confirmed, providing robust, methodologically coherent evidence for the study's objectives.

10. Model Stability Diagnostics: CUSUM and CUSUMSQ Tests

To assess the stability of the ARDL estimates, the study employed CUSUM and CUSUMSQ tests (Brown, Durbin, & Evans, 1975), which detect gradual parameter drift and abrupt structural breaks, respectively. These tests are essential for time series sensitive to regime changes and policy shifts, such as in Ghana. Both statistics remained within 5% critical bounds, indicating stable coefficients. This confirms that the ARDL model is well specified and that short- and long-run relationships between GDP and structural transformation variables are reliable. Incorporating these diagnostics enhances the robustness and credibility of the findings and their policy implications over 1990–2023.

11. Robustness and Alternative Cointegration Estimators

To ensure the robustness of ARDL long-run estimates, the study employed four additional cointegration estimators: VECM, FMOLS, DOLS, and CCR. Using multiple estimators enhances credibility by leveraging their complementary strengths (Phillips & Hansen, 1990; Stock & Watson, 1993). VECM captured short-run adjustments and long-run equilibrium in a multivariate framework, accounting for endogeneity and feedback effects. FMOLS and DOLS corrected for serial correlation, endogeneity, and small sample bias, while CCR addressed endogeneity and autocorrelation without altering long-run relationships. Consistent coefficient signs and significance across all methods confirmed stable long-run linkages between GDP and sectoral outputs, reinforcing the reliability of the study's findings and policy implications.

12. Diagnostic and Robustness Tests

Although ARDL was the primary estimation method, the Johansen cointegration test was applied as a robustness check. Despite assuming all variables are I(1) and favouring large samples, it confirmed multiple cointegrating vectors at the 5% level, reinforcing the ARDL long-run results. Johansen's (1988, 1991) maximum likelihood approach

uses a VAR in levels and decomposes long-run relationships via the Π matrix, whose rank indicates the number of cointegrating vectors. Inference is guided by the trace and maximum eigenvalue statistics, providing complementary evidence of long-run equilibrium among GDP and sectoral or macroeconomic variables, enhancing the credibility of the study's findings.

(i) Trace statistic, which tests the null hypothesis of r or fewer cointegrating relationships

(ii) Maximum eigenvalue statistic, which tests for exactly r cointegrating vectors

The test is applied with both intercept and trend specifications to ensure robustness. The presence of at least one significant cointegrating vector suggests a stable long-run relationship among the variables, thereby supporting the long-run elasticities estimated through the ARDL approach.

13. Dynamic Interaction Analysis: Impulse Response Functions (IRF) from VECM

To complement ARDL estimates, the study used Impulse Response Function (IRF) analysis within a VECM to examine how sectoral shocks dynamically affect GDP. While ARDL captures equilibrium relationships, IRFs reveal the timing, magnitude, and persistence of responses to disturbances in industry, services, agriculture, and other variables. Supported by Johansen-confirmed cointegration, the VECM incorporates lags, trends, and stochastic shocks. IRF plots illustrate immediate and subsequent GDP reactions, highlighting adjustment speed and volatility. This dynamic analysis informs policymakers on whether sectoral shocks are temporary or persistent, guiding strategies for stabilisation, diversification, and balanced structural transformation.

14. Forecast Error Variance Decomposition (VDA)

To enhance the interpretation of impulse response results, the study applied Variance Decomposition Analysis (VDA) within the VECM to quantify each structural transformation variable's contribution to GDP fluctuations. VDA decomposes forecast error variance, revealing the relative importance of agriculture, industry, services, and other sectors over time. While IRFs indicate direction and persistence, VDA measures magnitude, identifying dominant and subordinate growth drivers. This approach clarifies which sectors exert sustained influence on GDP, informing policy prioritisation. Combining IRF and VDA aligns with contemporary macroeconomic

practice, strengthening the explanatory power of the analysis and supporting evidence-based strategies for Ghana's structural transformation.

IV. Results

1. Descriptive Statistics

The descriptive statistics indicate a mean GDP growth rate of 2.71 percent, reflecting moderate but uneven expansion from 1990 to 2023. Industry averaged 25.30 percent of GDP, services 37.61 percent, and agriculture 29.93 percent, signalling a gradual shift toward services. Trade openness was high at 74.25 percent, while inflation averaged 23.57 percent, indicating persistent volatility. Labour participation remained strong at 71.76 percent. Skewness, kurtosis, and the Jarque–Bera test ($p < .01$) show non-normality in GDP and inflation. Overall, the descriptive profile reflects structural transition alongside macroeconomic instability, consistent with sub-Saharan transformation patterns (Nyamekye, Tian, & Cheng, 2021).

2. Correlation and Trends

Figure 1 shows strong positive correlations between GDP and both industrial and service output, indicating that non-agricultural sectors increasingly drive growth. Figure 2 reveals a long run decline in agriculture's GDP share alongside rising services and modest industrial expansion, reflecting a Kuznetsian shift of labour and capital toward higher productivity sectors in Ghana after 2000.

3. Stationarity Analysis

The ADF and PP results in Table 4 show that most variables are non-stationary at levels but become stationary after first differencing, indicating I(1) behaviour. GDP, inflation, and labour were stationary at a level, while agriculture, industry, investment, and services became stationary after differencing. This mixed integration order justifies using the ARDL bounds approach.

4. OLS Regression Results

An initial OLS regression provided a baseline assessment of sectoral output shares on GDP growth. Results indicated labour ($\beta = 0.588$, $p = .019$) and trade openness ($\beta = 0.063$, $p = .023$) significantly stimulate GDP, while investment showed a marginal negative effect ($\beta = -0.215$, $p = .068$). The model's R^2 was 0.41 with a significant F statistic ($p = .037$) and

no major diagnostic violations. Residual patterns suggested underlying dynamics and potential non-stationarity, prompting more robust modelling. Consequently, the OLS estimates were treated as preliminary, guiding ARDL specification to ensure credible long-run inference in line with cointegration-based structural transformation research (Bal, Dash, & Subhasish, 2016).

5. Lag Selection and ARDL Bound Test

Table 6 shows that a lag length of one minimises the Akaike Information Criterion (AIC = 30.002). The ARDL bounds test reports an F statistic of 8.09, exceeding the one percent upper critical bound of 4.43, confirming cointegration and a stable long run relationship between structural transformation variables and GDP.

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Figure 3 presents the CUSUM and CUSUMSQ plots used to assess the stability of the ARDL model parameters over the study period. Both statistics remain entirely within the 5 per cent significance boundaries, indicating the absence of structural breaks, parameter drift, or variance instability. This confirms that the estimated coefficients are stable across time and that neither policy shifts nor macroeconomic disturbances, such as the 2014–2016 fiscal crisis or the COVID-19 shock, introduced distortions strong enough to invalidate the model's long-run dynamics. The stability of the recursive residuals, therefore, validates the robustness of the ARDL specification and reinforces confidence in the reliability of the long-run and short-run estimates presented in the study.

7. Johansen Cointegration Results

Table 9 reinforces this conclusion, as both the trace and maximum eigenvalue statistics confirm four cointegrating relationships at the 5% level. This indicates long-term interdependence among GDP, industrial output, inflation, investment, labour, services,

trade, and agriculture, consistent with the premise that Ghana's economic structure evolves through complex cross-sector linkages rather than isolated sectoral movements.

8. Robust Estimators: VECM, FMOLS, DOLS, and CCR

The robustness checks show consistency across estimators. The VECM results suggest significant negative effects of industrialisation ($\beta = -2.556$, $p < 0.01$) and agriculture ($\beta = -1.672$, $p < 0.01$) on GDP, while inflation and investment are positive and significant, implying that moderate inflation and capital accumulation stimulate growth under macroeconomic stability. FMOLS and CCR estimators corroborate these patterns: agriculture remains significantly negative ($p < 0.05$), while labour remains a significant positive driver ($p < 0.01$). These findings affirm the persistence of *structural imbalance*, where services outperform goods-producing sectors, consistent with findings by Dorosh and Thurlow (2018) in African economies.

9. Variance Decomposition and Impulse Response

The variance decomposition analysis indicates that by the tenth forecast period, industrial output explains approximately 29.5% of GDP variations, while services contribute 14.9% and labour 10.2%. Agriculture contributes minimally (<1%). The impulse response plots (Figure 4) further confirm that positive shocks to industrial output and services lead to sustained increases in GDP, whereas agricultural shocks have limited long-term effects. These dynamics affirm that Ghana's economic transformation remains anchored in industry and services, while agriculture's multiplier effects are diminishing.

V. Discussion of Findings

The analysis shows that Ghana's structural transformation has been gradual and uneven, falling short of the productivity-driven shift expected in classical and modern growth theories. ARDL results indicate positive long-run effects of industry, services, and investment on GDP, while inflation and trade openness show mixed impacts. Overall, transformation remains hindered by macroeconomic instability and weak industrial productivity. The findings offer partial support for the Lewis dual sector model (Lewis, 1954), which argues that growth occurs when surplus agricultural labour shifts into a higher productivity industry. Ghana's industrial growth in construction, extractives, and light manufacturing aligns with this claim; however, the industry's limited capacity to absorb labour contradicts the model's assumption of unlimited labour absorption. This

gap reflects a persistent productivity trap where industrial expansion fails to generate broad employment or technological upgrading (Dorosh & Thurlow, 2018).

The findings align with endogenous growth theory (Romer, 1990), emphasising human capital, innovation, and knowledge as drivers of long-term growth. Positive investment and services elasticities suggest technologically adaptive sectors—finance, telecommunications, education—generate productivity spillovers. Low R&D expenditure (<1% of GDP) limits innovation and endogenous growth potential. The results also support Kuznets' structural shift hypothesis (1973), with agriculture declining from 45% of GDP in 1990 to under 20% in 2023, and services rising to nearly 40%. However, the prevalence of low-value, non-tradable services reflects a premature services-led transformation, consistent with trends across Sub-Saharan Africa (Lee & McKibbin, 2018; Loizou *et al.*, 2019).

The empirical findings are consistent with existing literature. Short-run agricultural effects are strong but long-run elasticity weakens, as reported by Nyamekye *et al.* (2021) and Awunyo-Vitor and Sackey (2018). Trade openness and industrialisation support growth, contingent on governance and stability (Adu-Gyamfi *et al.*, 2019; Akhter *et al.*, 2022). Inflation constrains investment and long-term output, reflecting macroeconomic instability (Bhatti *et al.*, 2024). Services now dominate growth, consistent with Dorosh and Thurlow's (2018) services-led transformation, which raises GDP but offers limited employment, highlighting capital-intensive, urban-focused expansion. Rahaman *et al.* (2023) describe Ghana's transformation as broad but shallow, reflecting persistent sectoral productivity gaps. Industrial output positively influences GDP, as global evidence suggests (Amir *et al.*, 2025), but Ghana's growth is concentrated in extractives, limiting jobs and value addition, underscoring the need for manufacturing, agro-processing, and technology-intensive expansion.

Overall, the findings show that Ghana's structural transformation remains incomplete and uneven. Persistent inflation, limited technological adoption, and weak export diversification constrain industrial and agricultural performance. Sustainable transformation, therefore, requires productivity gains, stronger innovation capacity, and improved institutional quality, supported by macroeconomic stability, infrastructure investment, and industrial policies that prioritise human capital development.

VI. Conclusions

The study examined the relationship between structural transformation and economic growth in Ghana from 1990 to 2023 using WDI data and robust econometric techniques.

The results show that although industry and services increasingly drive growth, agriculture's weak performance, macroeconomic instability, and structural rigidities continue to constrain transformation. Ghana's growth has therefore been service-led but insufficiently productivity-driven, resulting in an incomplete and uneven transformation trajectory. The study reinforces the relevance of the Lewis dual sector model, the Kuznets structural shift hypothesis, and Romer's endogenous growth theory, while extending their applicability to a lower-middle-income economy experiencing a service-led transition. It shows that modern structural transformation goes beyond the agriculture–industry pathway to include service innovation, technological diffusion, and digital integration. This synthesis provides an integrated theoretical lens linking sectoral change, innovation capacity, and long-run productivity.

VII. Policy Recommendations

The findings highlight key policy priorities to accelerate Ghana's structural transformation. Industrial diversification toward manufacturing and agro-processing, supported by fiscal incentives, reliable energy, and affordable credit, is crucial. Agricultural modernisation through mechanisation, irrigation, and technology adoption can boost productivity and linkages with industry. Investment in human capital and innovation, macroeconomic stability, export diversification, and leveraging ICT-enabled services will enhance productivity and SME growth. Strengthening institutions, governance, and evidence-based policy execution will improve transparency and implementation. Collectively, these strategies foster a more productive, inclusive, and resilient transformation, supporting sustainable long-term growth and structural development in Ghana.

VIII. Directions For Future Research

Future research should use firm-level and regional data to examine productivity, innovation, and employment disparities, guiding decentralised industrial policy. Studies should explore environmental and social dimensions, including green growth and inclusivity, and integrate digitalisation indicators to assess ICT's role in structural transformation. Advanced methods and cross-country comparisons can enhance insights and generalisability.

IX. Final Synthesis

In conclusion, the study offers an innovative and empirically grounded perspective on Ghana's structural transformation. It bridges classical development theory with

contemporary realities by highlighting the importance of innovation, institutional efficiency, and sectoral interdependence. The originality of its approach, methodological rigour, and contextual relevance provide new pathways for both academic inquiry and practical policymaking. Ghana's transformation, though incomplete, holds immense potential if guided by coherent industrial policy, technological advancement, and sustained macroeconomic stability. The study thus contributes significantly to the advancement of knowledge on transformation economics and offers a framework for accelerating Ghana's journey toward inclusive, resilient, and sustainable economic growth.

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TABLES AND FIGURES

Table 1: Variable Description

Variable	*Description*	*Measurement*	*Expected Sign*	*Source*
GDP	Economic growth	Annual percentage growth rate of real GDP	Dependent variable	WDI (2024)
IND	Industrialisation	Industry value added (% of GDP)	Positive	WDI (2024)
INF	Inflation	Annual percentage change in CPI	Negative	WDI (2024)
INV	Investment	Gross capital formation (% of GDP)	Positive	WDI (2024)
LAB	Labour force	Labour force participation rate (% ages 15+)	Positive	ILO (2024)
SER	Services sector	Services value added (% of GDP)	Positive	WDI (2024)
TRD	Trade openness	Exports + imports (% of GDP)	Positive	WDI (2024)
AGR	Agriculture	Agriculture value added (% of GDP)	Mixed	WDI (2024)

Table 2: Variable Description and Expected Signs

Symbol	*Variable*	*Description*	*Expected Sign*
GDP	Gross Domestic Product	Proxy for economic growth	—
IND	Industrial Output	Contribution of industry to GDP	+
INF	Inflation Rate	Proxy for price stability	–
INV	Investment	Gross capital formation (% of GDP)	+
LAB	Labour Force	Labour participation rate	+
SER	Services Output	Contribution of services to GDP	+
TRD	Trade Openness	(Exports + Imports)/GDP	+
AGR	Agriculture Output	Contribution of agriculture to GDP	±

Table 3: Descriptive statistics

	GDP	*IND*	*INF*	*INV*	*LAB*	*SER*	*TRD*	*AGR*
Mean	2.706	25.295	23.573	20.304	71.756	37.612	74.251	29.928
Median	2.186	25.241	18.229	20.511	72.369	39.203	70.332	30.201
Maximum	11.337	34.090	84.683	29.002	77.563	48.181	116.048	45.510
Minimum	-1.468	16.773	8.481	10.848	63.415	26.246	42.488	17.323
Std. Dev.	2.382	4.876	15.216	4.975	4.283	8.002	17.774	8.919
Skewness	1.529	-0.143	2.190	-0.035	-0.508	-0.169	0.429	0.063
Kurtosis	6.413	2.224	8.915	1.997	2.222	1.344	2.850	1.644
Jarque-Bera	29.745***	0.968	76.734***	1.431	2.321	4.049	1.075	2.626
Probability	0.000	0.616	0.000	0.489	0.313	0.132	0.584	0.269
Observations	34	34	34	34	34	34	34	34

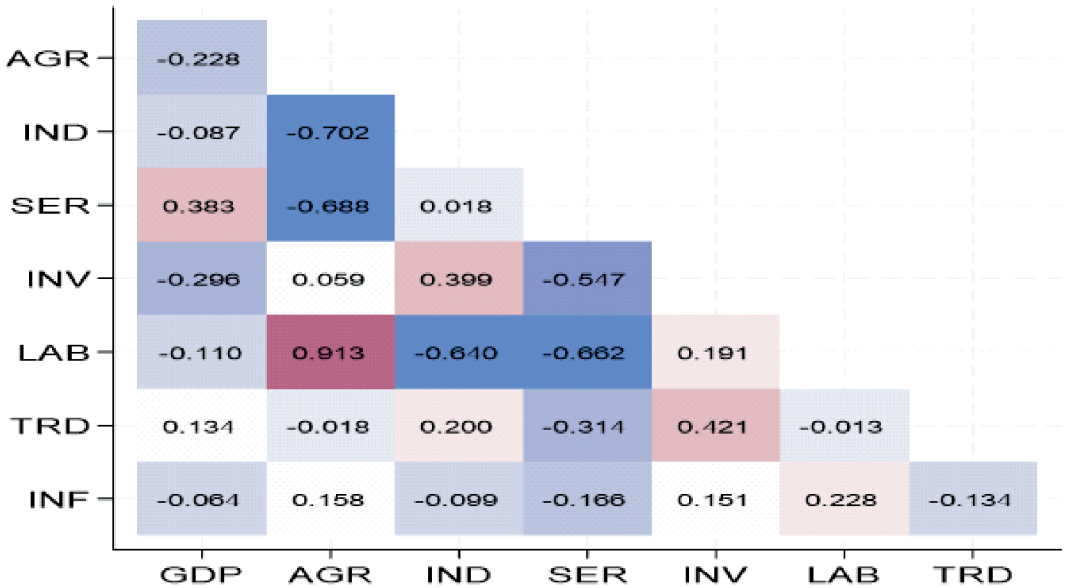

Figure 1: Correlation matrix

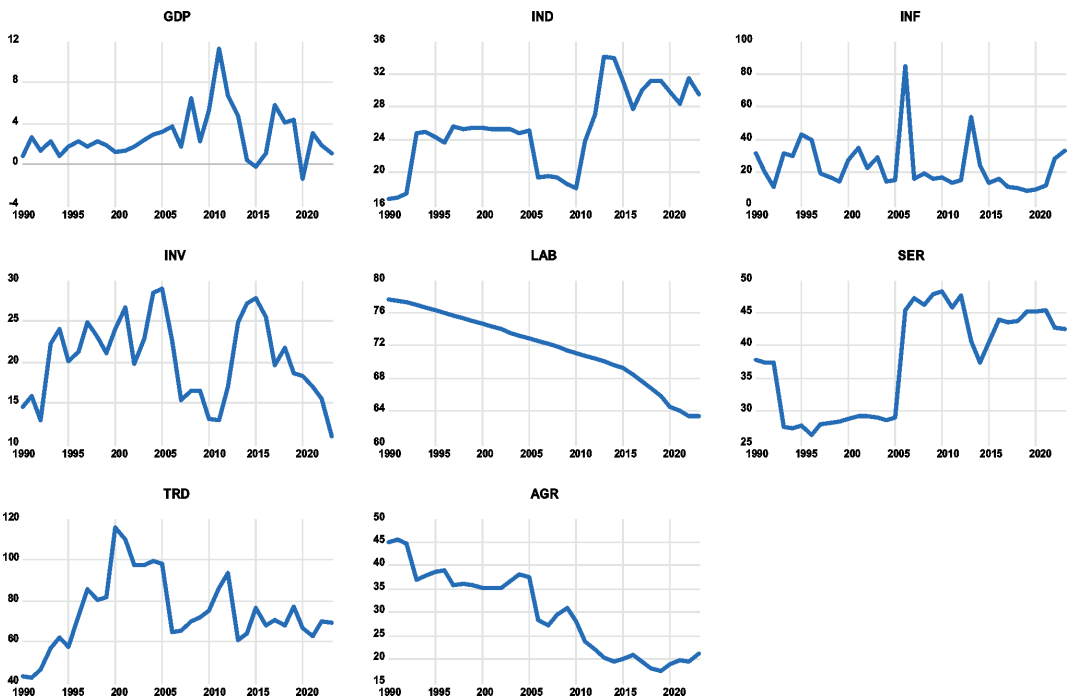

Figure 2: Trends of macroeconomic indicators for Ghana (1990-2023)

Table 4: Stationarity test results

Variable	*ADF*	*PP*
GDP	-3.766***	-3.800***
IND	-2.015	-2.120
INF	-5.261***	-5.243***
INV	-2.701*	-2.446
LAB	2.196	3.331***
SER	-1.305	-1.394
TRD	-2.515	-2.520
AGR	-1.404	-1.705
ΔGDP	-7.743***	-16.677***
ΔIND	-4.776***	-4.691***
ΔINF	-6.300***	-22.476***
ΔINV	-4.893***	-4.869***
ΔLAB	-1.139	-3.170**
ΔSER	-5.115***	-5.115***
ΔTRD	-5.573***	-5.908***
ΔAGR	-5.309***	-5.886***

Table 5: OLS Regression Test Results

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
IND	0.154	0.272	0.566	0.576
INF	0.007	0.025	0.264	0.794
INV	-0.215	0.113	-1.905	0.068
LAB	0.588	0.235	2.501	0.019
SER	0.191	0.178	1.072	0.293
TRD	0.063	0.026	2.412	0.023
AGR	-0.134	0.211	-0.638	0.529
C	-47.065	26.854	-1.753	0.091
R-squared	0.410	Akaike info criterion	4.487	
F-statistic	2.580	Schwarz criterion	4.846	
Prob(F-statistic)	0.037	Hannan-Quinn criterion.	4.610	
		Durbin-Watson stat	2.014	
Model Diagnostics				
		Test stat		
Normality test		0.401 (0.818)		
Serial Correlation Test		0.208(0.814)		
Heteroskedasticity		1.060(0.416)		

Note: p-values in parentheses ()

Table 6: Lag Selection Criteria

Lag	*LogL*	*LR*	*FPE*	*AIC*	*SC*	*HQ*
0	-611.126	NA	142000000.000	38.633	38.954	38.739
1	-424.036*	280.637*	27251.380*	30.002*	32.567*	30.852*
2	-377.700	49.232	52032.890	30.169	34.978	31.763

Table 7: ARDL Bound Test results

Model	F-statistic		t-statistic	
GDP= f (IND, INF, INV, LAB, SER, TRD, AGR)	8.090**		-5.804***	
Significance level	$I(0)$	$I(1)$	$I(0)$	$I(1)$
10%	2.120	3.230	-2.570	-4.040
5%	2.450	3.610	-2.860	-4.380
1%	3.150	4.430	-3.430	-4.990

Note: Asterisks (***) indicate rejection of the null hypothesis at the 1percent level of significance

Table 8: ARDL test results

Short-run estimates Selected model: ARDL (1,1,1,0,1,1,1)				
Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
ΔIND	0.441**	0.213	2.072	0.048
ΔINF	-0.012	0.014	-0.895	0.379
ΔLAB	3.141***	1.019	3.083	0.005
ΔSER	0.215	0.141	1.528	0.139
ΔAGR	-0.169	0.151	-1.121	0.273
ECT_{t-1}	-1.037***	0.121	-8.580	0.000
C	32.135***	3.693	8.701	0.000
Long-run estimates				
IND	-0.557*	0.296	-1.880	0.071
INF	-0.059	0.036	-1.635	0.114
INV	0.006	0.100	0.061	0.951
LAB	0.115	0.235	0.489	0.629
SER	-0.179	0.165	-1.083	0.288
AGR	-0.448*	0.220	-2.042	0.051
Diagnostic tests				
R-squared	0.757			
Adjusted R-squared	0.700			
Normality, p-value	0.582			
Serial correlation, p-value	0.777			
Heteroskedasticity, p-value	0.923			
Ramsey RESET, p-value	0.312			

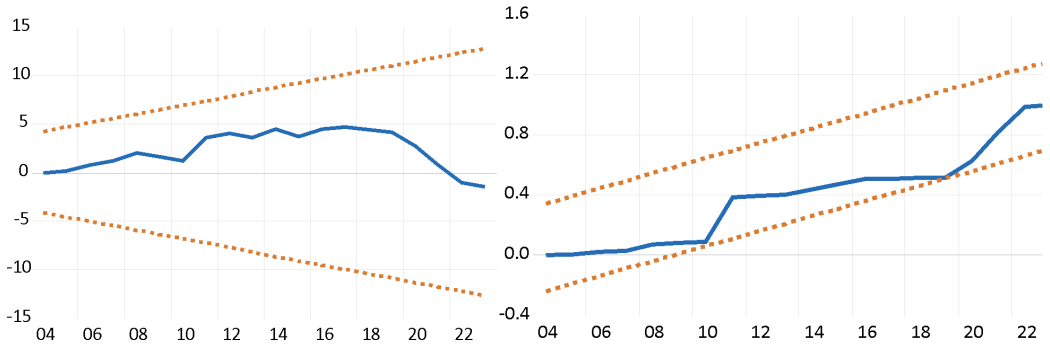

Figure 3: Plots of the cumulative sum of recursive and the cumulative sum of squares of recursive residuals.

Table 9: Outcome of Johansen Cointegration test

Hypothesised No. of CE(s)	*Eigenvalue*	*Trace Statistic*	*Critical value (5%)*	*P-value*
None *	0.800	162.823	125.615	0.000
At most 1 *	0.672	111.395	95.754	0.003
At most 2 *	0.545	75.728	69.819	0.016
At most 3 *	0.486	50.541	47.856	0.027
At most 4	0.418	29.232	29.797	0.058
At most 5	0.225	11.929	15.495	0.160
At most 6	0.111	3.776	3.841	0.052
Hypothesised No. of CE(s)	Eigenvalue	Max-Eigen Statistic	Critical value (5%)	P-value
None *	0.800	51.429	46.231	0.013
At most 1	0.672	35.667	40.078	0.145
At most 2	0.545	25.187	33.877	0.372
At most 3	0.486	21.308	27.584	0.258
At most 4	0.418	17.303	21.132	0.158
At most 5	0.225	8.153	14.265	0.363
At most 6	0.111	3.776	3.841	0.052

Table 10: Robust test results

Method	Constant	IND	INF	INV	LAB	SER	AGR
VECM	224.982	-2.556***	0.093***	0.611***	-0.999***	-1.510***	-1.672***
		(0.132)	(0.018)	(0.076)	(0.120)	(0.078)	(0.009)
FMOLS	-11.529	-0.173	-0.004	-0.131*	0.445***	-0.021	-0.325**
	(16.634)	(0.176)	(0.017)	(0.075)	(0.158)	(0.115)	(0.144)

DOLS	-52.731	0.642	-0.028	-0.066	0.027	0.547	0.631
	(50.123)	(0.546)	(0.030)	(0.128)	(0.267)	(0.309)	(0.352)
CCR	-9.046	-0.205	0.005	-0.115	0.418**	-0.024	-0.331**
	(19.339)	(0.201)	(0.026)	(0.101)	(0.199)	(0.123)	(0.160)

Table 11: Variance decomposition outcome

Period	*S.E.*	*GDP*	*IND*	*INF*	*INV*	*LAB*	*SER*	*AGR*
1	2.469	100.000	0.000	0.000	0.000	0.000	0.000	0.000
2	2.815	82.771	10.068	5.246	0.070	0.919	0.866	0.061
3	3.120	68.136	24.594	4.298	0.057	0.963	1.855	0.098
4	3.513	55.640	26.781	5.893	0.240	4.255	6.795	0.395
5	3.720	49.959	27.329	5.717	0.392	6.896	9.297	0.410
6	3.865	46.569	26.803	6.084	0.399	8.040	11.709	0.395
7	4.070	44.546	26.022	6.063	0.670	9.399	12.930	0.372
8	4.223	42.276	26.729	6.006	0.692	9.954	13.939	0.404
9	4.371	40.091	28.428	6.061	0.646	10.240	14.117	0.416
10	4.510	37.757	29.544	6.558	0.617	10.244	14.851	0.428

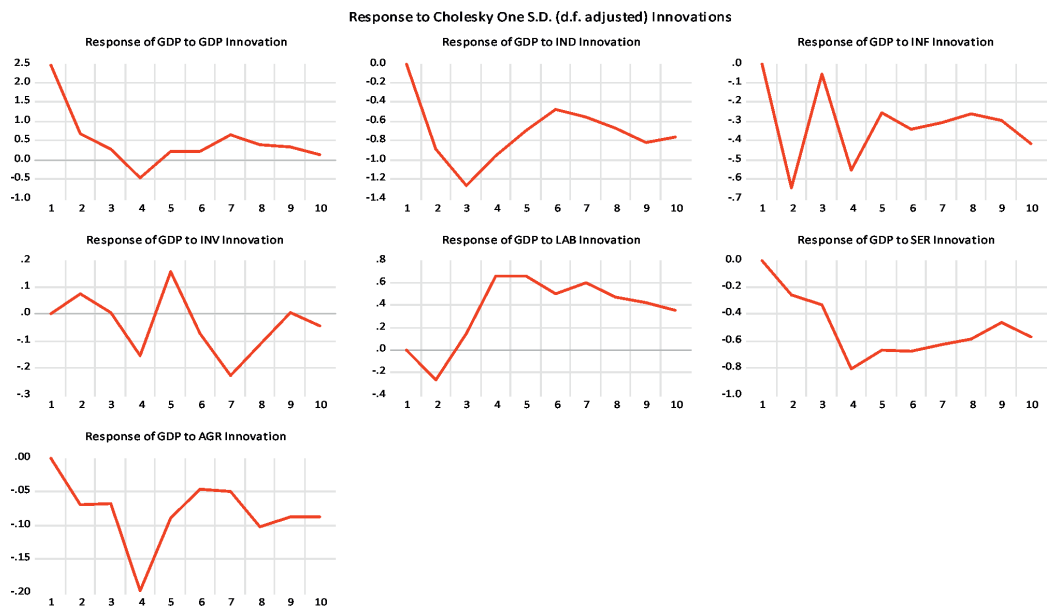

Figure 4: Plots of the impulse response of the VECM