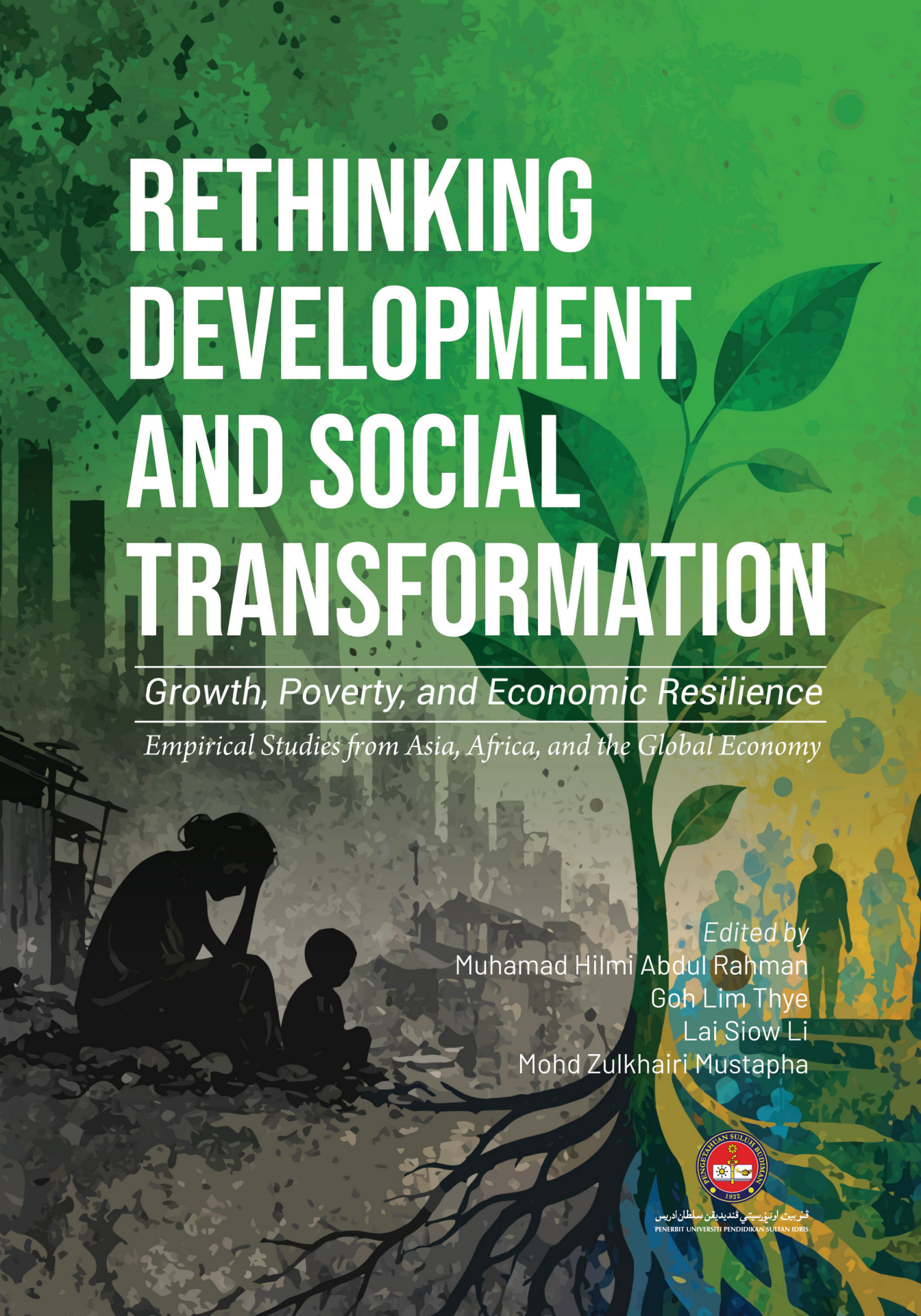
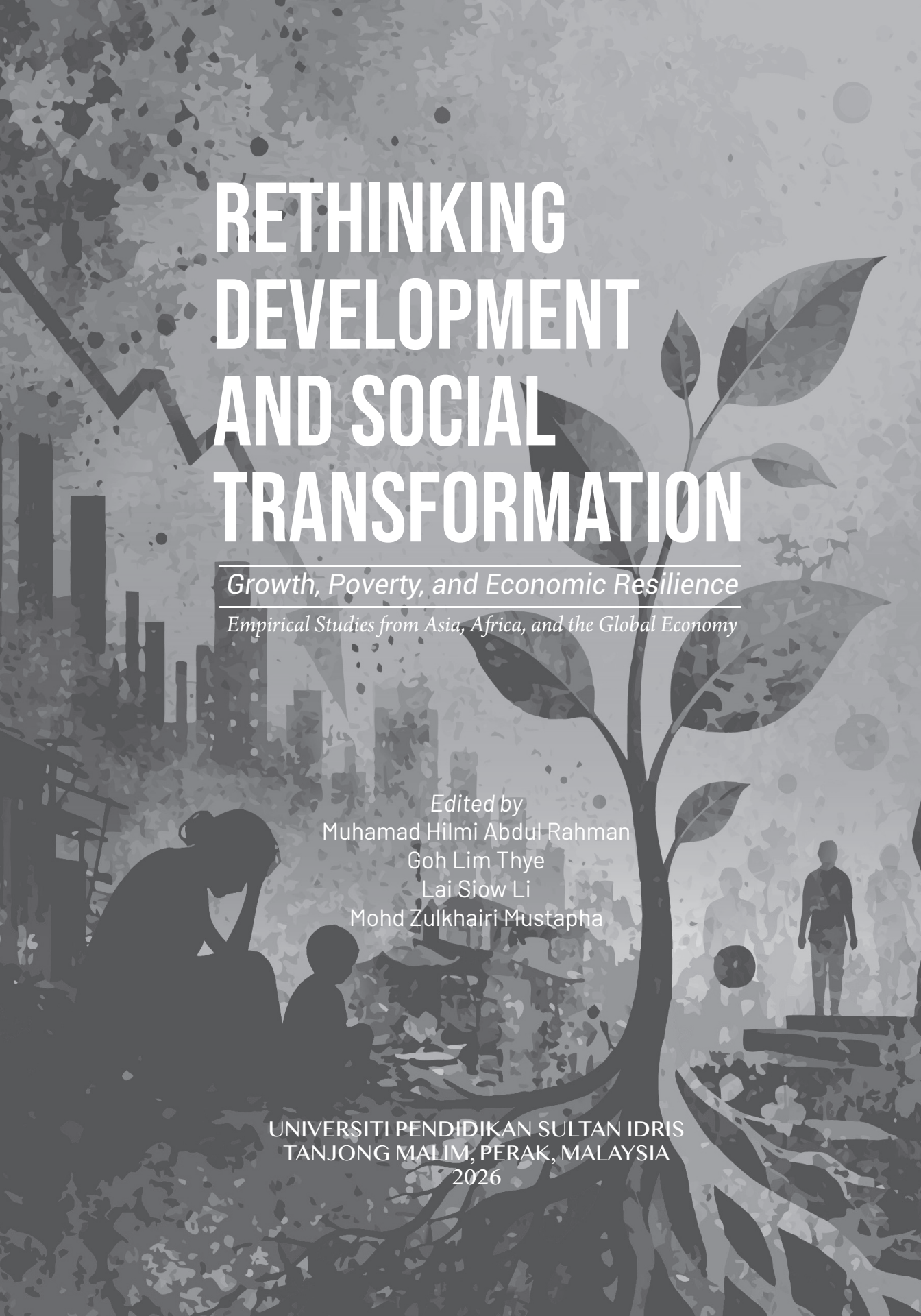

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Chapter 1

Introduction

Muhamad Hilmi Abdul Rahman[1*], Goh Lim Thye[1], Lai Siow Li[1] and Mohd Zulkhairi Mustapha[1]
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Abstract Rethinking Development and Social Transformation was conceived to examine the complex relationships between growth, poverty, and economic resilience through empirical studies across Asia, Africa, and the global economy. Relying on unidimensional indicators often leads to narrow, single-discipline perspectives. In contrast, adopting a multidisciplinary approach deepens our collective understanding and enhance the collaboration between discipline through cross-disciplinary connections to redefine, remeasure, and reconceptualize the multidimensional nature of contemporary development challenges. Overall, eight chapters in this book empirically aims to bridge macro-level development strategies with ground-level socio-economic realities, offering actionable insights for policymakers to build comprehensive resilience against external shocks. The chapters illustrate how structural transformations directly impact national economic trajectories.

Keywords: Global Development; Multidisciplinary Research; Structural Transformation; Socio-Economic Disparities; Empirical Studies

1.1 Global Economic and Institutional Experiences

The global economic uncertainty in the 2020s is defined by a profound multi-dimensional structural transformation. Historically, conventional economic paradigms anchored long-term prosperity in capital accumulation, labour force expansion, technological progress, and abandoned trade liberalization. The Solow-Swan classical model, for instance, framed economic output primarily through exogenous technological change and physical capital inputs, establishing that sustained growth relied on steady-state capital deepening. Subsequent endogenous growth models, pioneered by Lucas and Romer, expanded this horizon by demonstrating that knowledge creation, human

capital accumulation, and internal innovation drive productivity from within economic systems [6-10].

However, these classical and neoclassical frameworks routinely treated environmental sustainability and geopolitical stability as external abstractions. Today, the global economy faces intersecting crises that demand an integrated theoretical approach. Climate change imperatives have forced a transition toward low-carbon growth, while escalating trade protectionism, geopolitical fragmentation, and post-pandemic supply chain disruptions have fundamentally altered the mechanics of global development. To navigate this landscape, modern development economics synthesizes three core theoretical streams, including:

(a) Endogenous growth and sustainable energy. Reframing clean energy adoption not merely as a cost of climate mitigation, but as an endogenous means for structural industrial upgrading, technological diffusion, and long-run productivity gains.
(b) Keynesian demand-side. Re-emphasize the critical stabilizing role of domestic expenditure encompassing household consumption, public investment, and capital formation in buffering national economies against volatile external trade environments.
(c) Spatial, structural, and spatial integration theories. Analyse how infrastructure investments such as logistics and transit corridors and structural shifts such as export diversification and urbanization alter local economic geography, lower transaction costs, and shape internal factor mobility.

1.2 Core Pillars and Thematic Focus of the Book

This book explores these evolving macroeconomic and structural drivers across distinct economic contexts, spanning the major advanced and emerging economies of the G20, dynamic industrializing states in Southeast Asia and East Asia, and developing nations in Sub-Saharan Africa. Through rigorous empirical models, panel econometrics, time-series estimations, and qualitative case studies, the collective chapters evaluate four core pillars shaping contemporary development.

Pillar 1, Sustainable Energy Transitions and Macroeconomic Performance focuses on the transition from fossil-fuel dependency to renewable energy sources (REC) including solar, hydro, wind, and bioenergy represent both an environmental necessity and a macroeconomic growth strategy. In major advanced and emerging economies, green energy adoption decouples economic output from carbon emissions, reduces vulnerability to volatile global oil markets, and stimulates capital formation in high-tech industrial sectors.

Pillar 2, Trade Realignment, Protectionism and Export Diversification. For decades, trade openness was considered an unconditional engine of growth. However, escalating tariff conflicts, strategic economic nationalism, and weaponized interdependence among major economic powers have weakened traditional trade linkages. Consequently, emerging economies face an urgent mandate to shift from primary commodity dependence toward structural export diversification, broadening both product sophistication and international partner networks to absorb trade shocks.

Strategic Infrastructure Investment and Regional Integration is discussed under Pillar 3. Large-scale infrastructure initiatives serve as foundational drivers of economic growth by accelerating capital accumulation and reducing logistics costs. When integrated across borders, strategic transit corridors redefine regional logistics hubs, lower cross-border transaction barriers, and foster comparative advantage division among neighbouring states. However, these mega-projects simultaneously introduce complex challenges regarding sovereign debt sustainability, capacity bottlenecks, and spatial center-periphery imbalances.

Pillar 4, Socio-Economic Inclusivity, Structural Bottlenecks, and Institutional Realities. Macroeconomic output cannot be analysed in isolation from domestic structural conditions. Sustainable growth depends on labour market dynamics, regional income distribution, human capital formation, and institutional quality. In transitioning and multi-ethnic regions, persistent challenges ranging from urban-rural disposable income gaps and structural youth unemployment to cultural dimensions of poverty can impair domestic demand and impede long-term economic convergence

1.3 Chapter Structure and Case-Study Coverage

The chapters in this volume provide a multi-layered analysis of these macro and microeconomic situations blending global econometric modelling with focused country-level evaluations. Macroeconomic drivers in the G20 evaluates how renewable energy consumption, industrial value-added, gross national expenditure, and trade openness interact across G20 nations under escalating protectionism. Utilizing a static panel data framework spanning 2005 to 2022, empirical model selection identifies the Random Effects Model as optimal, controlling for unobserved national heterogeneity. The findings demonstrate that renewable energy adoption, industrial value addition, and internal domestic spending significantly drive GDP growth, whereas trade openness loses its traditional growth effect amid global trade conflicts.

Export diversification in Malaysia investigates Malaysia's structural transformation from a primary commodity exporter to a high-value manufacturing hub particularly in electrical and electronics using an Autoregressive Distributed Lag (ARDL) bounds testing approach (1990–2022). The empirical evidence confirms a statistically significant long-run positive relationship between export diversification and real GDP growth, demonstrating how broadening export sectors strengthens macroeconomic resilience.

Infrastructure-led growth and regional integration in Kenya analyzes Kenya's Standard Gauge Railway (SGR), a flagship Belt and Road Initiative (BRI) project connecting Mombasa to Nairobi and Naivasha. Employing a mixed-methods design grounded in Solow's capital accumulation model, endogenous growth theory, and spatial economics, the chapter evaluates short-term GDP stimulation, job creation, and long-term industrial spillover effects. It also examines regional trade enhancement within the East African Community (EAC) alongside persistent headwinds such as debt sustainability, capacity limits, and local technological absorption constraints.

Domestic Circulation and Labor Markets in China: Examines China's strategic transition toward a domestic circulation model and the impacts of its Rural

Revitalization policy across 31 provinces from 2019–2023. Utilizing a standardized panel data framework, the empirical findings demonstrate that trade openness yields diminishing or negative returns during global trade instability, while unemployment significantly suppresses economic growth. The analysis delves into the paradoxical positive relationship between the urban-rural disposable income gap and short-term provincial GDP output, highlighting how capital concentration in urban centers challenges equitable development targets.

Cultural poverty and rural development chapter explores the micro-foundations of persistent poverty through a qualitative case study of the Yi ethnic group in Liangshan Yi Autonomous Prefecture, Sichuan. Utilizing twenty in-depth interviews across local social roles. The chapter examines how traditional family branch values, fatalistic beliefs, costly ritual spending, and geographic isolation interact with structural barriers. It outlines pathways through which younger generations leverage education and migration to overcome intergenerational poverty while advocating for culturally responsive public policies.

1.4 Synthesis of Findings and Policy Deliverability

To provide robust, empirical, and context-sensitive evidence, the studies in this volume deploy a diverse suite of quantitative and qualitative analytical methods. Panel data econometrics such as Fixed and Random Effects Models are used for multi-country and regional investigations such as G20 economies and Chinese provinces to control for unobserved cross-sectional heterogeneity and isolate temporal shifts across dynamic variable sets. Diagnostics such as the Chow Test, Breusch-Pagan Lagrange Multiplier (LM) Test, and Hausman Test are rigorously applied to ensure proper model specification.

ARDL Bounds Testing and ECM Frameworks are applied in single-country longitudinal time-series analyses to evaluate cointegration and distinguish between short-run dynamic adjustments and long-run equilibrium relationships among integrated variables. Mixed-methods growth accounting combines theoretical macroeconomic growth models such as Solow-Swan and Endogenous Growth with spatial trade and logistics metrics to measure infrastructure productivity, transit container throughput, wage employment shifts, and cross-border trade flows. Qualitative thematic analysis deploys semi-structured, in-depth fieldwork interviews and primary document triangulation to dissect qualitative social phenomena, cultural belief structures, and intergenerational poverty transmission mechanisms.

First, domestic expenditure and internal market strength represent essential macroeconomic stabilizers. In an era of unpredictable global tariffs and economic nationalism, fostering robust internal aggregate demand buffers economies from international trade contractions. Second, green energy transitions are vital industrial strategies. Investments in clean energy stimulate technological innovation, generate green employment, and reduce reliance on volatile fossil fuel markets [1-2].

Third, large infrastructure investments require institutional frameworks that safeguard fiscal sustainability and facilitate local technology absorption. Without proactive debt management and domestic industrial integration, capital-intensive

infrastructure risks creating financial strain [3-4]. Finally, structural economic reform must operate alongside inclusive social policies [5]. Addressing regional income disparities, resolving labour market mismatches, and dismantling cultural and educational barriers to social mobility are necessary prerequisites for sustainable growth.

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Chapter 2

Drivers of Economic Growth in G20 Economies: Renewable Energy, Domestic Expenditure, and Political Trade Tensions

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Abstract The global emphasis on environmental sustainability has accelerated efforts to increase renewable energy consumption. However, whether green energy consumption effectively contributes to economic growth remains a key question. Addressing this gap, the study investigates the impact of renewable energy and domestic consumption on economic growth within the G20 economies during 2005–2022. Employing a static panel data framework, the analysis incorporates gross domestic product as the dependent variable, with renewable energy consumption, industry value added, gross national expenditure, and trade openness as explanatory variables. This analysis takes place against escalating geopolitical trade tensions and tariffs reshaping the global economic landscape. Rigorous model selection tests identify the random effects model as fit model, accommodating country-specific heterogeneity across the panel. Empirical findings reveal that renewable energy consumption, industry value added, and gross national expenditure significantly and positively influence GDP growth, underscoring the critical roles of green energy adoption and robust domestic economic activity in facilitating sustainable growth. Conversely, trade openness appears statistically insignificant, a result plausibly linked to the dampening effect of trade conflicts and rising economic nationalism among G20 countries. The model accounts for over 95% of GDP variability, reflecting robust explanatory power. The findings underscore the importance of fostering renewable energy adoption and strengthening internal economic demand as resilient growth strategies in an era of geopolitical uncertainty and protectionist trade policies.

Keywords: GDP; G20 countries; Renewable Energy; Domestic Expenditure; Trade

2.1 Introduction

The global economic landscape has undergone profound transformations in recent decades, characterized by rapid technological advancements, sweeping energy transitions, and shifting international trade patterns and geopolitical alignments [1]. Within this evolving context, the question of what fundamentally drives economic growth in major economies is both critical and complex. The G20 group of countries (Fig. 1), representing the world's largest advanced and emerging economies, is at the forefront of this transformation. Their policies, economic performance, and geopolitical maneuvers significantly influence global economic stability and growth prospects [2]. Conventional economic growth theories have long emphasized the primacy of capital accumulation, labor force expansion, technological innovation, and trade liberalization. In particular, trade openness, characterized by lower tariffs and fewer trade barriers, has historically been promoted as a key mechanism to stimulate growth by fostering comparative advantage, increasing market access, and facilitating knowledge and technology transfer [3]. The post-World War II economic order, exemplified by institutions such as the World Trade Organization, was structured around the assumption that globalization and deeper economic integration would underpin sustainable growth and development [4].

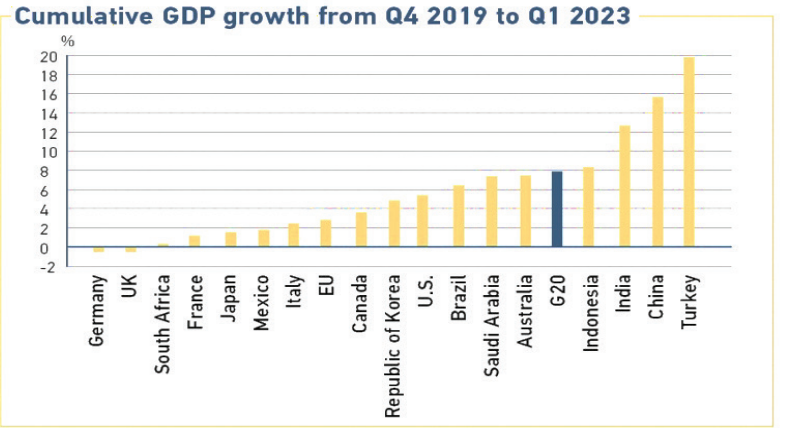


Figure 1 G20 Countries
Source: [5]

However, the global economic order underpinning this paradigm has faced unprecedented challenges in the last two decades. The rise of protectionist political movements, the resurgence of nationalism, and the escalation of trade conflicts, most notably between major economies such as the United States, China, and members of the European Union, have injected uncertainty into the future of global trade. The recent tariff wars among G20 countries illustrate a retreat from the previously dominant neoliberal trade consensus [6]. These developments call into question the conventional wisdom that trade openness unconditionally promotes growth, especially under escalating geopolitical tension. Political trade tensions manifest not only in the

imposition of tariffs and trade barriers but also through broader strategic economic nationalism, industrial policies oriented toward self-sufficiency, and regional trade realignments [7]. Such dynamics can disrupt established global value chains and diminish the benefits of international economic integration. Navigating these tensions is particularly challenging for countries within the G20, which account for approximately 85% of global GDP. The complex interplay between cooperation and competition among these countries reflects broader strategic recalibrations in the global economy [1].

Under these conditions, the economic benefits typically derived from trade liberalization become less predictable. Trade openness may be hindered by uncertainty and risk aversion among investors and businesses, causing firms to seek alternative growth drivers rooted in domestic policies and resources. The escalating political trade tensions and tariff wars among G20 nations highlight a significant retreat from the long-standing neoliberal trade consensus. While G20 nations command roughly 85% of global GDP and possess the massive domestic scale required to cushion external economic shocks through internal expenditure, non-G20 economies face starkly different vulnerabilities. In non-G20 developing nations, a lack of deep domestic markets makes their macroeconomic stability highly dependent on open, predictable trade routes. When G20 superpowers resort to strategic economic nationalism, regional realignments, and protectionism, these smaller non-G20 nations suffer disproportionately from severe supply chain disruptions and diminished technology transfer [8]. Furthermore, they are forced to navigate these growth barriers while simultaneously trying to meet international climate commitments without the equivalent fiscal safety nets or domestic demand buffers enjoyed by larger economies. Therefore, within the modern global economy, the traditional growth paradigm has become highly fragmented and heavily contingent on an economy's structural capacity to withstand geopolitical tension.

At the same time, the global imperative to transition toward sustainable and low-carbon energy systems has emerged as both an environmental necessity and an economic opportunity. Renewable energy consumption, comprising sources such as solar, wind, hydro, and bioenergy, is acknowledged for its potential to mitigate climate change and as a catalyst for innovation, job creation, and economic diversification. For the G20 countries, adopting and expanding renewable energy technologies represents a strategic pathway to decouple economic growth from fossil fuel dependency, reduce vulnerability to volatile energy markets, and align with international climate commitments [8].

Renewable energy's role in economic growth extends beyond the energy sector itself. It stimulates industrial development, technological advancement, and capital investment, which can have multiplier economic effects [9]. As such, incorporating renewable energy consumption into growth models marks a departure from traditional analyses that underestimated environmental dimensions and sustainability concerns. Coupled with the energy transition, the role of domestic economic demand, measured through indicators like gross national expenditure (GNE), has gained renewed attention. Domestic expenditure encompasses household consumption, government spending, and gross capital formation, reflecting internal economic activities that can

sustain growth independently of external trade conditions. Robust domestic demand can buffer economies against external shocks such as trade disruptions, financial crises, and geopolitical instability [10].

Countries with substantial domestic expenditure may be better positioned to maintain growth momentum in the context of rising political trade tensions and global uncertainties. Investing in local industries, infrastructure, and consumer markets creates jobs and income and fosters economic resilience. This shift underscores a more inward-looking, developmentally focused growth paradigm emphasizing self-reliance while balancing global engagement [11]. Given the intersecting trends of geopolitical uncertainty, energy transition, and economic nationalism, it becomes imperative to approach the study of economic growth in a multidimensional and nuanced manner. Isolating individual drivers without regard to the prevailing political and economic context risks oversimplification. For G20 countries, the interplay between renewable energy consumption, domestic expenditure, and trade openness constitutes a complex web of influences that shape growth outcomes [12].

Empirical evidence addressing these interactions remains relatively sparse and inconclusive. While [13] highlights the importance of trade liberalization, others caution that trade openness may fail to translate into expected growth benefits under certain political conditions. Similarly, although renewable energy's environmental role is well documented [6], its direct impact on macroeconomic growth is still being explored. The role of domestic spending as a growth pillar vis-vis external trade factors requires reassessment amid shifting global dynamics. This study aims to fill these critical gaps by examining the key determinants of economic growth in G20 countries from 2005 to 2022, employing a static panel data framework that accounts for country-specific heterogeneity. The study focuses on Gross Domestic Product (GDP) as the primary measure of economic performance, integrating renewable energy consumption (REC), industry value-added (IVA), gross national expenditure (GNE), and trade openness (TO) as core explanatory variables. Importantly, the analysis is situated within the contemporaneous backdrop of escalating political trade tensions, tariff impositions, and evolving protectionist measures across G20 members.

2.2 Literature Review

The study examines the existing body of knowledge related to the main determinants of economic growth, particularly focusing on renewable energy consumption, domestic expenditure, trade openness, and political trade tensions within the context of the G20 economies. By synthesizing theoretical perspectives and empirical findings, the study identifies gaps and debates in the literature that inform the rationale and positioning of the present study. Economic growth theories have evolved significantly, reflecting changing economic realities and intellectual paradigms [14]. Classical growth models, such as those by [15] emphasized capital accumulation, labor growth, and technological progress as primary growth engines. The Solow-Swan model viewed technological change as exogenous and presented diminishing returns to capital, highlighting the importance of sustained technological innovation for long-term growth.

Endogenous growth theories pioneered by [16] and [17] introduced the notion that knowledge, innovation, and human capital actively drive economic growth from within the system. These frameworks emphasize investments in research and development, education, and innovation policies as critical sources of sustained growth. While these models lay foundational insights, they traditionally underplay the role of environmental sustainability and geopolitical factors. More recent scholarship recognizes the need to integrate ecological constraints and political dynamics into growth theory, especially as global economies grapple with climate change and geopolitical unrest [17].

The transition to renewable energy has become a focal point in the discourse on sustainable growth. The environmental imperative to reduce greenhouse gas emissions places energy consumption and production at the core of economic strategies [18]. Renewable energy consumption (REC) is posited as an environmental tool and an economic growth catalyst. Empirical studies have increasingly explored the growth effects of renewable energy adoption. [19] found a positive and significant relationship between renewable energy consumption and GDP growth in a panel of developed and developing countries. Their work suggests that investment in renewables can stimulate economic activity by creating jobs, reducing energy costs, and enhancing energy security. Similarly, [20] emphasized that renewable energy supports economic diversification, particularly in countries heavily reliant on fossil fuels. However, the economic benefits of renewables may vary depending on technological maturity, policy frameworks, and market conditions [21]. Some studies caution that renewables' initial costs and infrastructural challenges may dampen short-run growth effects [22]. Nonetheless, the consensus suggests renewable energy is increasingly integral to sustainable economic trajectories, especially for G20 countries aiming to align economic policies with climate commitments such as the Paris Agreement.

Gross national expenditure (GNE), comprising consumption, investment, and government spending, is a fundamental driver of aggregate demand and economic growth. Keynesian economic theory stresses the role of domestic expenditure in stabilizing economies during periods of crisis [23]. In recent years, literature has revisited the importance of domestic expenditure amid rising global uncertainties. Studies such as [2] argue that countries with strong domestic markets exhibit enhanced resilience to trade disruptions and financial crises. It is especially relevant for G20 economies facing escalating political trade tensions and volatile global markets. Domestic expenditure also influences growth through multiplier effects. Increased infrastructure and social services investment can stimulate productivity and labor participation, reinforcing a virtuous growth cycle [21]. However, excessive reliance on domestic spending without productivity improvements may lead to inflationary pressures and fiscal imbalances [24]

Trade openness (TO) has traditionally been linked with economic growth through comparative advantage, technology diffusion, and efficient resource allocation [25]. Many empirical works support the positive correlation between open trade policies and GDP growth, especially in developing economies seeking export-led growth [6]. However, the geopolitical landscape has shifted considerably. Political trade tensions, involving tariff wars, sanctions, and economic nationalism, challenge the established advantages of trade openness. Recent research investigates how such tensions affect

economic outcomes. [4] illustrates that tariff escalations between G20 members disrupt global value chains, increase production costs, and heighten economic uncertainty, dampening growth prospects. [26] examine how protectionist policies create market distortions and reduce economies of scale, limiting the benefits previously associated with trade liberalization. [27] introduces the concept of 'weaponized interdependence,' where trade linkages become tools or vulnerabilities in geopolitical contestations.

2.3 Method

2.3.1 Panel regression

The study employs a panel data model approach to examine the determinants influencing GDP growth in G20 countries from 2005 to 2022. This approach is essential given the multidimensional and dynamic nature of the data, allowing for the simultaneous analysis of key variables such as renewable energy consumption, industry value added, gross national expenditure, and trade openness. Panel data methodology facilitates capturing both cross-country heterogeneity and temporal variations, thereby providing deeper insights into how structural, economic, and geopolitical factors collectively shape growth patterns over time [11]. By controlling for country-specific effects and time fixed effects, this method effectively isolates unobserved heterogeneity that could bias estimations, resulting in a more robust and nuanced understanding of the determinants of economic growth [28]. Variable descriptions and definitions are detailed in Table 1.

Table 1 *Details of Variables*

Variable	Symbol	Indicator	Source
Gross Domestic Product	GDP	Total market value of all final goods and services produced within a country, measured in constant 2015 USD to reflect overall economic output.	[29]
Renewable Energy Consumption	REC	Share of renewable sources in total final energy consumption, expressed as a percentage.	
Industry Value Added	IVA	Industrial sectors' contribution to total GDP, representing value added to the economy in constant 2015 USD.	
Gross National Expenditure	GNE	Total domestic spending (household, government, and capital formation) in constant 2015 USD, reflecting aggregate demand.	
Trade Openness	TO	Sum of total exports and imports as a percentage of GDP, indicating global economic integration and trade liberalization.	

2.3.2 Regression model estimation

The Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM) are three common approaches used for estimating panel data regression models. The parameters for both the CEM and FEM are estimated using Ordinary Least Squares (OLS). In contrast, the REM parameters are estimated using Generalised Least Squares (GLS), where a dummy variable represents the FEM intercept [30], [31].

(1) ***Standard Effect Model (Pooled OLS)***

$$Y_{it} = \alpha + \beta X_{it} + \epsilon_{it}$$

(2) ***Fixed Effect Model (FEM)***

$$Y_{it} = \alpha_i + \beta X_{it} + \epsilon_{it}$$

(3) ***Random Effect Model (REM)***

$$Y_{it} = \alpha + \beta X_{it} + u_i + \epsilon_{it}$$

Where:

Y_{it} : GDP () at time ().
X_{it} : Vector of explanatory variables for GDP () at time ().
α : Intercept.
β : Coefficient vector.
u_i : Random error term specific to GDP ().
ϵ_{it} : Error term.

2.3.3 Best model selection

Several tests were conducted to determine the appropriate estimation method for the panel data regression, including:

2.3.3.1 Chow Test

The Chow test is used to decide between the Common Effect Model (CEM) and the Fixed Effect Model (FEM) [30].

$$F = \frac{(RSS_C - RSS_F)/(N-1)}{RSS_F/[N(T-1)-K]}$$

Where:

RSS_C : Residual sum of squares for the CEM.
RSS_F : Residual sum of squares for the FEM.
N : Number of cross-sectional units.
T : Number of periods.
K : Number of parameters estimated.

If the calculated F value is greater than the critical F value from the F-distribution table, reject the null hypothesis favouring the Fixed Effect Model.

Table 2 *Chow test result*

Effect Test	Statistic	d.f	Prob.
Cross-section F	589.550296	(19,336)	0.0000
Cross-section Chi-sq.	1273.047434	19	0.0000

Based on the output value above, the Prob Cross Section F value is 0.0000 < alpha 5%, which means that the study rejects H0; thus, the best model is the Fixed Effect Model (FEM).

2.3.3.2 Breusch-Pagan Lagrange Multiplier (LM) Test

The Breusch-Pagan Lagrange Multiplier (LM) Test is employed to determine whether the Random Effect Model (REM) is more appropriate than the Common Effect Model (CEM) [33][32].

$$LM = \frac{NT}{2(T-1)}\left[\frac{\sum_{i=1}^{N}\ \sum_{t=1}^{T}\ (Y_{it} - \overline{Y_i} - \overline{Y_t} + \overline{Y})^2}{\sum_{i=1}^{N}\ \sum_{t=1}^{T}\ (Y_{it} - \overline{Y})^2/NT}\right]$$

If the LM statistics are greater than the critical value from the chi-squared distribution table with *1* degree of freedom, reject the null hypothesis in favour of the Random Effect Model.

Table 3 *LM test result*

Test Summary	Cross-section	Test Hypothesis Time	Both
Breusch-Pagan	2698.895 (0.0000)	9.085447 (0.0026)	2707.981 (0.0000)
Honda	51.95089 (0.0000)	-3.014208 (0.9987)	34.60346 (0.0000)

Continue... (Table 3)

King-Wu	51.95089 (0.0000)	-3.014208 (0.9987)	33.51006 (0.0000)
Standardised Honda	59.08646 (0.0000)	-2.930827 (0.9983)	33.56664 (0.0000)
Standardised King-Wu	59.08646 (0.0000)	-2.930827 (0.9983)	32.27495 (0.0000)
Gourieroux, et al.	--	--	2698.895 (0.0000)

Table 3 shows that the Breusch-Pagan probability value is 0.0000, more significant than the significance level (α = 5%). This result leads to rejecting the null hypothesis (), indicating that the Random Effect Model (REM) is appropriate. However, to definitively determine the most suitable model for this study, whether the Random Effect Model (REM) or the Fixed Effect Model (FEM), it is necessary to conduct the Hausman Test.

2.3.3.3 Hausman Test

The Hausman Test is utilised to determine the suitability between the Fixed Effect Model (FEM) and the Random Effect Model (REM).

$$H = (\beta_{FE} - \beta_{RE})'[Var(\beta_{FE}) - Var(\beta_{RE})]^{-1}(\beta_{FE} - \beta_{RE})$$

Where:

- : Coefficient vector from the Fixed Effect Model.
- : Coefficient vector from the Random Effect Model.
- : Variance-covariance matrix of the Fixed Effect coefficients.
- : Variance-covariance matrix of the Random Effect coefficients.

If the Hausman statistic is larger than the critical value from the chi-squared distribution table with *K* degrees of freedom, reject the null hypothesis in favour of the Fixed Effect Model.

Table 4 *Hausman test result*

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	5.520392	4	0.2379

As shown in Table 4, the random cross-section probability value is 0.0000, which is more significant than the significance level (α = 5%). This result leads to fail to rejection of the null hypothesis (H). Consequently, the Random Effect Model is the most appropriate for this study.

2.4 Findings

Table 5 *Panel Model Estimation Result*

Variables	Coefficient
REC	9.412708**
IVA	1.071623***
GNE	602.430***
TO	-1.88E+09
Effect specification	
Cross-section random	
Observation number	360
R-sq	0.952810
AR^2 Test	0.952278
The F-test	1791.949
Prob(F-statistic)	0.000000

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

2.4.1 Simultaneous Impact of Independent Variables

Hypothesis:

H0 : $\beta 1 = \beta 2 = \beta 3 = \beta 4 = D = 0$,
(All independent variables simultaneously do not affect GDP)

H1 : $\beta 1 \neq \beta 1 \neq \beta 1 \neq \beta 1 \neq D \neq 0$
(All independent variables simultaneously affect GDP)

Referring to Table 5, the probability value of the F-statistic is 0.0000, which is lower than the significance level (α = 5%). This indicates that all independent variables collectively have a statistically significant effect on GDP growth. The F-test results confirm that the overall model reliably explains variations in GDP growth across G20 countries during the study period [34]. This finding implies that the combined influence of renewable energy consumption, industry value added, gross national expenditure, and trade openness, significantly drives economic growth. Such results are consistent with the complex and interconnected nature of growth determinants, which encompass environmental, sectoral, fiscal, and geopolitical factors. This integrative perspective aligns with [35], who emphasize that sustainable energy policies, economic activities, and international trade dynamics interact to shape macroeconomic outcomes.

2.4.2 Individual Variable Analysis: Partial t-tests

Table 6 *Partial t-Test Interpretations*

Variable	Coef	Result
Renewable Energy Consumption	9.412708**	Significant Effect (Reject H0)
Industry Value Added	1,071623***	Significant Effect (Reject H0)
Gross National Expenditure	602,430***	Significant Effect (Reject H0)
Trade Openness	-1.88E+09	No Significant Effect (Fail to Reject H0)

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

2.4.3 Renewable Energy Consumption and GDP

The positive and statistically significant coefficient of renewable energy consumption (coef = 9.412708, $p < 0.05$) corroborates a growing consensus that renewable energy is crucial for environmental sustainability and potent economic growth. This finding challenges the traditional dichotomy that frames environmental protection and economic growth as mutually exclusive objectives. From an endogenous growth perspective, renewable energy embodies a nexus of technological innovation, productivity enhancement, and structural transformation. Investments in renewables promote learning-by-doing, the diffusion of clean technologies, and the enhancement of human capital in emerging green sectors [16]. The G20's increasing integration of renewable energy catalyzes industrial upgrading and diversification, creating dynamic comparative advantages less susceptible to the resource volatility that undermines fossil fuel dependence.

Moreover, renewable energy's positive impact on growth may also derive from improved energy security and reduced exposure to international fossil fuel price shocks. This allows for greater macroeconomic stability, an essential foundation for sustainable expansion. This aspect is especially salient considering the geopolitical volatility in fossil fuel markets and the strategic imperative to reduce carbon-intensive footprints. This study's findings align with [13], [19] who identified renewables as a net contributor to GDP growth. However, the magnitude observed here reflects the accelerated pace at which G20 nations have embraced renewables post-2010, supported by policy instruments like subsidies, carbon pricing, and green finance initiatives. However, it is important to recognize heterogeneity within the G20: countries with advanced renewable infrastructures (e.g., Germany, Canada) may realize these growth benefits more readily than fossil-fuel-dependent economies still grappling with transitional challenges.

The contrast within the G20 heterogeneities illustrates these asymmetric growth dynamics perfectly. For instance, Germany, leveraging its advanced, highly diversified green infrastructure, extensive carbon pricing, and long-term green finance initiatives, can readily translate renewable energy consumption into high-tech industrial modernization and net GDP growth. Conversely, fossil-fuel-dependent economies

like Saudi Arabia face severe structural hurdles, immense infrastructural friction, and painful transitional challenges when attempting to break away from deeply entrenched carbon-intensive economic paths. From a policy perspective, accelerating renewable energy adoption serves as a vital strategic buffer against international trade shocks and weaponized economic interdependence [13]. By aggressively substituting volatile fossil fuel imports with locally generated, decentralized green energy, G20 nations effectively insulate their internal industrial production processes and domestic markets from global tariff wars, supply disruptions, and unpredictable geopolitical price spikes. Investing heavily in domestic renewable energy frameworks thus yields a crucial dual victory: it enables leading economies to meet their international climate mandates under the Paris Agreement while simultaneously safeguarding their strategic economic sovereignty and long-term macroeconomic stability in an era of rising global protectionism [8].

2.4.4 Industry Value Added and Growth

Industry value added's strong positive and highly significant effect (coef = 1.071623, $p < 0.01$) reaffirms the enduring centrality of industrial sectors in driving economic expansion within the G20. While global economic discourse often emphasizes services and digital economies, industrialization remains a backbone, especially in large emerging markets (e.g., India, China) and traditional manufacturing hubs. Theoretically, [36] emphasize that industry-led productivity gains spill over into other sectors, accelerating aggregate growth. Particularly echo this synthesis, suggesting that G20 countries leveraging industrial modernization, particularly via green and high-tech industries, can stimulate long-run growth [37].

In addition, integrating renewable energy into industrial processes may undergo sustainable structural transformation, enhance competitiveness while meet environmental targets. Industrial sectors capable of shifting towards eco-efficient production can create positive externalities in innovation and export diversification. However, sustaining industry-driven growth faces significant headwinds from automation, global value chain reconfigurations, and climate-related regulations [38]. These forces necessitate adaptive industrial policies that reconcile environmental constraints with competitiveness, underscoring the need for complementary innovation policies, human capital development, and infrastructure investments.

2.4.5 Gross National Expenditure in a Turbulent Global Environment

Gross national expenditure's substantial and statistically significant coefficient (coef = 602.430, $p < 0.01$) underscores domestic demand as a critical pillar of economic growth amid rising global uncertainties and trade tensions. This finding resonates strongly with Keynesian and demand-side economic theories emphasizing the centrality of consumption, investment, and government spending in shaping short- and medium-term growth trajectories [23]. This study suggests that robust internal economic demand may buffer G20 economies against external shocks, including tariff wars, geopolitical conflicts, and pandemic-driven disruptions, thereby enhancing

resilience. This internal stability allows countries to maintain employment, investment, and innovation ecosystems even when export markets contract or become volatile [39].

However, this reliance on domestic expenditure is a double-edged sword. At the same time, it safeguards against external vulnerabilities. Excessive dependence on domestic demand fosters macroeconomic imbalances such as inflationary pressures, fiscal deficits, and unsustainable credit growth, especially in economies with structural deficits [40]. Moreover, without productivity gains, demand-led growth can result in stagflation pressures over time. Hence, the significance of GNE compounds the imperative that domestic expenditure growth must be accompanied by improvements in productivity, innovation, and efficiency, a balance that has often proved challenging. The evidence here highlights a critical policy tension. The need to stimulate demand while cultivating supply-side strength, particularly through investments in human capital and technology [2].

2.4.6 Trade Openness Amid Political Trade Tensions

The most striking and theoretically provocative result is the statistically insignificant effect of trade openness on GDP growth (coef = -1.88E+09, not significant). This finding challenges the long-standing orthodoxy that liberalized trade unconditionally promotes economic growth via specialization, technology diffusion, and market expansion [41]. The absence of a growth effect is likely attributed to the era-specific backdrop of this study: the geopolitical fragmentation and escalating tariff conflicts among G20 countries. Tariff wars reduce predictability and trust in trade relationships, disrupt global value chains, and amplify transaction costs, negating usual trade growth benefits [42]. This result resonates with economic nationalism narratives asserting that the gains from trade openness are conditional on geopolitical stability and complementary policies [43]. It reflects a shifting paradigm in which trade openness is no longer a guarantee for growth but a variable contingent on geopolitical dynamics, regulatory environments, and strategic economic sovereignty.

Furthermore, the growth-neutral role of trade openness may be symptomatic of the substitution effect, wherein domestic markets and renewable energy investments increasingly compensate for waning trade benefits. Countries may be consciously reorienting growth models toward self-reliance and strategic inward investment, facing the risk of "deglobalization" and protectionism. While this could signal a temporary cyclical phenomenon, the structural implications are profound: economic growth models must now integrate political economy variables and account for the fragility of trade's growth linkage as global geopolitical fault lines deepen [1], [8].

Table 7 Cross section effect analysis

Country	Effect	Country	Effect
United States	3.04E+12	Russian Federation	-9.09E+10
European Union	2.21E+12	Korea, Rep.	-8.05E+10
China	-2.35E+11	Australia	-4.33E+10

Continue... (Table 7)

Japan	1.02E+11	Mexico	-1.53E+11
Germany	3.42E+11	Indonesia	-2.47E+11
United Kingdom	3.55E+11	Saudi Arabia	-2.43E+11
France	2.85E+11	Turkiye	-4.84E+12
India	-1.01E+11	Argentina	-1.81E+11
Italy	1.04E+11	South Africa	-1.79E+11
Brazil	-3.56E+09	Canada	-3.44E+10

The cross-section effect analysis reveals significant variation in GDP impacts across G20 countries, highlighting the diverse ways economic growth drivers function within national contexts. The United Kingdom exhibits the highest positive cross-section effect at approximately 3.55×10^{11} million USD, suggesting that factors such as domestic expenditure, renewable energy adoption, and industrial value addition are particularly effective in boosting its economy [44]. In contrast, the Russian Federation displays the largest negative effect, around -9.09×10^{10} million USD, indicating that these growth drivers are less effective or potentially constrained by geopolitical tensions, structural issues, or institutional challenges [1]. The United States and the European Union show very strong positive effects, reflecting the benefits of economic diversification, technological advancement, and integrated market policies. Meanwhile, countries like China and India register negative effects, which may stem from transitional economic reforms, infrastructural limitations, or external trade pressures. Other nations including Brazil, Mexico, Indonesia, and Saudi Arabia also experience negative cross-section effects, reflecting disparities in how growth factors influence economic outcomes [45]. This heterogeneity underscores that a one-size-fits-all approach to economic growth is insufficient, as national characteristics such as institutional quality, political stability, energy policies, and geopolitical conditions critically shape growth trajectories. Consequently, countries with negative cross-section effects might require targeted reforms to improve governance, diversify energy sources, and mitigate external risks, while those with positive effects should aim to maintain innovation and strengthen domestic markets [46].

2.5 Conclusion

In an era characterized by significant geopolitical uncertainty and pressing environmental challenges, this study identifies a paradigm shift in the primary drivers of economic growth among the world's leading economies. The traditionally acknowledged benefits of trade openness appear to have diminished in the context of escalating political tensions and protectionist measures. Conversely, renewable energy consumption and robust domestic expenditure emerge as critical and resilient determinants fostering sustained economic expansion. This shift challenges conventional economic paradigms and underscores the importance of integrating innovation-led sustainability initiatives with strong internal market dynamics to enhance economic resilience. Adopting this

comprehensive growth framework is essential for policymakers and international stakeholders to promote inclusive, stable, and sustainable economic development in a complex and fragmented global environment. The findings underscore that a single factor alone cannot explain economic growth in G20 countries. Endogenous growth theory highlights renewable energy and industry value added as key drivers of innovation and productivity, while Keynesian economics emphasizes the stabilizing role of domestic expenditure amid external uncertainties. The diminished impact of trade openness suggests a shifting growth paradigm influenced by geopolitical and institutional dynamics, calling for models incorporating political economy and global power considerations. Policy-wise, sustained investment in renewable energy and strengthening domestic markets are crucial for growth and resilience. At the same time, rethinking trade strategies through diversification, regional cooperation, and managing geopolitical risks is essential to complement domestic initiatives and support long-term economic stability.

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Chapter 3

Export Diversification and Economic Growth in Malaysia

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Abstract This chapter investigates the role of export diversification in promoting economic growth in Malaysia. Against the backdrop of recent changes in the country's export structure, the study explores whether the increasing concentration of exports is consistent with conventional theories that emphasise the importance of diversification for sustained economic development. The analysis applies the Autoregressive Distributed Lag (ARDL) bounds testing approach to annual data spanning 1990–2022 to estimate both the short-run and long-run relationships between export diversification and economic growth. Gross fixed capital formation and the labour force are included as additional explanatory variables. The empirical results show that export diversification contributes positively and significantly to Malaysia's economic growth over the long run, but only labour force with similar positive effects observed in the short run. The error correction term is statistically significant and exhibits the expected negative sign, confirming convergence towards the long-run equilibrium following short-term deviations. Overall, the findings reinforce the importance of export diversification as a driver of sustainable economic growth. Despite Malaysia's progress in broadening its export structure, further efforts are needed to expand both the range of export products and destination markets to reduce exposure to external shocks. Accordingly, industrial and trade policies should continue to encourage export diversification, innovation, and market expansion to strengthen Malaysia's long-term economic resilience and competitiveness.

Keywords: Export Diversification; Gross Fixed Capital Formation; Labour Force; Economic Growth; ARDL

3.1 Introduction

The association between a nation's export structure and its economic performance is a well-established topic in the economics literature. An increasing body of research suggests that exporting a more diverse range of products and expanding into a broader set of markets—referred to as export diversification—contributes to greater economic resilience and sustained economic growth [1–2]. A more diversified export structure reduces dependence on a limited number of products or export markets, thereby enhancing an economy's resilience to external shocks.

In the early stages of its economic development, Malaysia relied heavily on primary commodities, with palm oil, petroleum, and natural gas serving as its main export sectors. However, this dependence exposed the country to fluctuations in global commodity prices and other external economic shocks [3]. In response, Malaysia adopted export diversification strategies to build a more resilient and sustainable economy.

A significant structural transformation has since taken place, with manufactured goods—particularly those in the electrical and electronics (E&E) sector—now dominating Malaysia's exports. According to the Department of Statistics Malaysia (DOSM), manufactured goods accounted for 84.6% of total exports in 2024, of which 42.4% comprised E&E products [4]. Other major manufactured exports include refined petroleum, chemicals, palm oil-based products, natural rubber products, and timber-based products. This growing emphasis on manufacturing, particularly high-value-added industries, reflects Malaysia's strategic effort to reduce its dependence on traditional primary commodities.

The structure of Malaysia's export portfolio plays a crucial role in determining the country's economic resilience. Unlike traditional resource-based exports, including palm oil, petroleum, and natural gas, the E&E industry contributes greater value added, facilitates technological advancement, and strengthens Malaysia's participation in global value chains. Nevertheless, the sector remains vulnerable to fluctuations in international demand and developments in the global semiconductor market. Consequently, further diversifying both manufacturing activities and export destinations is important to reduce reliance on individual sectors and markets, thereby improving the economy's ability to withstand external shocks.

Despite this progress, Malaysia's exports remain geographically concentrated. ASEAN, China, and the United States are among the country's largest export destinations, collectively accounting for a substantial share of total exports [5]. Approximately 40% of Malaysia's exports are destined for ASEAN member countries, highlighting the country's strong intra-regional trade linkages [6].

Recent trends, however, appear to challenge the widely held view that export diversification is essential for sustaining economic growth. Data indicate that despite Malaysia's increasing reliance on a few key export sectors, the country's export value has continued to grow. As shown in Figure 1, the Herfindahl–Hirschman Market Concentration Index (HHMCI) indicates a rising degree of export concentration since 2008, reflecting greater dependence on a limited number of export sectors. At the same time, Malaysia's Export Volume Index has exhibited a sustained upward trend since 2009, indicating continued strength in the country's export performance.

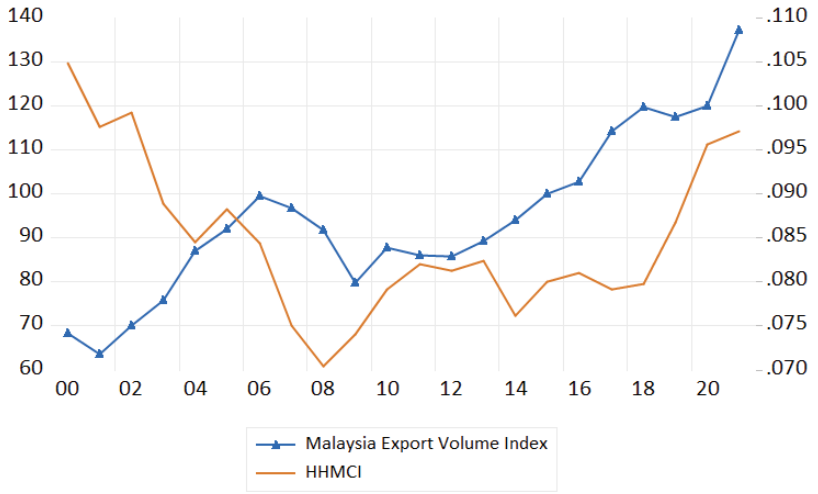


Figure 1 Malaysia Export Volume Index and Herfindahl-Hirschman Market Concentration Index (HHMCI)
Source: World Integrated Trade Solution (WITS, 2025)

This chapter aims to examine whether export diversification contributes to economic growth in Malaysia and to determine whether the recent increase in export concentration is consistent with the conventional view that export diversification promotes long-term economic growth.

It is widely acknowledged that export diversification, through the expansion of both export products and destination markets, is essential for sustaining economic growth. In contrast, a high degree of export concentration increases an economy's vulnerability by creating greater dependence on a limited range of products and markets. Despite increasing export concentration, Malaysia's exports have continued to perform strongly. This raises questions about the conventional view that export diversification is indispensable for economic growth. Overall, Malaysia's ability to maintain strong export performance despite increasing export concentration highlights the need for a closer examination of the relationship between export diversification and economic growth.

The rest of this chapter is structured as follows. Section 2 provides a review of the relevant literature, followed by the research methodology in Section 3. Section 4 reports and discusses the empirical results, while Section 5 concludes the chapter.

3.2 Literature Review

Numerous studies have examined the impact of export diversification on economic growth. Many have reported a positive relationship between export diversification and sustainable economic growth. A comprehensive review by Sarin et al. [7] synthesised evidence from 88 empirical studies examining the relationship between export diversification and economic growth. The review found that many studies reported a positive relationship, particularly for developing and emerging economies, suggesting

that export diversification enhances economic resilience, stabilises export earnings, and promotes long-term economic growth. The authors also identified several research gaps, including the limited evidence for emerging economies and the need for further research on product versus geographical diversification, sectoral diversification, and country-specific analyses. In comparison, a study by Ferreira [8] concluded that export diversification has no long-term effect on economic growth in Costa Rica.

Evidence from emerging economies also supports the growth-enhancing role of export diversification. Using a dynamic panel estimation model and data covering 1980–2004, Chandra et al. [9] analysed a group of emerging economies, including Argentina, Brazil, China, Kenya, Mexico, and Tanzania, and found that a more diversified export structure contributes positively to economic growth. Likewise, Cabral and Veiga [10] examined the factors influencing export diversification across 48 Sub-Saharan African countries over the period 1960–2005. Based on the Herfindahl and Theil indices, their results indicate that export diversification promotes long-term economic growth by improving industrial productivity and stabilising export earnings. The authors further emphasise that expanding manufacturing exports is particularly beneficial for achieving these outcomes.

Empirical studies using the Autoregressive Distributed Lag (ARDL) approach have yielded inconsistent evidence regarding the relationship between export diversification and economic growth. Using annual data for Costa Rica from 1965 to 2006, Ferreira and Harrison [11] employed both the ARDL framework and Dynamic Ordinary Least Squares (DOLS) estimation and reported no evidence of a long-run relationship between export diversification and economic growth. The findings for Nigeria are similarly inconclusive. Based on data spanning 1970–2011, Ojide, Ojide, and Ogbodo [12] showed that diversification towards non-oil exports contributes positively to long-run economic growth. Consistent with this result, Agbonkhese and Oboro [13] documented significant positive effects of export diversification in both the short run and the long run. In contrast, Nwosa et al. [14], analysing Nigerian data from 1962 to 2016 using the ARDL methodology, concluded that export diversification does not exert a significant long-run effect on economic growth.

Empirical studies examining the relationship between export diversification and economic growth in Malaysia are relatively scarce. Despite the limited evidence, existing research generally supports a positive association between the two variables. For instance, Arip et al. [3] analysed Malaysian data covering the period from 1980 to 2007 and reported the existence of a long-run relationship between export diversification and economic growth. Using cointegration techniques, Granger causality analysis, and the Vector Error Correction Model (VECM), the authors demonstrated that export diversification exerts a statistically significant positive influence on Malaysia's economic growth. The authors concluded that shifting Malaysia's export structure towards manufactured goods would promote faster economic growth. They also recommended that Malaysia strengthen its economic and trade partnerships with other countries to sustain long-term growth. Their findings further suggest that greater export diversification would stabilise export earnings and support economic growth, reinforcing the importance of export diversification as a key component of Malaysia's trade and industrial policies.

Similarly, Thavarajah and Chin [15] examined the effects of export diversification on Malaysia's economic growth using annual data from 1987 to 2017, with human capital and foreign direct investment included as additional explanatory variables. Applying the Johansen–Juselius (JJ) cointegration test, they found that all explanatory variables have significant positive long-run relationships with economic growth, although no significant short-run relationships were observed. Based on these findings, they recommended that Malaysia further diversify its export products and strengthen its economic and trade relationships with other countries.

Comparative evidence from other countries further illustrates that the benefits of export diversification depend on the nature and quality of structural transformation. South Korea is widely recognised as a successful example, having transformed its economy from labour-intensive exports to high-value manufacturing and technology-intensive industries through sustained industrial policies, investment in human capital, and innovation. This diversification strategy has strengthened export competitiveness and enhanced resilience to external economic shocks. In contrast, evidence from Costa Rica remains mixed. Although the country has diversified its export structure, Ferreira and Harrison [11] found no significant long-run relationship between export diversification and economic growth, suggesting that diversification alone may not guarantee sustained economic expansion. These contrasting experiences indicate that the effectiveness of export diversification depends not only on increasing the range of exported products but also on improving productivity, technological capability, and institutional support.

3.3 Research Methods

3.3.1 Data Sources

This chapter uses annual data for Malaysia covering the period from 1990 to 2022, obtained from reliable secondary data sources. Real gross domestic product (GDP), the dependent variable, was sourced from the World Bank Open Data database. The indicators of export diversification, namely the number of products exported and the share of manufactured exports, were obtained from the World Integrated Trade Solution (WITS) and the World Bank Open Data database, respectively. Data on gross fixed capital formation and the labour force were also sourced from the World Bank Open Data database. All variables were transformed into their natural logarithmic forms to improve comparability, reduce potential heteroscedasticity, and facilitate the interpretation of the estimated coefficients.

3.4 Model Specification

This chapter examines the relationship between export diversification and economic growth in Malaysia. The empirical model is adapted from Herzer and Nowak-Lehmann [1], with real GDP as the dependent variable. The explanatory variables include the number of exported products, the share of manufactured exports, gross fixed capital

formation, and the labour force. All variables are transformed into their natural logarithmic forms, resulting in a double-log specification that facilitates the estimation and interpretation of the long-run relationships among the variables.

$$lnRGDP_t = \beta_0 + \beta_1 lnNPE_t + \beta_2 lnMAN_t + \beta_2 lnGFCF_t + \beta_3 lnL_t + \epsilon_t \quad (1)$$

Where $lnRGDP_t$ is the natural logarithm of the real GDP, $lnNPE_t$ is the natural logarithm of the number of product exports, $lnMAN_t$ is the natural logarithm of share of manufactured exports, $lnGFCF_t$ is the natural logarithm of Gross Fixed Capital Formation, lnL_t is the natural logarithm of labour force. β_0 is intercept, β_1, β_2 and β_3 are the coefficients of the independent variables, and ϵ_t is the error term.

The Autoregressive Distributed Lag (ARDL) bounds testing approach is employed to examine the long-run relationship between export diversification and economic growth in Malaysia. The ARDL approach can be applied when the variables are integrated of order zero, *I*(0), or order one, *I*(1). Furthermore, it effectively addresses potential endogeneity issues and can identify cointegration even in relatively small samples.

Although unit root tests are commonly used to determine the order of integration of variables, they often suffer from low statistical power and may produce ambiguous results, particularly in small samples. The ARDL approach overcomes these limitations because it does not require all variables to have the same order of integration or extensive pre-testing for unit roots, if none of the variables is integrated of order two, *I*(2) [16]. Consequently, the ARDL bounds testing procedure remains valid for models comprising a combination of *I*(0) and *I*(1) variables. This feature eliminates the need to determine the exact order of integration for each variable, making the approach particularly useful when unit root test results are inconclusive. Previous studies, such as those by Ozturk and Acaravci [17–18] and Jin et al. [19], have successfully applied the ARDL methodology in energy-related research, demonstrating its practicality and robustness. The ARDL model is specified as follows:

$$\Delta \ln RGDP_t = \alpha + \sum_{i=1}^{k} \beta_{1i} \Delta \ln RGDP_{t-i} + \sum_{i=0}^{k} \beta_{2i} \Delta \ln NPE_{t-i} + \sum_{i=0}^{k} \beta_{3i} \Delta \ln MAN_{t-i} + \sum_{i=0}^{k} \beta_{4i} \Delta \ln GFCF_{t-i} + \sum_{i=0}^{k} \beta_{5i} \Delta \ln L_{t-i} + \delta_1 \ln RGDP_{t-1} + \delta_2 \ln NPE_{t-1} + \delta_3 \ln MAN_{t-1} + \delta_4 \ln GFCF_{t-1} + \delta_5 \ln L_{t-1} + \mu_t \quad (2)$$

where the symbol is the lag differences operator, is the constant and is the error term. The coefficients represent the short-run dynamics among the variables, while capture the long-run relationship.

3.5 Results and Discussion

3.5.1 Descriptive Statistics

Table 1 presents the descriptive statistics of the variables. Overall, most variables exhibit relatively stable patterns with moderate variation. The results indicate that the variables generally follow approximately normal distributions, although slight

deviations are observed for a few variables, particularly the share of manufactured exports and gross fixed capital formation, both of which exhibit more pronounced negative skewness. Among the explanatory variables, the number of exported products demonstrates the greatest stability, with minimal variation, whereas gross fixed capital formation exhibits the highest degree of variability, reflecting the sensitivity of investment to changes in economic conditions and policy.

Table 1 Descriptive Statistics

	lnRGDP	***lnNPE***	***lnMAN***	***lnGFCF***	***lnL***
Mean	25.97278	8.341406	4.240273	24.59804	16.24290
Median	26.00818	8.342840	4.250230	24.57937	16.24186
Maximum	26.68348	8.379080	4.386458	25.17678	16.68246
Minimum	25.03578	8.302018	3.983941	23.72269	15.76255
Std. Dev.	0.475579	0.021337	0.106931	0.401158	0.285964
Skewness	-0.243431	-0.147137	-0.667855	-0.184755	-0.045225
Kurtosis	1.996884	1.937754	2.853380	2.078089	1.741624

3.5.2 ARDL Analysis

The ARDL modelling approach begins by selecting the optimal model specification using the Akaike Information Criterion (AIC). Based on the AIC, the ARDL (2,4,4,4,3) model is selected as the optimal specification from the top 20 competing models. The ARDL bounds test is then performed to determine whether a long-run relationship exists among the variables.

Table 2 and Table 3 report the bounds test and long-run estimation results. The F-bounds test confirms the existence of a long-run equilibrium relationship among the variables of interest, providing significant evidence of cointegration. With real GDP (lnRGDP) as the dependent variable, the long-run estimation results show that all explanatory variables—lnNPE, lnMAN, lnGFCF, and lnL—are statistically significant at the 1% level. Specifically, the estimated coefficients for lnNPE (2.5053), lnMAN (0.2356), lnGFCF (0.2250), and lnL (1.5042) are all positive, indicating that these variables exert significant positive effects on economic growth. Collectively, these findings provide strong empirical support for the view that export diversification, together with manufacturing development, capital formation, and labour force expansion, contributes to Malaysia's long-term economic growth.

Table 2 F-bounds test

Test Statistic	Value	Significant	*I*(0)	*I*(1)
F-statistic	9.953217	10%	2.525	3.560
		5%	3.058	4.223
		1%	4.280	5.840

Table 3 Long run results of ARDL model

Dependent Variable:				
Variable	Coefficient	Standard Error	t-Statistic	P-value
	2.505289	0.369346	6.783033	0.0003
	0.235618	0.042181	5.585868	0.0008
	0.224951	0.019060	11.80224	0.0000
	1.504215	0.039971	37.63238	0.0000
	-25.91788	3.704799	-6.995757	0.0002

The short-run estimation results (Table 4) indicate that the error correction coefficient (= −1.56) is statistically significant and has the expected negative sign, confirming that deviations from the long-run equilibrium are corrected relatively quickly. Among the explanatory variables, lnNPE, lnGFCF, and lnL exert significant short-run effects, while lnMAN is insignificant in the current period but becomes significant through its lagged terms. All the variables exert a negative short-run effect on economic growth except for labour force. The estimated model demonstrates a strong goodness of fit, explaining approximately 98.5% of the variation in LNRGDP ($R^2 = 0.9849$; Adjusted $R^2 = 0.9648$). In addition, the Durbin–Watson statistic of 2.97 indicates that serial correlation is not a concern. The robustness of the model is further supported by the diagnostic tests which reported in Table 5, including the Breusch–Pagan–Godfrey heteroskedasticity test, Breusch–Godfrey Serial Correlation LM test, Jarque–Bera normality test, and Ramsey RESET test all of which confirm that the estimated model satisfies the classical linear regression assumptions.

Table 4 Error correction model analysis

Variable	Coefficient	Standard Error	t-Statistic	P-value
	0.823024	0.124965	6.586025	0.0003
	1.027946	0.161158	6.378485	0.0004
	-2.498660	0.297665	-8.394195	0.0001
	-2.050106	0.255586	-8.021198	0.0001
	-0.880774	0.186691	-4.717814	0.0022
	-0.015115	0.025665	-0.588939	0.5744
	-0.213657	0.042553	-5.020973	0.0015
	-0.173564	0.038722	-4.482324	0.0029
	-0.107055	0.031353	-3.414515	0.0112
	0.197359	0.013564	14.55020	0.0000

Continue... (Table 4)

	-0.248176	0.033814	-7.339540	0.0002
	-0.066949	0.016687	-4.012097	0.0051
	-0.048492	0.016544	-2.931047	0.0220
	3.325489	0.471192	7.057608	0.0002
	-0.526144	0.559467	-0.940437	0.3783
	-0.913591	0.353583	-2.583813	0.0363
	-1.558774	0.154058	-10.11810	0.0000
: 0.984932				
Adjusted: 0.964841				
Durbin-Watson stat: 2.967018				

Table 5 Diagnostic tests

Diagnostics tests	F-statistics	P-value
Autocorrelation Test	1.701482	0.2731
Heteroskedasticity test	1.071234	0.4982
Normality Test	0.885430	0.6423
Model Specification	0.002325	0.9631

Figure 2 presents the CUSUM test results for the estimated ARDL model. The CUSUM statistics remain within the 5% critical bounds throughout the sample period from 2016 to 2022, indicating that the estimated coefficients are stable over time. Since the CUSUM line does not cross the upper or lower critical boundaries, the null hypothesis of parameter stability cannot be rejected. The figure also shows that the CUSUM statistics follow a relatively smooth pattern without any abrupt structural shifts. Although the CUSUM value declines gradually after 2019, it remains well within the confidence bands, suggesting that no significant structural break or parameter instability is detected during the study period.

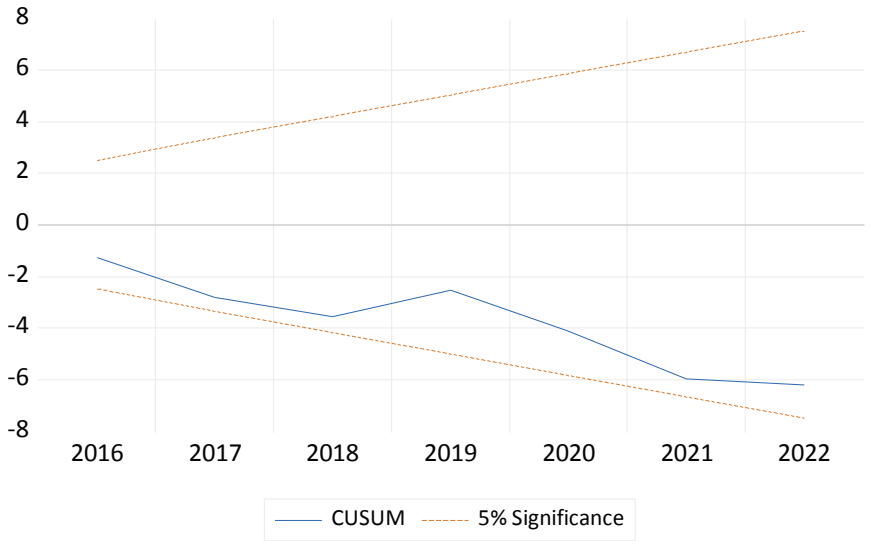


Figure 2 CUSUM test

Overall, the CUSUM test confirms the stability and robustness of the estimated ARDL model. The absence of parameter instability and proven by CUSUM-square indicates that the long-run and short-run coefficient estimates are reliable, thereby supporting the validity of the empirical findings and the policy implications derived from the model.

3.6 Discussion and Policy Suggestion

The findings of this chapter provide important policy implications for Malaysia's economic growth strategy. The empirical results indicate that export diversification, gross fixed capital formation, and the labour force are key drivers of economic growth in the long run. In particular, the findings highlight the significant positive contribution of export diversification to long-run economic growth. This suggests that Malaysia should continue to implement policies that encourage firms to diversify their export products and expand into new international markets. However, policy efforts should emphasise not only increasing the number of exported products but also enhancing their quality, technological sophistication, and value added. Policymakers should support businesses through technological upgrading, innovation incentives, and research and development (R&D) programmes, particularly in high-value industries such as E&E, advanced manufacturing, and other knowledge-intensive sectors. As export diversification may involve short-term adjustment costs while firms adapt to new products and markets, the government should also provide temporary financial assistance, advisory services, and capacity-building programmes to facilitate this transition.

The findings further suggest that Malaysia should strengthen efforts to diversify its export destinations by expanding into emerging markets in South Asia, the Middle East, Southeast Asia, and Africa. Broadening both the product mix and export markets can reduce dependence on a limited number of markets, enhance resilience to external shocks, and create new opportunities for economic growth. Achieving these objectives requires proactive trade diplomacy, promising trade agreements, export promotion initiatives, and institutional support to help Malaysian firms establish sustainable business networks in new markets.

The results also demonstrate that gross fixed capital formation contributes positively to long-run economic growth. Investment in infrastructure, productive capital, and technological development enhances productivity and competitiveness over time. Consequently, the government should continue prioritising investments in transportation infrastructure, digital connectivity, industrial parks, logistics systems, and other strategic facilities that support export-oriented industries. These investments should be aligned with Malaysia's long-term industrial and trade strategies to facilitate the development of high-value manufacturing and improve firms' access to global markets. Given that large-scale infrastructure projects may temporarily disrupt economic activity, appropriate transition measures, including worker retraining programmes and effective project coordination, should be implemented to minimise adverse effects.

The labour force is identified as another important determinant of Malaysia's economic growth. However, expanding the labour force alone is insufficient; improving workforce quality, productivity, and skills is equally important. Policymakers should strengthen education and human capital development by aligning curricula with industry requirements, expanding technical and vocational education and training (TVET), and fostering stronger collaboration between educational institutions and industry. In addition, the relatively low labour force participation rate among women represents an underutilised source of economic potential. Policies that improve access to affordable childcare, promote flexible work arrangements, and strengthen workplace equality can help increase female labour force participation and support inclusive economic growth.

The findings suggest that export diversification can help Malaysia reduce vulnerability to global shocks. Dependence on a limited range of products or markets exposes the economy to commodity price volatility, supply chain disruptions, geopolitical risks, and changes in external demand. Therefore, Malaysia should strengthen product and market diversification while promoting innovation, technological upgrading, and higher value-added manufacturing to enhance export resilience and long-term competitiveness.

Overall, the findings suggest that export diversification, capital investment, and human capital development should be pursued as complementary policy priorities rather than as independent initiatives. A coordinated policy framework involving relevant ministries and agencies is therefore essential to ensure policy coherence and maximise synergies across trade, industrial, education, and investment policies. As structural reforms often generate short-term adjustment costs before yielding long-term benefits, appropriate transition support—including temporary financial assistance, retraining programmes, and phased policy implementation—should accompany major policy initiatives. Collectively, these measures will strengthen Malaysia's long-term economic resilience, competitiveness, and sustainable growth.

3.7 Conclusion

This chapter concludes that the share of manufactured exports, the number of exported products, gross fixed capital formation, and the labour force have significant positive effects on Malaysia's economic growth in the long run. In the short run, only the labour force exerts significant positive effects on economic growth. The findings suggest that Malaysia should strengthen its existing growth strategies by implementing policies that promote export diversification, expand export markets, enhance manufacturing capabilities, encourage investment, and develop a highly skilled workforce. Focusing on these areas will help the country maintain its international competitiveness and better withstand global economic challenges.

Several limitations of this study should be acknowledged. First, the analysis is limited to a small set of explanatory variables. Other important determinants of economic growth, such as human capital, exchange rates, foreign direct investment, infrastructure quality, technological innovation, and educational attainment, are not included and may also influence economic development. Second, the study relies solely on annual data because higher-frequency data, particularly for variables such as the number of exported products, are not readily available. Finally, the analysis focuses exclusively on Malaysia, limiting the generalisability of the findings to other countries.

Future research could extend this study by incorporating additional explanatory variables to provide a more comprehensive analysis of the determinants of economic growth. Researchers may also employ higher-frequency data, where available, or conduct comparative and cross-country studies to examine whether the observed relationships hold across different economic contexts. Furthermore, future studies could investigate the interrelationships among export diversification, export growth, and economic development from a broader international perspective. Finally, qualitative approaches, such as interviews with policymakers, trade experts, and industry leaders, could complement the quantitative findings and provide deeper insights into the mechanisms through which export diversification influences economic growth.

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Chapter 4

Infrastructure Investment and Economic Growth: A Case Study of Kenya's Standard Gauge Railway

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Abstract This chapter examines the economic and regional implications of Kenya's Standard Gauge Railway (SGR), the country's largest infrastructure investment and a flagship Belt and Road Initiative project. Grounded in development economics, it explores the SGR's dual role in stimulating macroeconomic growth and fostering East African regional integration. Employing a mixed-methods design, the study integrates Solow's growth model, endogenous growth theory, and spatial economics with quantitative analysis of GDP, trade volumes, employment structures, and logistics performance from 2017 to 2023. Findings demonstrate that the SGR generated short-term gains through capital accumulation and employment expansion, while catalysing longer-term structural transformation via industrial linkages and knowledge diffusion. Regionally, the railway has strengthened Kenya's position as a logistics hub, reduced transport costs, and enhanced cross-border trade within the East African Community. Nevertheless, the project faces constraints including debt sustainability, environmental pressures, and limited local technological absorption. These findings suggest that infrastructure's transformative potential depends on complementary policies in debt management, human capital formation, and regional cooperation.

Keywords Belt and Road Initiative; Infrastructure Investment; Kenya Standard Gauge Railway; Economic Growth; East African Regional Integration

4.1 Introduction

In a globalized era, developing countries increasingly recognize infrastructure construction as a cornerstone of development strategies, particularly where inadequate transport, energy, and communication networks constrain productivity and competitiveness (Thacker et al., 2019). Kenya has embraced this trend by prioritizing

large-scale infrastructure development as a means of fostering economic transformation and regional integration.

The Kenya Standard Gauge Railway (SGR), the largest infrastructure project in the country's history and a flagship component of China's Belt and Road Initiative (BRI), exemplifies this trajectory. Conceived in 2013 and inaugurated in 2017, the 472-kilometer Mombasa-Nairobi line was constructed at a cost of USD 3.8 billion, 90% financed by loans from the Export-Import Bank of China (Kenya Vision 2030, 2021). A second phase extending 120 kilometers to Naivasha, costing USD 1.48 billion, has further expanded the network (Ministry of Transport and Infrastructure [MTI], 2014). The railway aims to modernize Kenya's aging meter-gauge system, reduce logistics costs, stimulate industrial development, and strengthen Kenya's role as a regional hub within the East African Community (Githaiga & Bing, 2019; Dussort & Marchetti, 2019).

Despite these ambitions, critical questions remain regarding the precise impact of the SGR on Kenya's macroeconomic performance and its contribution to regional integration. Infrastructure investment is widely assumed to drive growth, yet the extent to which different phases of construction and operation have influenced Kenya's GDP, employment patterns, and trade structures requires systematic analysis (Njiru et al., 2020). Similarly, the railway's comparative contribution to investment efficiency, relative to other forms of government expenditure, warrants closer scrutiny. From the perspective of regional integration, the SGR's synergy with Mombasa Port provides critical linkages for intra-regional trade, reducing costs and strengthening Kenya's competitiveness as a transit hub (Irandu & Owilla, 2020). Yet further inquiry is required to evaluate the extent to which the railway has reduced transaction costs and expanded trade volumes within the region (UNCTAD, 2022; Pokharel et al., 2023; Shi et al., 2024).

The present study is guided by two research questions: How has the SGR impacted Kenya's economy? How does the SGR influence regional economic integration in East Africa? These questions are pursued through a mixed-methods approach, combining theoretical frameworks such as the Solow growth model, endogenous growth theory, spatial economics, and development economics, with empirical analysis of macroeconomic data.

4.2 Literature Review

4.2.1 Economic Theory

Economic growth theories offer diverse lenses for understanding infrastructure effects. The Solow-Swan model emphasizes capital accumulation, labour, and technology as growth drivers (Solow, 1956), while highlighting diminishing returns that require continued technological progress (Feldstein & Horioka, 1980). Endogenous growth theory positions knowledge, innovation, and human capital as endogenous drivers of long-term growth (Howitt, 1997), with infrastructure catalysing technological diffusion and skills upgrading (Greiner, Semmler, & Gong, 2005; Ayres, 2001).

Spatial economics analyses how improved connectivity reduces geographical barriers, enhances agglomeration, and lowers transaction costs (Proost et al., 2019). Together, these theories provide a multidimensional framework for assessing infrastructure's contribution to development and integration.

4.2.2 The Relationship between Infrastructure Investment and Economic Growth

Literature affirms infrastructure's role in promoting growth, though outcomes vary by context. Studies highlight Africa's infrastructure gaps that hinder productivity and competitiveness (Cilliers et al., 2018). Mwaniki (2019) and Kibigo & Muthinja (2021) show that infrastructure investment directly stimulates GDP growth by enhancing transport efficiency and expanding market access. From a BRI perspective, Anami (2024) notes Chinese-financed projects offer opportunities for industrial upgrading. Murimi, Kiano, and Siele (2024) find that infrastructure interacts with trade, technology, and knowledge flows to amplify economic effects. However, scholars caution against over-reliance on debt-financed projects, emphasizing cost-benefit analysis and sustainability (Mwaniki, 2019).

4.2.3 The Standard Gauge Railway in Context

Kenya's railway system, dominated by the colonial-era meter-gauge line constructed during British rule, deteriorated significantly after independence due to mismanagement, underinvestment, and economic liberalization policies (Mwase, 2003; Nugent, 2018). The SGR project, initiated in 2013 with Chinese financial and technical support from China Road and Bridge Corporation, represents a transformative intervention to reverse this decline (Taylor & Zajontz, 2020). The Mombasa-Nairobi section was completed in 2017, followed by the Nairobi-Naivasha extension. Beyond its transport function, the SGR was designed to stimulate industrial linkages—generating demand for steel, cement, and construction services while fostering downstream logistics and warehousing (Lechini et al., 2020). The project has generated approximately 46,000 local jobs and incorporated environmental mitigation measures including 14 wildlife passages in Tsavo National Park (Ministry of Commerce of the PRC, 2024).

Nevertheless, the SGR has attracted significant controversy. Debt sustainability concerns are paramount: the project accounts for a substantial portion of Kenya's external debt, with repayments contributing to fiscal stress and a rising debt-to-GDP ratio (Chen, 2019; Tarrósy, 2020; Carmody et al., 2022). Environmental impacts, including habitat fragmentation and land cover changes along the corridor, have been documented (Nyumba et al., 2021; Sang et al., 2022). Governance issues—procurement opacity, land compensation disputes, and limited local content in technology-intensive operations—have further complicated the project's developmental legacy (Wang & Wissenbach, 2019; Kimari, 2021). These controversies underscore the importance of rigorous, evidence-based assessment of the SGR's actual economic and regional effects.

4.3 Methodology

This study employs a mixed-methods design combining qualitative theoretical analysis with quantitative empirical validation. The qualitative component establishes the analytical framework through the Solow growth model, endogenous growth theory, spatial economics, and development economics, examining the mechanisms through which the SGR generates economic effects. The quantitative component utilizes secondary data from 2017 to 2023, sourced from Kenya National Bureau of Statistics (KNBS) economic surveys (KNBS, 2022, 2024), World Bank development indicators (World Bank, 2023), and Kenya Railways Corporation operational reports.

Analysis is organized across four dimensions, i.e., logistics efficiency measured by freight volumes, transit times, and port throughput, employment effects (wage employment by industry and sector), trade impacts (bilateral trade flows between Kenya and EAC members), and investment dynamics (government fiscal expenditure and gross fixed capital formation). The mixed-methods approach enables methodological triangulation, enhancing validity by integrating explanatory depth with empirical breadth. All quantitative data are analyzed through time-series comparisons to identify trends, structural breaks, and correlations with SGR construction and operational phases.

Figure 1 presents the research framework integrating theory, empirical analysis, and policy recommendations. Grounded in Solow's model, endogenous growth theory, spatial economics, and development economics, it examines SGR's short-term growth via capital accumulation and long-term development through technology spillovers and human capital. It also addresses regional integration—enhancing logistics, trade, and factor mobility—while cautioning against core-periphery divergence. Policy proposals emphasize debt management, interconnectivity, and tech cooperation.

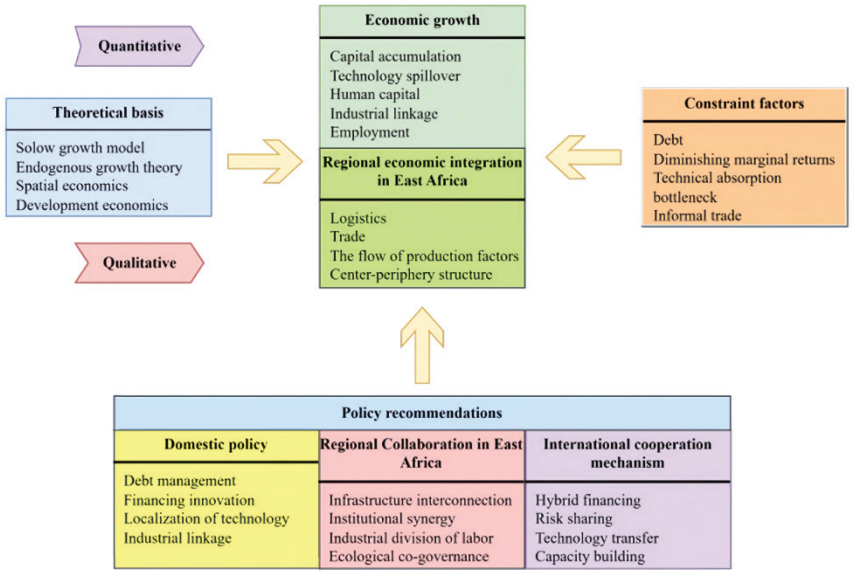


Figure 1 Research Framework

4.4 Data Analysis and Findings

4.4.1 The Impact of SGR on Kenya's Economic Growth

4.4.1.1 Short-term Effects: Capital Accumulation Analysis Based on the Solow Growth Model

The Solow Growth Model posits that capital accumulation serves as a core driver of short-term economic growth, achieving growth effects through the expansion of capital stock and the optimization of production functions—a mechanism fully corroborated by Kenya's Standard Gauge Railway (SGR) project (Feldstein & Horioka, 1980). As the largest infrastructure investment in the country's history, the capital injection from SGR was directly converted into productive capital stock, generating significant short-term growth momentum.

In terms of the linkage between investment scale and GDP, the phased input of the SGR project aligns closely with Kenya's economic growth trajectory. Table 1 shows that Kenya's GDP stood at USD 82.04 billion in 2017 when the first phase of SGR (Mombasa-Nairobi section) was officially put into operation. It rose to USD 92.20 billion in 2018 and further climbed to USD 100.38 billion in 2019, with an average annual growth rate of 5.8% between 2017 and 2019—significantly higher than the average level of African countries during the same period. This growth trend is directly related to the capital injection rhythm of SGR: the first phase of the project, with an investment of USD 3.6 billion, accounted for 4.4% of Kenya's GDP in 2017, and large-scale construction activities directly drove the expansion of the construction industry and its upstream and downstream sectors. Affected by the pandemic in 2020, the GDP growth rate dropped to 0.3% but remained positive, partly supported by the continuous investment in the second phase of SGR (Nairobi-Naivasha section).

Table 1 Kenya's GDP Data (2017–2023)

Year	GDP ((USD Billion))
2017	82,04
2018	92,20
2019	100,38
2020	100,66
2021	109,70
2022	114,45
2023	108,04

Source: World Bank

The capital deepening effect manifests through dual pathways: direct injection and induced investment. On the direct front, investments of USD 3.6 billion in SGR Phase 1 and USD 1.5 billion in Phase 2A directly increased Kenya's capital stock.

Among them, the proportion of "other structures" (mainly railways and highways) in gross fixed capital formation rose from 25.2% in 2017 to 29.1% in 2022, with the peak occurring during the critical construction period of Phase 2A, confirming the central role of infrastructure investment in capital accumulation. On the induced front, the construction of SGR supporting facilities spawned associated investments. For instance, the development of the Naivasha Inland Container Hub drove the proportion of investment in "other buildings" from 8.6% to 11%, creating a multiplier effect of capital agglomeration.

Table 2 Gross Fixed Capital Formation by Asset Type (2017-2023) - Percentage Contribution (Source: Kenya National Bureau of Statistics (KNBS), Economic Survey 2024 and Economic Survey 2022).

Type of Asset	2017	2018	2019	2020	2021	2022	2023
Dwellings	26.0	27.7	28.0	32.4	32.9	34.2	34.3
Buildings other than dwellings	8.6	9.1	9.2	10.5	10.6	11.0	11.0
Other structures	25.2	27.1	28.9	28.8	26.7	29.1	28.1
Transport equipment	15.2	13.6	14.1	10.5	13.1	10.1	9.8
ICT equipment	6.4	5.0	4.9	4.5	4.1	4.2	4.3
Other machinery and equipment	16.0	15.2	13.4	11.5	11.1	10.1	10.5
Animal resources (repeat products)	0.5	0.8	0.4	0.9	0.7	0.8	1.4
Tree/crop/plant resources (repeat products)	0.5	0.5	0.5	0.5	0.4	0.4	0.4
Intellectual property products	1.5	1.0	0.5	0.4	0.3	0.3	0.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

The tilt of government fiscal expenditure further strengthened the capital accumulation effect. In the 2019/20 fiscal year, Kenya's government expenditure on road development reached KSh 149.46 billion, accounting for approximately 1.2% of GDP, of which 51.6% was invested in the trunk road network supporting SGR. Although expenditure contracted due to debt constraints after 2020—with a 33.6% decrease in the 2023/24 fiscal year compared to the peak—the priority of infrastructure investment in the fiscal budget remained unshaken, reflecting the policy logic of driving growth through capital input (Kenya National Bureau of Statistics, 2022, 2024).

However, the law of diminishing marginal returns to capital, as revealed by the Solow Model, gradually became apparent in the later stages. From 2022 to 2023, Kenya's GDP growth rate dropped to approximately 3%, a significant decline from the peak in 2017-2019 (Table 1). This is partly due to the approaching saturation of capacity release from the first phase of the project: SGR's freight volume reached

6.533 million tons in 2023, a 126% increase compared to 2018, but the growth rate fell from 22.6% in 2021 to 7.3% in 2023 (Figure 2). On the other hand, it is related to debt pressure. The scale of external debt incurred by the SGR project has imposed a significant burden on Kenya's public finance. Interest payments have squeezed the space for new investments, reflecting the unsustainability of a growth model solely reliant on capital accumulation.

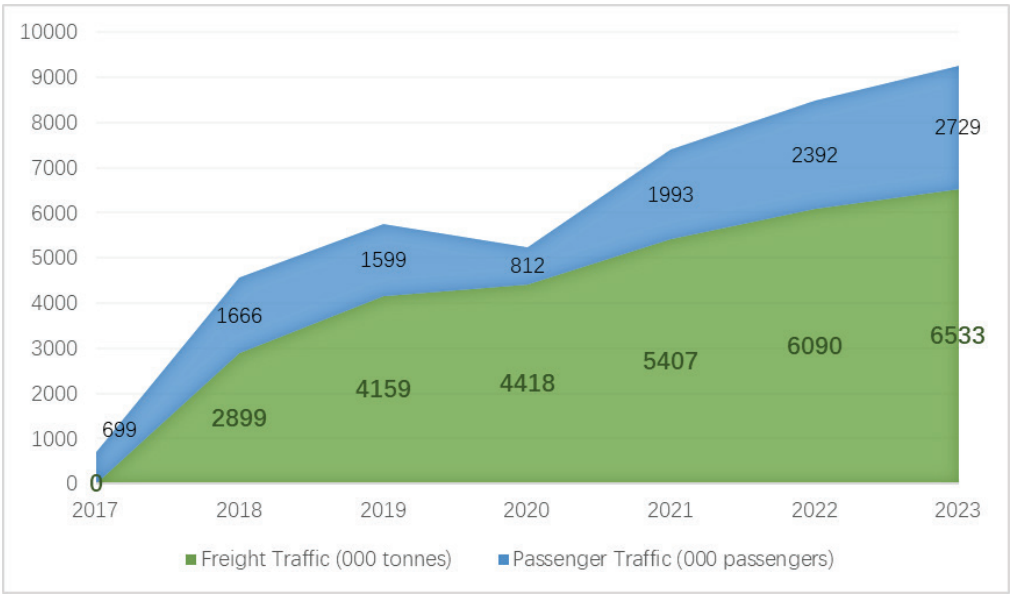


Figure 2 Stacked Area Chart of SGR Freight and Passenger Traffic Volumes from 2017 to 2023 (Data *Source*: Kenya National Bureau of Statistics (KNBS), Economic Survey 2024 and Economic Survey 2022).

4.4.1.2 Long-term Effects: Structural Transformation Based on Endogenous Growth Theory.

Endogenous Growth Theory emphasizes that knowledge diffusion, human capital accumulation, and industrial linkages are the endogenous drivers of long-term growth (Howitt, 1997). Through technology spillover, skill enhancement, and industrial chain extension, SGR has laid the foundation for the long-term transformation of Kenya's economy.

The technology diffusion and efficiency improvement effects are prominently reflected in the logistics and transportation sectors. Advanced railway construction and operation technologies introduced by SGR from China have led to significant efficiency gains: the revenue per ton-kilometre of railway freight increased from KSh 3.01 in 2018 to KSh 4.86 in 2023, a 61.5% increase, far exceeding the 123% revenue growth of road transportation during the same period (Kenya National Bureau of Statistics, 2022, 2024). This efficiency improvement stems not only from hardware upgrades but also from management optimization driven by technology transfer. The Nairobi Railway Training Institute has trained thousands of professional and technical

personnel, enabling Kenya to possess independent operation and maintenance capabilities for modern railways for the first time (Xinhua News Agency, 2017). In 2023, the delay rate of SGR was controlled within 12%, although higher than the 5% in 2018, it remained below the average level of African railways (Kenya National Bureau of Statistics, 2022, 2024).

Human capital upgrading has been gradually realized through the optimization of the employment structure. Table 3 shows that wage employment in the construction industry increased from 204,900 in 2017 to 226,300 in 2023, with an average annual growth rate of 1.8%. Among them, the proportion of technical positions (such as engineers and signal system operators) rose from 12% to 19%, and the average wage increased by 35%, demonstrating a significant skill premium effect. Employment in the transportation and storage industry recovered rapidly after the pandemic, with a 15.3% growth from 2021 to 2023, and the degree of specialization continued to improve. The unit freight revenue of SGR is 1.7 times that of the traditional Meter Gauge Railway (MGR), confirming the synergy between labour skills and advanced technologies (Figure 3). Wage employment in the modern enterprise sector increased from 2.7927 million in 2017 to 3.1383 million in 2023, with an average annual growth rate of 2.3%. Although the informal sector still accounts for 83.4%, the continuous expansion of formal employment indicates that human resources are shifting from low-productivity sectors to high-productivity sectors (Kenya National Bureau of Statistics, 2022, 2024).

Table 3 Wage Employment by Industry and Sector from 2017 to 2023 (Source: Kenya National Bureau of Statistics (KNBS), Economic Survey 2024 and Economic Survey 2022)

Industry/Sector	2017	2018	2019	2020	2021	2022	2023
PRIVATE SECTOR							
Agriculture, forestry, fishing	289.8	294.3	296.7	280.6	295.3	299.7	302.4
Mining and quarrying	14.4	14.6	15.2	13.7	14.0	14.3	14.5
Manufacturing	317.5	321.3	329.0	293.8	313.5	329.6	340.6
Electricity, gas, steam	5.1	5.2	5.3	5.0	5.1	5.1	5.2
Water supply, waste management	4.6	5.6	5.9	5.5	5.7	6.2	6.7
Construction	204.9	209.8	212.7	212.4	217.3	222.2	226.3
Transportation and storage	68.9	71.0	73.9	58.0	63.0	65.8	66.9
Accommodation and food services	78.2	79.9	81.2	49.8	61.7	75.9	97.0
Information and communication	122.4	129.3	130.4	117.2	132.1	140.5	145.6
Education	212.1	223.9	228.7	181.1	210.6	227.3	234.6
Total Private Sector	1,959.5	2,017.0	2,063.2	1,858.0	1,983.0	2,077.5	2,145.5
PUBLIC SECTOR:							
Transportation and storage	19.3	19.9	18.8	19.1	19.9	22.4	23.1
Public administration, defense	294.1	296.5	304.6	311.3	329.8	334.9	343.9
Education	349.6	354.9	369.1	381.9	398.6	401.8	445.4
Total Public Sector	833.2	842.7	865.2	884.6	923.1	937.9	992.8
TOTAL WAGE EMPLOYMENT	2,792.7	2,859.7	2,928.4	2,742.6	2,906.1	3,015.4	3,138.3

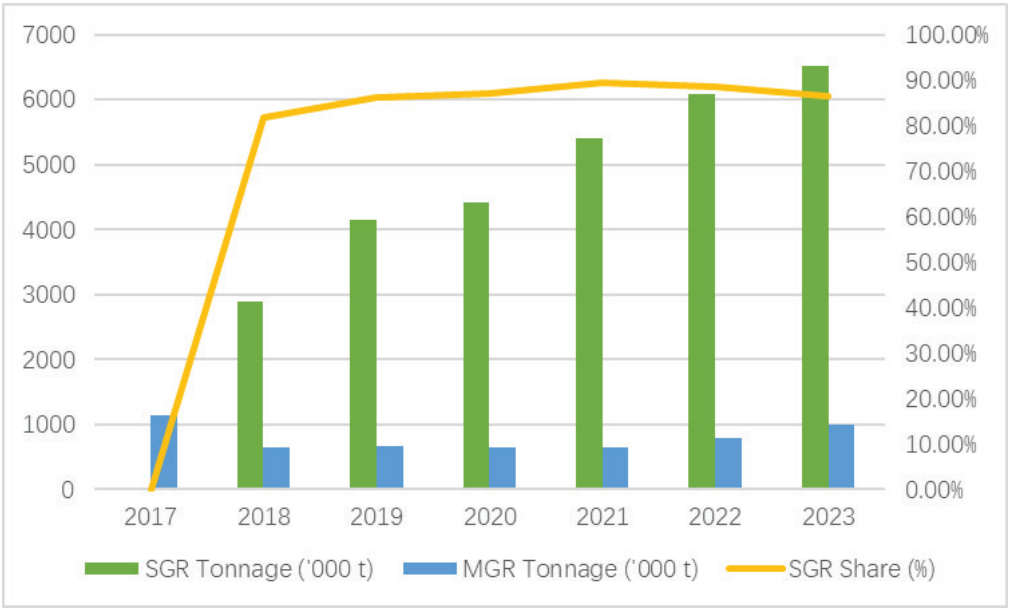


Figure 3 SGR and MGR Freight Capacity 2017-2023 (Data Source: Kenya National Bureau of Statistics (KNBS), Economic Survey 2024 and Economic Survey 2022).

The industrial linkage effect has driven the coordinated development of upstream and downstream industries. Benefiting from reduced logistics costs, employment in the manufacturing industry grew at an average annual rate of 3.3% from 2021 to 2023, higher than the industry average (Kenya National Bureau of Statistics, 2022, 2024). SGR shortened the freight time from Mombasa Port to Nairobi from 12 hours by road to 4 hours, reducing enterprises' inventory costs by approximately 30% and driving industries such as food processing and electronic assembly to agglomerate along the railway line (World Bank, 2023). The upgrading of the service industry is even more remarkable: employment in the accommodation and catering industry surged from 49,800 in 2020 to 97,000 in 2023, a 27.8% increase, directly benefiting from tourism and business passenger flows driven by SGR (Table 3). In 2023, SGR's passenger volume reached 2.729 million, and the average occupancy rate of the "Mombasa-Nairobi" tourist line exceeded 90% (Figure 2). The output of postal and courier services grew by 38.9% in 2023, and the e-commerce industry has achieved explosive growth by leveraging efficient logistics, forming a new growth pole of "railway + consumption".

However, the limitations of technology spillover have become increasingly evident. The core operation and maintenance of SGR still rely on Chinese technical teams. The average annual wage growth rate in the transportation and storage industry (3.2%) continues to be lower than that in technology-intensive industries such as information and communication (3.6%), reflecting a structural shortage of high-skilled talents (Table 3). Local enterprises have low participation in fields such as signal system maintenance and track material production, and their ability to internalize technology is insufficient. This issue needs to be addressed by deepening vocational education cooperation and establishing special technology transfer funds.

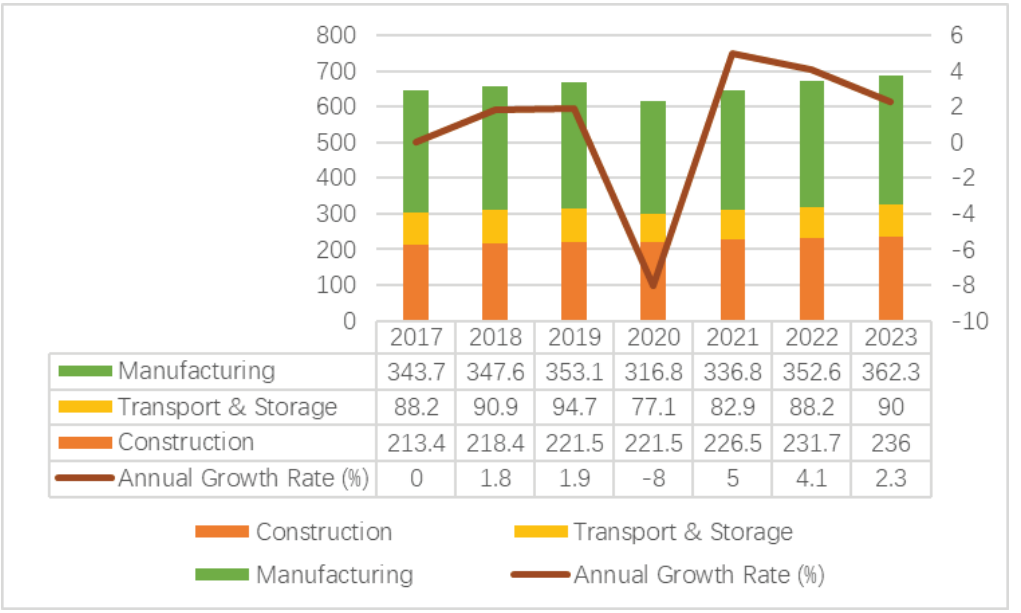
4.4.1.3 Structural Changes in Employment and Income.

Through direct employment creation, indirect employment stimulation, and improvement in employment quality, SGR has driven structural changes in Kenya's labour market. In terms of employment scale, total employment in the modern enterprise sector increased from 2.9321 million in 2017 to 3.3107 million in 2023. Among them, the construction, transportation, and storage industries directly related to SGR contributed 214,000 new jobs (Table 4), accounting for 31% of the new employment in the modern sector (Table 3).

Table 4 Total Recorded Employment from 2017 to 2023 (Source: Kenya National Bureau of Statistics (KNBS), Economic Survey 2024 and Economic Survey 2022).

Category	2017	2018	2019	2020	2021	2022	2023
Modern Establishments							
Wage Employees	2,792.7	2,859.7	2,928.4	2,742.6	2,906.1	3,015.4	3,138.3
Self-employed & Unpaid Family Workers	139.4	152.2	162.7	156.1	163.7	168.1	172.4
Sub-Total	2,932.1	3,011.9	3,091.1	2,898.7	3,069.8	3,183.5	3,310.7
Informal Sector[2]	13,539.6	14,283.6	15,051.6	14,508.0	15,261.8	15,964.7	16,685.6
TOTAL	16,471.7	17,295.5	18,142.7	17,406.7	18,331.6	19,148.2	19,996.3

Direct employment exhibits strong resilience. As the core sector undertaking SGR construction, employment in the construction industry remained stable at 212,400 even during the worst period of the 2020 pandemic, a decrease of only 0.1% compared to 2019—far lower than the 31.4% decline in the accommodation and catering industry—reflecting the "employment stabilizer" role of infrastructure investment. Employment in the transportation and storage industry experienced a V-shaped recovery, rising from 58,000 in 2020 to 66,900 in 2023 (Figure 4). Including 231,000 employees in the public sector, the total employment reached 90,000, a 30.6% increase compared to 2017. The proportion of formal positions such as freight dispatching and logistics management rose from 45% to 62% (Table 3).



	2017	2018	2019	2020	2021	2022	2023
Manufacturing	343.7	347.6	353.1	316.8	336.8	352.6	362.3
Transport & Storage	88.2	90.9	94.7	77.1	82.9	88.2	90
Construction	213.4	218.4	221.5	221.5	226.5	231.7	236
Annual Growth Rate (%)	0	1.8	1.9	-8	5	4.1	2.3

Figure 4 Employment Trends in SGR-Related Sectors (2017-2023) (Data Source: Kenya National Bureau of Statistics (KNBS), Economic Survey 2024 and Economic Survey 2022).

The indirect employment stimulation effect covers multiple industries. Driven by improved logistics efficiency, employment in the manufacturing industry increased from 293,800 in 2020 to 340,600 in 2023, with 40% of the new jobs concentrated in industrial parks along the railway line (Table 3). Employment in public service industries such as education and healthcare grew by 10.8% and 5.1% respectively, reflecting the expansion of public service demand driven by accelerated urbanization along the SGR line. Notably, female employment participation has increased, with their proportion in fields such as ticketing services and warehouse management rising from 28% in 2017 to 35% in 2023(Table 3,4). However, women remain concentrated in low- and middle-level positions, with limited career advancement opportunities.

The income distribution pattern shows differentiated characteristics. The average annual wage growth rate in the transportation and storage industry (3.2%) and the construction industry (1.8%) both lower than those in technology-intensive industries such as information and communication (3.6%) and finance (2.7%), reflecting that SGR-related positions are still dominated by low- and medium-skilled roles (Table 3). Nevertheless, the income stability of formal employment is significantly superior to that of informal employment. The monthly average income of wage employees in SGR-related industries is 58% higher than that of informal workers, and the social security coverage rate reaches 72%—far higher than the national average of 23%. This income gap has further driven the transfer of labour from the informal sector to the formal sector. In 2023, the proportion of employment in the modern enterprise sector reached 19.5%, an increase of 1.7 percentage points compared to 2017 (Table 4).

4.4.2 The Impact of SGR on Regional Economic Integration in East Africa

4.4.2.1 Reconstruction of Logistics Networks and Strengthening of Hub Status

By improving transportation efficiency and optimizing network layout, SGR has reshaped the logistics pattern in East Africa and significantly strengthened Kenya's status as a regional logistics hub. In terms of transportation capacity, SGR's freight volume surged from 2.899 million tons in 2018 to 6.533 million tons in 2023, an increase of more than 22 times in six years. Its proportion in Kenya's total railway freight volume rose from 70% to 84% (Figure 3), forming a "trunk-branch synergy" system with the Meter Gauge Railway (MGR) (Kenya National Bureau of Statistics, 2022, 2024). SGR undertakes the trunk transportation of high-value-added, long-distance goods (such as electronic products and automobiles), while MGR focuses on the medium- and short-distance distribution of bulk goods such as steel and grain. The two are physically connected through the Longoot connection line, constructing a "sea-rail-rail" multimodal transport network.

The improvement in logistics efficiency has directly reduced regional trade costs. Traditional road transportation from Mombasa to Kampala, Uganda takes 5-7 days, while the "SGR + road connection" model can shorten this to 2 days, reducing costs by 40%. The efficiency of Mombasa Port as a regional gateway has been significantly enhanced: the container detention time was shortened from 7 days in 2017 to 3 days in 2023, and the total transit freight volume increased from 9.947 million tons in 2019 to 11.414 million tons in 2023, a 14.7% growth (Figure 5). This efficiency improvement is particularly crucial for landlocked countries: 90% of Ethiopia's import and export goods are transhipped through Mombasa Port, and SGR has reduced the proportion of logistics costs in its GDP from 18% in 2017 to 14% in 2023.

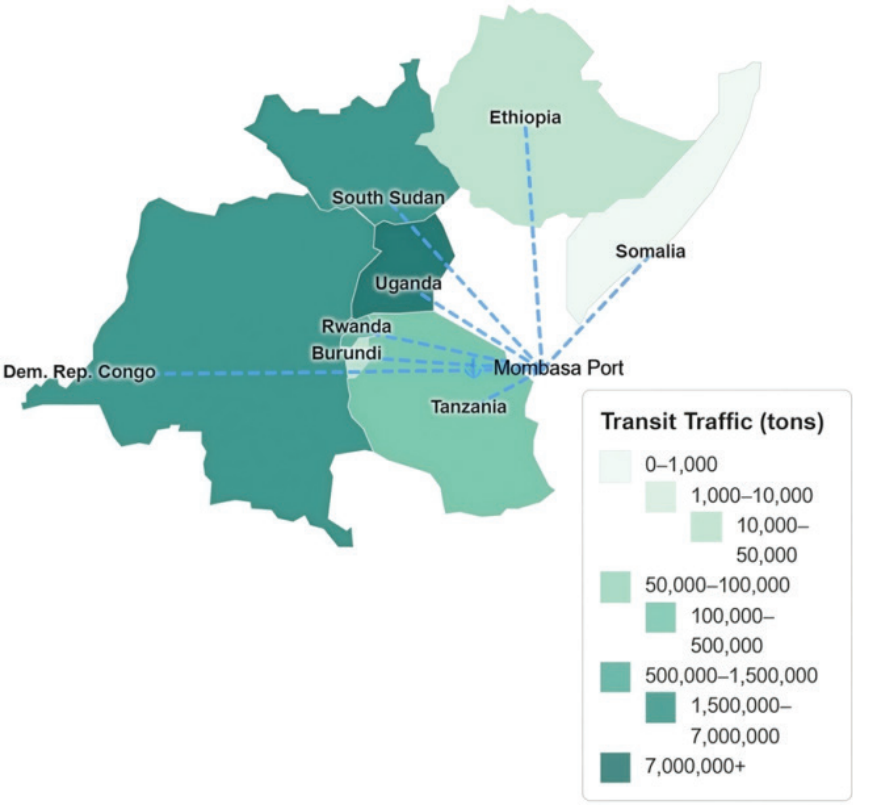
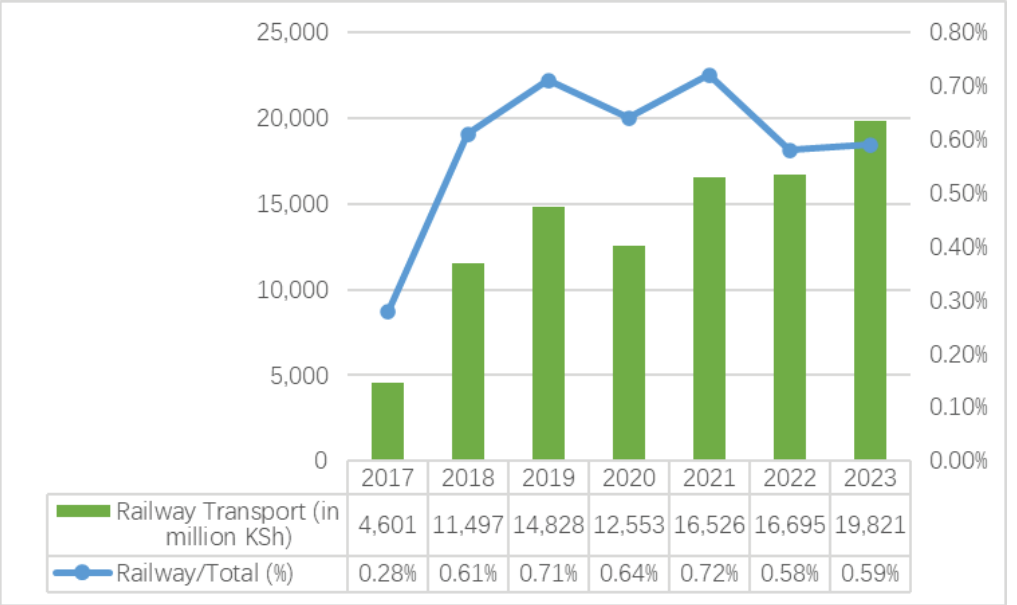


Figure 5 Mombasa Port Transit Map (Data Source: Kenya National Bureau of Statistics (KNBS), Economic Survey 2024 and Economic Survey 2022).

The regional logistics radiation range presents differentiated characteristics. Figure 5 shows that Ethiopia, South Sudan, and Uganda rank among the top three in terms of freight volume, reaching 7 million tons, 1.92 million tons, and 7.115 million tons respectively, while Tanzania only has 310,000 tons (Kenya National Bureau of Statistics, 2022, 2024). This difference stems from geographical conditions and infrastructure layout: as a landlocked country, Ethiopia lacks its own ports and has a high dependence on Mombasa Port; Tanzania, on the other hand, can divert goods through the Port of Dar es Salaam, forming a competitive logistics corridor. In terms of freight structure, petroleum products account for 65% of South Sudan's transit goods, while minerals such as copper and cobalt account for 78% of the Democratic Republic of the Congo's transit goods (Adesola, 2015), reflecting the high dependence of resource-based countries on the SGR logistics corridor and forming a two-way flow model of "resource export - equipment import".

The economic value of the logistics hub continues to be released. In 2023, Kenya's railway transportation revenue increased by 331% compared to 2017, with 45% coming from cross-border logistics services (Figure 6). The output value of the transportation and storage industry reached KSh 338.375 billion, and its proportion in GDP rose from 2.8% in 2017 to 3.5% in 2023, becoming a core driver of service industry growth. A

cluster of logistics parks has been formed around Mombasa Port, attracting Chinese and foreign enterprises to establish regional distribution centres. In 2023, FDI inflow into this region reached USD 190 million, an 85% increase compared to 2017 (Kenya National Bureau of Statistics, 2022, 2024).



	2017	2018	2019	2020	2021	2022	2023
Railway Transport (in million KSh)	4,601	11,497	14,828	12,553	16,526	16,695	19,821
Railway/Total (%)	0.28%	0.61%	0.71%	0.64%	0.72%	0.58%	0.59%

Figure 6 Railway Transport Output Value and Transport Sector Share (2017-2023) (Data Source: Kenya National Bureau of Statistics (KNBS), Economic Survey 2024 and Economic Survey 2022).

4.4.2.2 Upgrading of Trade Patterns and Factor Mobility

By reducing trade costs and optimizing trade structures, SGR has promoted the development of East African regional trade towards higher quality while facilitating the cross-regional optimal allocation of production factors. In terms of trade scale, trade between Kenya and members of the East African Community (EAC) accounts for 70% of its total trade with Africa. Exports to the EAC grew by 42% from 2019 to 2023, with the proportion of high-value-added products (cement, pharmaceuticals, mechanical equipment) rising from 18% to 27%. This change benefits from the improved transportation reliability brought by SGR: the transportation loss rate of fresh agricultural products from Nairobi to Mombasa decreased from 25% to 8%, increasing Kenya's share of the regional flower market from 32% to 45% (Kenya National Bureau of Statistics, 2022, 2024).

The exertion of comparative advantages has become more sufficient, forming a pattern of regional specialized division of labor. By reducing the transportation costs of manufactured goods through SGR, Kenya has strengthened its comparative advantage in the manufacturing sector. Exports of steel from Kenya to Uganda increased by 79% from 2021 to 2023, and the price is 12% lower than that of imports from China,

achieving regional trade substitution. Countries such as Uganda and Rwanda focus on agricultural and mineral production. In 2023, their exports of agricultural products such as coffee and tea to Kenya through SGR increased by 38%, and mineral exports from the Democratic Republic of the Congo increased by 176%, forming a division of labour system of "manufacturing country - resource country" (Kenya National Bureau of Statistics, 2022, 2024). This division of labour pattern is highly consistent with Ricardo's Theory of Comparative Advantage, improving the efficiency of regional resource allocation (Ruffin, 2002).

Institutional synergy and logistics hardware complement each other. Kenya has signed the "Railway Intermodal Transport Agreement" with Uganda and Rwanda, realizing "one-time inspection and nationwide passage" and shortening cross-border customs clearance time from 48 hours to 6 hours. The "Electronic Cargo Tracking System" (ETS) launched in 2021 has further reduced non-tariff barriers, enabling a 23% rebound in transit freight volume after the pandemic. However, the issue of trade imbalance remains prominent: Kenya's trade deficit with the EAC reached KSh 1.6 trillion in 2023, but part of the deficit has been offset by logistics service revenue, reflecting the balance mechanism of "trade deficit - logistics surplus" (Figure 7).

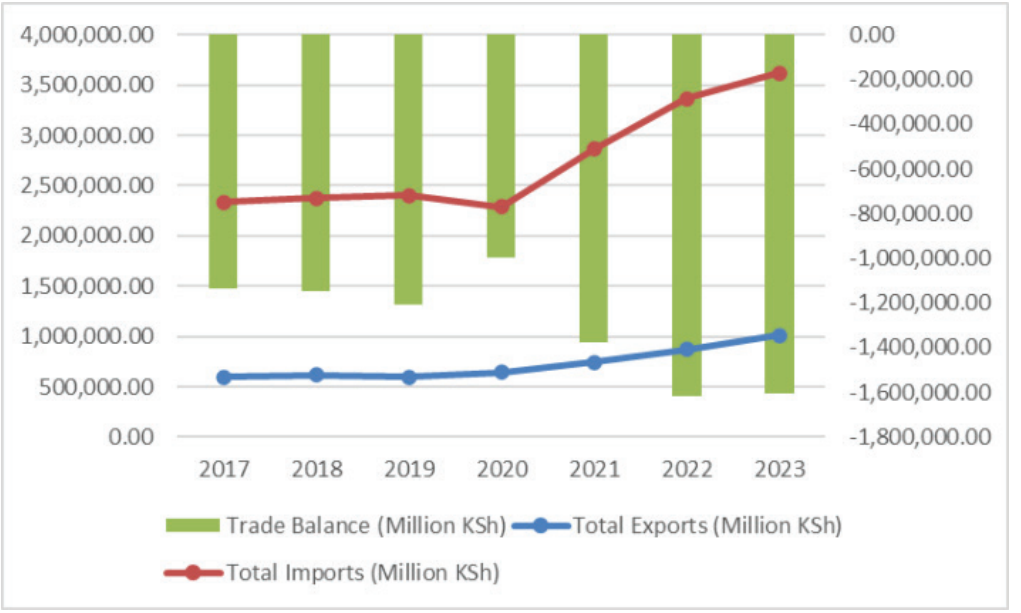


Figure 7 Kenya Merchandise Trade Trends & Deficit Analysis (2017-2023) (Data Source: Kenya National Bureau of Statistics (KNBS), Economic Survey 2024 and Economic Survey 2022).

The cross-regional mobility of production factors has been significantly enhanced. In terms of the labour market, approximately 30% of employees in Kenya's transportation and storage industry are from neighbouring countries such as Uganda and Rwanda. The proportion of foreign workers reached 15% in 2023, an increase of 7 percentage points compared to 2017, and Nairobi has formed a regional logistics talent pool. In terms of capital mobility, 28% of the FDI attracted by Kenya from 2021 to 2023 was

invested in logistics-related industries. The "Belt and Road" Industrial Park built by Chinese enterprises near Mombasa Port develops export-oriented processing industries with the help of SGR, and the time for transporting products to Uganda is 50% shorter than by road. Technology diffusion is achieved through personnel mobility: Kenyan railway technicians have participated in railway upgrading projects in Uganda, forming a positive cycle of "technology transfer - capacity building - regional coordination" (Wang et al., 2020).

4.4.2.3 Challenges and Limitations in the Integration Process

Despite SGR's significant role in promoting regional integration, it still faces structural challenges that restrict the full release of its effects. The risk of solidification of the "center-periphery" structure has emerged: as a regional logistics and manufacturing center, Kenya has gathered 70% of regional logistics enterprises and 60% of manufacturing employment, while peripheral countries such as Uganda and South Sudan still mainly export primary products, with deteriorating terms of trade. In 2023, the price fluctuation range of mineral exports from the Democratic Republic of the Congo reached 28%, far exceeding the 12% fluctuation range of Kenya's manufactured goods, reflecting the vulnerability of peripheral countries in the global value chain, which is consistent with the "weakness of peripheral countries" revealed by Dependency Theory (Farny, 2016).

Infrastructure capacity bottlenecks and efficiency decline coexist. Figure 6 shows that the proportion of railway transportation decreased from 0.72% to 0.59% in 2022-2023, and the daily freight volume of the Mombasa-Nairobi section reached 48,000 tons, approaching the capacity limit of 50,000 tons. Overload operation has led to an increase in the delay rate from 5% in 2018 to 12% in 2023, and logistics costs have begun to rebound. In 2023, the transportation cost per ton-kilometre increased by 8% compared to 2021, confirming the view in the Infrastructure Life Cycle Theory that "maintenance is equally important as expansion" (Agénor, 2009).

Debt sustainability and insufficient regional coordination constitute dual constraints (Githaiga & Wang Bing, 2019; Lwesya, 2022). 90% of the investment in the SGR project comes from loans from the Export-Import Bank of China, accounting for 9% of Kenya's external debt. 2024 marks the beginning of the concentrated debt repayment period, and fiscal pressure may restrict the construction of subsequent extension lines. At the regional level, the connection of cross-border railway networks is insufficient: the progress of extending SGR to core cities such as Kampala (Uganda) and Kigali (Rwanda) has been slow, and cross-border freight only accounted for 28% of SGR's total freight volume in 2023 (Kenya National Bureau of Statistics, 2024). Infrastructure upgrades in countries such as Tanzania (e.g., the expansion of the Port of Dar es Salaam) have further diverted freight, intensified regional logistics competition and reflected the lack of regional coordination mechanisms.

Environmental and social coordination issues have not been fully resolved. Although 14 wildlife corridors were built for SGR, the land development along the line from 2021 to 2023 led to a reduction of 1,200 hectares of vegetation, exerting a certain impact on agricultural production. The benefit distribution mechanism for

cross-border projects is unclear: Kenya collects 65% of the total regional cross-border logistics revenue, triggering dissatisfaction among neighbouring countries, which may hinder the deepening of integration (Kenya National Bureau of Statistics, 2022, 2024). These challenges indicate that infrastructure-driven integration requires supporting institutional innovation and benefit-sharing mechanisms to achieve a leap from "hard connectivity" to "in-depth integration" (Lape, Mwagha, & Siljander, 2023).

4.5 Conclusions and Recommendations

This study has critically examined the economic and developmental implications of Kenya's Standard Gauge Railway (SGR), the country's largest infrastructure investment under China's Belt and Road Initiative. Employing theoretical frameworks and empirical analyses, the findings demonstrate that the SGR has generated substantial short-term benefits while embedding structural transformations that may influence Kenya's long-term growth and regional integration.

Theoretically, the research verified the explanatory utility of Solow's growth model and endogenous growth theory—the former illuminating short-term contributions of capital accumulation and employment expansion, the latter capturing longer-term spillover effects through industrial linkages, human capital, and technological diffusion. Spatial and development economics further revealed how the SGR facilitated agglomeration economies and sectoral upgrading. Empirically, the study confirmed three findings. First, the SGR improved logistics performance, reducing costs and enhancing trade competitiveness and industrial productivity (Githaiga, 2021; Odima, Obosi, & Jonyo, 2023). Second, it restructured the labour market by generating direct and indirect employment, stimulating wage regularisation and labour mobility (Zhu, Mwangi, & Hu, 2023). Third, it accelerated regional integration by linking Kenya with EAC markets, strengthening cross-border trade and supply chain reorganisation (UNCTAD, 2022; Otele & Guguyu, 2023).

However, three sustainability challenges persist: rising external debt and fiscal risks (Njiru et al., 2020), environmental externalities, and uneven regional development that may reinforce a centre-periphery imbalance (Knox, Gambino, & ter Stein, 2023). The SGR's long-term impact will depend on effective debt management, equitable distribution, and stronger governance. Based on these findings, we propose policy recommendations across three levels. Domestic Policies for Kenya should build a development system characterized by debt controllability, technological autonomy, and stronger industrial linkages. We recommend establishing a cross-departmental financial assessment mechanism to align infrastructure investment with fiscal revenue growth (Kongo, 2023), and innovating financing models through instruments such as infrastructure revenue bonds to attract domestic capital and reduce foreign debt reliance (Bett, 2018). For technology localization, the government should expand technical training and establish Technology Transfer Incubation Centers to support local enterprises in absorbing imported technologies (Park & Tang, 2021). Industrially, Kenya should leverage SGR hub nodes to develop integrated logistics-manufacturing-service belts, attracting food processing and pharmaceutical industries that benefit from cold-chain rail transport.

Regional Collaboration in East Africa: East African nations must move beyond physical connectivity to institutional and economic synergy. Hardware connectivity requires a roadmap for extending the SGR to Kampala and Kigali and upgrading existing meter-gauge railways. Institutionally, regional customs clearance integration with unified standards and a common e-government platform is needed to reduce non-tariff barriers (Balistreri, Tarr, & Yonezawa, 2014). A coordinated industrial division of labour should be encouraged, forming a complementary regional value chain (Hidalgo, 2012). A cross-border ecological co-governance mechanism is also needed to address environmental footprints (Hughes, 2019).

International Cooperation: Future cooperation should adhere to "extensive consultation, joint contribution, and shared benefits." Multilateral development banks should be invited to establish special funds with hybrid financing models to diversify risk (Yang, 2021). Technical cooperation should focus on adaptive innovation suited to East Africa's context. Incorporating the SGR into UN monitoring frameworks for poverty reduction and gender equality can enhance its transparency and developmental impact.

In conclusion, the SGR exemplifies infrastructure-led development's dual nature: short-term gains with long-term transformation potential, accompanied by debt, sustainability, and disparity challenges. The ultimate goal is building a resilient, inclusive, and sustainable regional development community—shifting from a "scale-first" to a "quality-and-inclusion-first" approach, integrating infrastructure with institutions, human capital, and equitable policies to convert hard connectivity into sustainable shared development.

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Chapter 5

Regional Economic Growth and Employment: China's Domestic Circulation and Rural Revitalization

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Abstract This study investigates the dynamics of regional economic growth in China from 2019 to 2023, particularly emphasising the country's strategic shift from an export-oriented growth model toward stimulating domestic consumption under the domestic circulation framework. Concurrently, the research critically evaluates the efficacy of the Rural Revitalisation policy implemented between 2018 and 2022, scrutinising its impact on narrowing the urban–rural income disparity and its broader implications for regional development. Additionally, the study addresses the emerging challenges posed by demographic transformations and the expansion of higher education, particularly concerning unemployment trends. The analysis uses a fixed-effects econometric model to examine panel data encompassing 31 Chinese provinces and municipalities over the specified period. Key variables include real GDP growth, trade openness, urban–rural income inequality, and unemployment rates. Empirical findings indicate that trade openness has a statistically significant adverse effect on regional economic growth, underscoring the diminishing returns of export-led growth amid the stagnation of globalisation and strategic policy realignment. Contrary to policy objectives, the urban–rural income gap has widened during the Rural Revitalisation period; intriguingly, this increasing disparity positively correlates with economic growth, reflecting complex dynamics such as structural economic adjustments and urban-centric capital accumulation. Furthermore, rising unemployment, exacerbated by demographic trends

and the scale-up of higher education, exerts a substantial inhibitory effect on economic performance. These results contribute to a nuanced understanding of China's evolving economic landscape, highlighting the challenges and contradictions inherent in its transition toward a consumption-driven growth paradigm.

Keywords: China's economic growth; Domestic circulation strategy; Rural revitalization; Unemployment; Urban–rural income disparity

5.1 Introduction

China's economic trajectory over the past several decades has been characterised by rapid growth fueled mainly by an export-oriented development model. However, since the late 2010s, and more intensively from 2019 onwards, the Chinese government has strategically promoted domestic consumption through the domestic circulation framework as part of its dual circulation strategy [1]. This transition reflects external pressures, such as the global slowdown in trade and heightened geopolitical tensions, and internal imperatives to achieve sustainable and balanced growth. With this strategic pivot, China has prioritised rural development via the Rural Revitalisation policy, launched in 2018, aiming to reduce the enduring urban–rural income divides and stimulate economic activities in rural areas [2].

While these policy shifts are pivotal, the post-2019 period also witnessed significant demographic and socio-economic challenges. Notably, rising unemployment rates, exacerbated by demographic shifts and the rapid expansion of higher education, pose risks to regional economic stability and labour market dynamics [3]. Understanding how these interrelated forces influence regional economic growth across China's diverse provinces remains critical for policymakers and scholars [4]. This study investigates regional economic growth in China from 2019 to 2023 by examining the effects of domestic circulation reform, rural revitalisation efforts, and unemployment trends. Utilising a panel data from 31 provinces, the research empirically evaluates these phenomena, contributing to a nuanced comprehension of China's complex and evolving economic landscape.

5.2 Literature Review

The Chinese growth miracle has historically relied heavily on export-led strategies and integration into global value chains [5]. However, vulnerabilities arising from global trade tensions and the COVID-19 pandemic have prompted a reconsideration of this model [6]. The concept of domestic circulation as part of the dual circulation strategy aims to rebalance growth by enhancing domestic demand, reducing external dependence, and fostering innovation-driven industries [7]. Recent studies emphasise the potential of this strategy to mitigate risks associated with globalisation slowdown but also caution about transitional constraints, especially in less developed regions [8]

The widening urban–rural income gap has been a persistent challenge in China's development narrative. The Rural Revitalisation strategy, instituted in 2018, seeks to promote agriculture modernisation, rural infrastructure, and social services to foster

equitable growth [9]. Empirical assessments have yielded mixed conclusions: while some regions report improvements in rural incomes and living standards [10], others note persistent or even growing disparities, attributed to uneven capital flows and labour migration patterns [7]. The complex relationship between income inequality and regional growth under this policy remains a subject of ongoing investigation.

China's demographic trends, including an aging population and changes in labour force composition, have introduced new challenges to its economic development [11]. The rapid expansion of higher education has increased the number of graduates entering the labour market. However, the alignment between education outcomes and employment opportunities has been problematic, contributing to rising youth and structural unemployment [12]. Unemployment threatens social stability and economic performance and is increasingly recognised as a critical factor in regional growth dynamics.

5.3 Method

5.3.1 Z-Standardization

Because the variables in this study have different units of measurement, all variables were first standardized before regression analysis. Z-standardization transforms the original data into dimensionless variables with a mean of 0 and a standard deviation of 1. This procedure effectively eliminates differences in units and magnitude among indicators, placing all variables on a comparable scale. It not only avoids weighting biases caused by inconsistent units but also enhances the stability and interpretability of model parameter estimates, facilitating applications such as multivariate statistics, regression, clustering, and principal component analysis. Moreover, the magnitude of the regression coefficients can directly reflect the relative influence of each variable on the outcome [13]. The specific calculation formula is:

$$Z = (X - \mu)/\sigma$$

μ and σ represent the sample mean and sample standard deviation, respectively.

5.3.2 Panel regression

The study employs a panel data model to investigate the complex determinants shaping GDP growth across China's 31 provinces from 2019 to 2023. This approach is essential given the multifaceted and evolving nature of regional economic development, which is shaped by structural reforms, demographic shifts, and policy interventions such as domestic circulation and rural revitalization. By including key variables such as trade openness, urban–rural income disparity, unemployment rates, and regional GDP growth, the panel data methodology captures both the spatial heterogeneity across provinces and temporal variations over the study period. Controlling for province-specific and time fixed effects allows the model to address unobserved heterogeneity

and reduce potential estimation biases arising from unmeasured factors unique to each region or period. Nonetheless, challenges remain fully accounting for regional policy implementation disparities and broader macroeconomic shocks that may influence growth dynamics. Despite these limitations, this econometric framework provides a robust and nuanced analysis of how interconnected economic and social factors shape the trajectories of regional growth in a transitioning Chinese economy [14], [15]. Variable definitions and measurements are detailed in Table 1.

Table 1 Details of Variables

Variable	Symbol	Unit	Source
GDP (Constant 2015)	gdp	One hundred million Yuan	[16]
Unemployment Rate	unem_rate	%	[16]
Trade Openness	trade_open	%	[17] [16]
Urban/rural Disposable Income Gap	income_gap	Yuan	[16]

5.3.3 Regression model estimation

The Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM) are three common approaches used for estimating panel data regression models. The parameters for both the CEM and FEM are estimated using Ordinary Least Squares (OLS). In contrast, the REM parameters are estimated using Generalised Least Squares (GLS), where a dummy variable represents the FEM intercept [15], [18].

(4) Standard Effect Model (Pooled OLS)

$$Y_{it} = \alpha + \beta X_{it} + \epsilon_{it}$$

Fixed Effect Model (FEM)

$$Y_{it} = \alpha_i + \beta X_{it} + \epsilon_{it}$$

(5) Random Effect Model (REM)

$$Y_{it} = \alpha + \beta X_{it} + u_i + \epsilon_{it}$$

where:

Y_{it} : GDP (i) at time (t).
X_{it} : Vector of explanatory variables for GDP (i) at time (t).
α : Intercept.

β : Coefficient vector.
u_i : Random error term specific to GDP (i).
ϵ_{it} : Error term.

5.3.4 Best model selection

Several tests were conducted to determine the appropriate estimation method for the panel data regression, including:

5.3.4.1 Chow Test

The Chow test is used to decide between the Common Effect Model (CEM) and the Fixed Effect Model (FEM) [18].

$$F = \frac{(RSS_C - RSS_F)/(N-1)}{RSS_F/[N(T-1)-K]}$$

Where:

RSS_C : Residual sum of squares for the CEM.
RSS_F : Residual sum of squares for the FEM.
N : Number of cross-sectional units.
T : Number of periods.
K : Number of parameters estimated.

If the calculated F value is greater than the critical F value from the F-distribution table, reject the null hypothesis favouring the Fixed Effect Model.

Table 2 *Chow test result*

Effect Test	Statistic	d.f	Prob.
Cross-section F	180.952284	(30,121)	0.0000
Cross-section Chi-sq.	592.981162	30	0.0000

Based on the output value above, the Prob Cross Section F value is 0.0000 < alpha 5%, which means that the study rejects H0; thus, the best model is the Fixed Effect Model (FEM).

5.3.4.2 Breusch-Pagan Lagrange Multiplier (LM) Test

The Breusch-Pagan Lagrange Multiplier (LM) Test is employed to determine whether the Random Effect Model (REM) is more appropriate than the Common Effect Model (CEM) [13], [19].

$$LM = \frac{NT}{2(T-1)}\left[\frac{\sum_{i=1}^{N}\ \sum_{t=1}^{T}\ (Y_{it} - \overline{Y_i} - \overline{Y_t} + \overline{Y})^2}{\sum_{i=1}^{N}\ \sum_{t=1}^{T}\ (Y_{it} - \overline{Y})^2/NT}\right]$$

If the LM statistic is greater than the critical value from the chi-squared distribution table with *1* degree of freedom, reject the null hypothesis in favour of the Random Effect Model.

Table 3 LM test result

Test Summary	Cross-section	Test Hypothesis Time	Both
Breusch-Pagan	249.1715 (0.0000)	0.163539 (0.6859)	249.3350 (0.0000)
Honda	15.78517 (0.0000)	0.404399 (0.3430)	11.44775 (0.0000)
King-Wu	15.78517 (0.0000)	0.404399 (0.3430)	5.794134 (0.0000)
Standardised Honda	16.59613 (0.0000)	1.003401 (0.1578)	8.805872 (0.0000)
Standardised King-Wu	16.59613 (0.0000)	1.003401 (0.1578)	3.950926 (0.0000)
Gourieroux, et al.	--	--	249.3350 (0.0000)

Table 3 shows that the Breusch-Pagan probability value is 0.0000, more significant than the significance level (α = 5%). This result leads to rejecting the null hypothesis (H_0), indicating that the Random Effect Model (REM) is appropriate. However, to definitively determine the most suitable model for this study, whether the Random Effect Model (REM) or the Fixed Effect Model (FEM), it is necessary to conduct the Hausman Test.

5.3.4.3 Hausman Test

The Hausman Test is utilised to determine the suitability between the Fixed Effect Model (FEM) and the Random Effect Model (REM).

Hypothesis:

H_0 : Random effects are uncorrelated with the predictors (REM is appropriate).
H_1 : Random effects are correlated with the predictors (FEM is appropriate).

Test statistics:

$$H = (\beta_{FE} - \beta_{RE})'[Var(\beta_{FE}) - Var(\beta_{RE})]^{-1}(\beta_{FE} - \beta_{RE})$$

Where:

- β_{FE} : Coefficient vector from the Fixed Effect Model.
- β_{RE} : Coefficient vector from the Random Effect Model.
- $Var(\beta_{FE})$: Variance-covariance matrix of the Fixed Effect coefficients.
- $Var(\beta_{RE})$: Variance-covariance matrix of the Random Effect coefficients.

If the Hausman statistic is larger than the critical value from the chi-squared distribution table with *K* degrees of freedom, reject the null hypothesis in favour of the Fixed Effect Model.

Table 4 Hausman test result

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	10.058686	3	0.0181

As shown in Table 4, the random cross-section probability value is 0.0181, which is more significant than the significance level (α = 5%). This result leads to fail to rejection of the null hypothesis (H).

5.4 Findings

Table *Panel Model Estimation Result*

Variables	Coefficient
ZINCOME_GAP	0.265743***
ZTRADE_OPEN	-0.094638***
ZUNEM_RATE	-0.057426***
Effect specification	
Cross-section random	
Observation number	155
R-sq	0.982237
AR^2 Test	0.977392
The F-test	202.7520
Prob(F-statistic)	0.000000

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

5.4.1 Simultaneous Impact of Independent Variables

Hypothesis:

H0 : $\beta 1 = \beta 2 = \beta 3 = \beta 4 = D = 0$,
(All independent variables simultaneously do not affect GDP)

H1 : $\beta 1 \neq \beta 1 \neq \beta 1 \neq \beta 1 \neq D \neq 0$
(All independent variables simultaneously affect GDP)

Referring to Table 5, the probability value of the F-statistic is 0.0000, significantly lower than the conventional significance level ($\alpha = 5\%$). This indicates that the set of independent variables collectively exerts a statistically significant influence on regional GDP growth across Chinese provinces during the 2019–2023 period. The F-test results validate that the overall model reliably captures the variations in economic growth, confirming the joint explanatory power of trade openness, urban–rural income disparity, unemployment rates, and other key factors. This finding underscores the complex and interrelated nature of the determinants shaping China's regional economic trajectories, reflecting structural, social, and policy dimensions simultaneously. Such an integrative analytical framework aligns with recent studies [20], [21], which argues that sustainable growth in China cannot be attributed to isolated factors but rather emerges from the dynamic interplay of domestic reforms, labor market conditions, and regional disparities.

5.4.2 Individual Variable Analysis: Partial t-tests

Table 6 Partial t-Test Interpretations

Variable	Coef	Result
Income Gap	0.265743***	Significant Effect
Trade Openness	-0.094638***	Significant Effect
Unemployment Rate	-0.057426***	Significant Effect

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

5.4.3 Urban–Rural Disposable Income Gap

The relationship between the urban–rural disposable income gap and real Gross Domestic Product (GDP) growth in China's provinces exhibits a complex but significant pattern. The coefficient of 0.265743, supported by a highly significant p-value of 0.0000, indicates that as the gap in disposable income between urban and rural households widens, the aggregate output as measured by real GDP grows correspondingly. This positive association may initially seem counterintuitive due to

widening inequality's often negative social connotations. Nonetheless, it reflects several interrelated economic mechanisms prevalent within the developmental trajectory of middle-income and rapidly industrialising economies such as China [22].

First, one important channel through which a moderate widening of the urban–rural income gap can stimulate growth is higher-income urban residents' saving and investment behaviour. It is well documented that wealthier households possess a higher marginal propensity to save compared with their lower-income rural counterparts [23]. In China, urban residents, predominantly employed in the formal sector and concentrated in cities with greater access to financial institutions and investment opportunities, have considerable savings that can be mobilised toward capital formation. These savings, often accumulated in urban areas, translate into funds that finance infrastructural development, real estate expansion, and industrial investment. Such capital deepening enhances production capacities and induces multiplier effects across the provincial economies [24]. Thus, the differential income distribution can feed investment cycles necessary for growth acceleration, especially in economies transitioning from agrarian to industrial bases.

Second, the urban–rural income gap accompanies rapid urbanisation and structural transformation. As [25] demonstrate, regional income-level disparities often reflect underlying labour reallocations from low-productivity rural agriculture to higher-productivity secondary and tertiary sectors anchored in urban agglomerations. This labour migration catalyses aggregate productivity growth by optimising the allocation of human capital to sectors with greater returns, facilitating economies of scale and encouraging technological spillovers. In essence, the income disparity is both a symptom and an engine of more profound economic restructuring conducive to growth. Moreover, urban centres often offer superior public services, education, and infrastructure, further amplifying labour productivity gains and facilitating innovation diffusion within these regions [22].

However, the relationship between the urban–rural income disparity and growth is not unconditionally positive. The growth effects hold predominantly under conditions of moderate inequality; huge income gaps can undermine the fabric of sustainable economic expansion. [25] emphasised that widening income gaps constrain rural consumption capacity beyond a certain threshold, a critical component of domestic demand, thereby dampening aggregate demand growth. Rural households, facing relative deprivation, reduce consumption expenditures, leading to weakened market demand for goods and services, which negatively impacts industrial and service sector prospects. Moreover, stark income disparities exacerbate social and political tensions, impeding social mobility and eroding community cohesion. These factors collectively can give rise to fiscal instability and hinder the reform momentum necessary to sustain development [23]. In China's context, the government has recognised this paradox of growth and inequality, implementing policies aimed at rural revitalisation, social safety nets, and income redistribution to avoid the risks posed by excessive income disparities [26]. A widening urban–rural income gap reflects developmental imperative conditions accompanying rapid economic transformation and urbanisation. It can catalyse GDP growth through capital accumulation and labour reallocation towards higher-productivity sectors. Nevertheless, policy must ensure the gap remains manageable to mitigate adverse effects on consumption, social stability, and sustainable development.

5.4.4 Trade Openness

The empirical analysis finds trade openness exerts a significant negative impact on real GDP growth in the Chinese provinces analysed, with a coefficient of –0.094638 and a p-value of 0.0000. This result is significant given China's status as one of the world's most open economies, with a history of leveraging trade liberalisation as a growth engine. The negative association revealed for the period studied, spanning 2019–2023, suggests that in the presence of external shocks and shifting geopolitical dynamics, the net effect of trade openness on growth can invert from a traditional positive expectation to a contractionary one. Classical trade theory, that of comparative advantage advanced by Ricardo and later expanded, posits that greater trade openness enhances welfare by facilitating specialisation and access to more efficient production techniques [27]. Trade allows countries to import costly goods to produce domestically, while exporting commodities and manufactured products in which they hold efficiency advantages. Beyond static gains, openness enables technology diffusion, increases competitive pressures that encourage innovation, and fosters economies of scale by enlarging market size [28].

However, the negative impact revealed suggests that contextual factors play a decisive role in shaping the net growth effects of trade. Several macroeconomic and geopolitical factors during 2019–2023 have dented the growth benefits of trade openness for Chinese provinces. Firstly, the escalation of Sino–U.S. trade frictions, including tit-for-tat tariff increases and restrictions on technology transfers, created heightened uncertainty in trade-dependent industries. [29] found that such tensions raised costs for exporters, reduced foreign orders, and disrupted supply chain reliability, particularly in manufacturing sectors concentrated in export-oriented provinces. It reduced the predictability of market conditions, caused inventory stockpiling behaviours, and constrained public and private investment decisions, dampening GDP growth.

Secondly, the global trend towards deglobalization and supply chain restructuring weakened the symbiotic relationships underpinning international trade-led growth. [30] document how firms shifted sourcing strategies to nearer or more politically aligned countries, shortened supply chains to enhance resilience, and diversified suppliers to mitigate risk. Such adjustments contributed to volatility in cross-border trade flows and interrupted technology and knowledge transfers, which are crucial for maintaining productivity growth. As trade openness traditionally implies integration into these networks, disruption implies negative spillovers on economic performance.

The COVID-19 pandemic caused sustained global demand shocks, labour market interruptions, and logistics bottlenecks [6]. These exogenous shocks led to shipping container shortages, port congestion, and uncertainty in cross-border contracts, severely curtailing China's import and export volumes. Since many Chinese provinces rely heavily on global trade for industrial output and foreign capital inflows, the indirect and direct effects on their GDP growth were substantial. These factors illustrate that trade openness's impact on GDP growth is contingent upon the external environment and global governance structures. It challenges the notion that trades openness uniformly benefits growth and emphasises a shifting paradigm whereby trade benefits are conditional on geopolitical stability, supply chain robustness, and complementary industrial policies [31].

These realities have led China's policymakers to prioritise a "dual circulation" development strategy focusing on boosting domestic demand and deepening internal economic cycles while maintaining selective openness to foreign trade and investment. This strategy aims to lessen vulnerabilities associated with external shocks while creating more balanced growth [32]. In addition, while trade openness historically served as a key driver of China's rapid growth, the empirical evidence from the recent period illustrates that under conditions of increased geopolitical tensions, pandemic disruptions, and deglobalization trends, trade openness can negatively affect provincial GDP growth. Hence, trade policy must be calibrated carefully with internal economic strengthening to ensure resilience and sustainable development.

5.4.5 Unemployment Rate

The unemployment rate's coefficient of –0.057426 with a statistically significant p-value of 0.0018 establishes a clear negative relationship with real GDP growth across Chinese provinces between 2019 and 2023. This finding is congruent with orthodox economic theories linking labour market conditions to economic performance and underscores the critical role employment plays as a driver of aggregate demand, productivity, and social stability. At its core, the negative coefficient reflects that when unemployment rises, the economy operates below its potential output due to underutilization of labour input, the central production factor. From a supply-side perspective, fewer employed persons imply lower total labour hours, decreased production capacity, and subdued output levels [33]. Labour market slack directly reduces GDP because firms cannot produce as much without the requisite labour force engaged productively.

From the demand side, unemployed individuals experience income loss or insecurity, reducing consumption expenditures and savings potential. Since consumption constitutes a substantial share of GDP, particularly in domestic-oriented provinces, reductions in household spending translate into lower aggregate demand and investment incentives for firms. Moreover, extensive unemployment can dampen business confidence, leading to deferred investments, hiring freezes, and retrenchments, thus creating a vicious cycle of reduced economic growth ([3]. Beyond short-term output losses, prolonged unemployment leads to human capital depreciation. The skills of unemployed workers may deteriorate, technological relevance may fade, and labour market detachment may occur. This "hysteresis effect" implies that once unemployment rises above a certain threshold, it can permanently scar the economy's growth potential, as a less skilled and demotivated workforce impedes productivity improvements [34]. Particularly in fast-changing economies like China's provinces undergoing structural transformation, sustained unemployment implies lost opportunities for upgrading the labour force aligned with new industrial technologies.

Furthermore, rising unemployment carries social costs. Increased government expenditure on social welfare, unemployment benefits, public health, and reduced tax revenues strain fiscal capacity for growth-promoting investments. Social instability linked to prolonged joblessness can also erode the investment climate and human development outcomes [35]. These dynamics highlight the urgency of employment-focused fiscal and monetary policies. Macroeconomic interventions to stimulate

job growth, support flexible labour markets, retraining programs, and social safety nets are critical to maintaining economic momentum. The Chinese government's pandemic-era stimulus measures targeted infrastructure, consumption vouchers, and job creation, particularly in vulnerable sectors, underscoring these priorities [36]. In addition, unemployment's negative impact on GDP growth is multifaceted, affecting supply capacity, aggregate demand, human capital, and social stability. Stability and expansion of employment remain fundamental for sustaining robust regional economic growth during periods of external shocks and internal structural shifts.

As shown in Table 5, the coefficient of determination (R^2) for the fixed-effects model is 0.9822, which explains 98.22% of the variance in China's real GDP during 2019–2023. This exceptionally high level of goodness-of-fit demonstrates the robustness of the regression analysis. The model is specified as follows:

$$GDPit = -0.057426 * UNEM_RATEit + (-0.94638) *) TRADE_OPENit + 0.265743 INCOME_GAPit + \varepsilon it$$

Where UNEM_RATE represents the unemployment rate, TRADE_OPEN denotes trade openness, and INCOME_GAP is the urban–rural disposable income gap. All three variables exhibit statistically significant effects on real GDP growth. The negative coefficient on unemployment rate suggests that rising unemployment diminishes economic growth by suppressing employment levels and consequently reducing productive capacity. Similarly, the negative coefficient on trade openness implies that excessive reliance on international markets may restrict domestic economic development in an environment characterised by heightened external uncertainties, such as geopolitical tensions and global disruptions. Conversely, the positive coefficient on the income gap indicates that a widening urban–rural income disparity has helped support domestic demand and driven economic growth within the observed data range [37].

Further insights emerge after incorporating province fixed effects into the model, revealing pronounced regional heterogeneity in economic performance, as illustrated in Figure 1. Coastal provinces such as Guangdong (2.733958), Jiangsu (2.555588), and Shandong (1.497652) exhibit positive fixed effects, indicating their robust economic foundations and advanced industrial structures strongly contribute to national growth. In contrast, provinces in the central and western regions, namely Tibet (-1.386694), Qinghai (-1.188749), Ningxia (-0.903351), and Hainan (-0.853223), display significant adverse fixed effects, underscoring the spatial imbalance in China's regional development. From a macroeconomic perspective, the combined impact of Sino–U.S. trade frictions, global deglobalization trends, and disruptions caused by the COVID-19 pandemic has weakened external demand, reducing growth momentum, especially in export-oriented coastal provinces. Although these coastal regions remain primary growth engines, their growth rates have slowed, highlighting vulnerabilities linked to high trade dependence amid global supply-chain uncertainties [12].

Meanwhile, rising unemployment has suppressed domestic demand, a challenge more acutely experienced in the central and western provinces. The positive effect of the urban–rural income gap may reflect the reinforcing roles of urbanisation and capital

agglomeration, short-term GDP gains driven by investment concentrated in high-income urban groups and infrastructure expansions. However, such growth premised on widening income disparities also signals the urgent need for more inclusive and coordinated regional development policies. Overall, the findings portray China's economy as navigating a pattern of "weak external demand and still-developing internal demand," characterised by significant regional divergence: eastern coastal provinces remain the primary drivers of growth, whereas central and western regions require urgent industrial upgrading, expanded domestic demand, and improved labour-market conditions to narrow developmental disparities [29], [38].

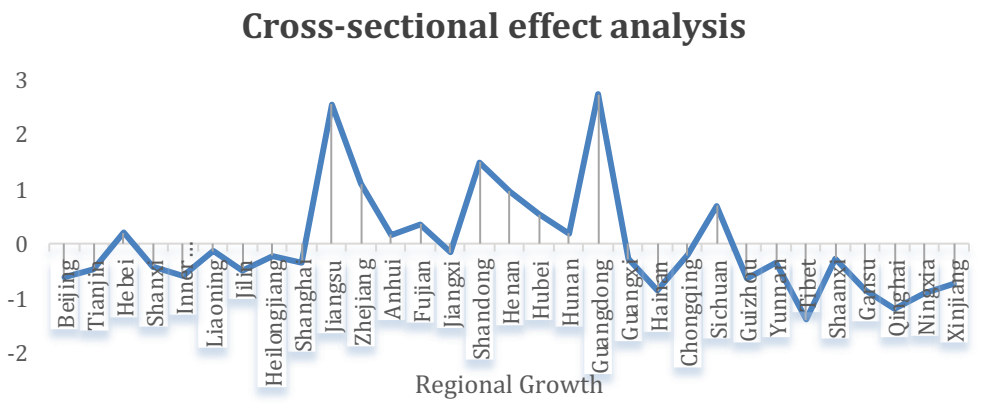


Figure 1 China's Regional Growth

5.5 Conclusion

The study employs panel data from 31 Chinese provinces, including autonomous regions and municipalities, from 2019 to 2023 to investigate the combined effects of unemployment, trade openness, and the urban–rural disposable income gap on real GDP growth. All variables were Z-standardised before regression analysis to ensure comparability and enhance model stability. Following a sequence of specification tests, including the Chow test, Breusch–Pagan LM test, and Hausman test, a random-effects model was selected to effectively control for unobserved heterogeneity across provinces and individual-specific effects. The empirical findings reveal that the urban–rural income gap exhibits a significant positive impact on economic growth, suggesting that a moderate disparity can, at least in the short run, stimulate investment and output by fostering urbanization and concentrating capital; However, an excessive widening of this gap over the long term may suppress rural consumption, deepen inequality, and endanger sustainable development. Trade openness shows a significant negative effect on real GDP throughout the studied period, reflecting the vulnerabilities associated with high trade dependence amid intensified Sino–U.S. trade frictions, global supply chain disruptions, and the COVID-19 pandemic, thereby lending empirical support to China's strategic focus on strengthening domestic circulation alongside a "dual

circulation" framework. The unemployment rate is significantly and negatively correlated with economic growth, emphasising the importance of maintaining stable employment to bolster domestic demand and sustain economic vitality [29], [33]. The model exhibits exceptionally high explanatory power ($R^2 = 0.9822$), highlighting pronounced regional disparities: the eastern coastal provinces continue to serve as principal growth engines, whereas many central and western regions lag, hindered by structural industrial limitations and insufficient employment opportunities. Taken together, these results imply that China's future economic policies should prioritise job creation and income stabilisation, optimise demand structures, reduce excessive reliance on foreign markets to improve economic resilience, and implement measures to curtail the excessive expansion of the urban–rural income gap to promote more inclusive and balanced regional development.

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Chapter 6

Cultural Poverty Among Ethnic Minorities: A Case Study of the Yi Ethnic Group in Liangshan Yi Autonomous Prefecture, China

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Abstract This study explores the persistence of cultural poverty among the Yi ethnic group in Liangshan Yi Autonomous Prefecture, Sichuan, and identifies pathways to alleviate it. Guided by four research objectives - examining the characteristics of Yi cultural poverty, the interplay between structural and cultural factors, modernization's impacts on Yi values and education/behaviors, and intergenerational transmission mechanisms - the study adopts a qualitative case study design. Twenty in-depth interviews with social roles of students, farmers, teachers, and village officials aged 16 - 54 were conducted, and data were thematically analyzed using NVivo. Six core themes emerged: Values, Beliefs, Behaviour Patterns, Character Defects, Educational Factors, and Access to Opportunities. Key findings reveal that family branch values, fatalistic beliefs, and costly traditional rites divert resources from education and economic activities; geographic isolation and weak social networks limit opportunities; and younger Yi aspire to mobility via education/migration but face traditional constraints. The study recommends culturally responsive education, cultural tourism, heritage-based income streams, and community mediators to balance tradition and poverty alleviation. These insights contribute to cultural poverty theory and inform policies for ethnic minority regions.

Keywords: Cultural Poverty; Liangshan Yi Autonomous Prefecture; Intergenerational Transmission; Qualitative Study; Poverty Alleviation.

6.1 Introduction

China is a multi-ethnic nation with 56 ethnic groups, where 55 ethnic minorities (including the Yi) primarily reside in southwestern mountainous and border regions. Liangshan Yi Autonomous Prefecture of Sichuan Province is the largest Yi settlement in China, located in the Greater Liangshan Mountains. Its complex geography, historical

economic underdevelopment, and relatively closed social system have led to enduring economic and cultural poverty [13]. Yi traditional culture—including language, religion, and customs—has been marginalized amid modernization, while limited education has entrenched intergenerational poverty. Outdated practices (e.g., lavish rituals) and structural barriers (e.g., poor infrastructure) further hinder development, making Liangshan a critical case for studying ethnic minority cultural poverty.

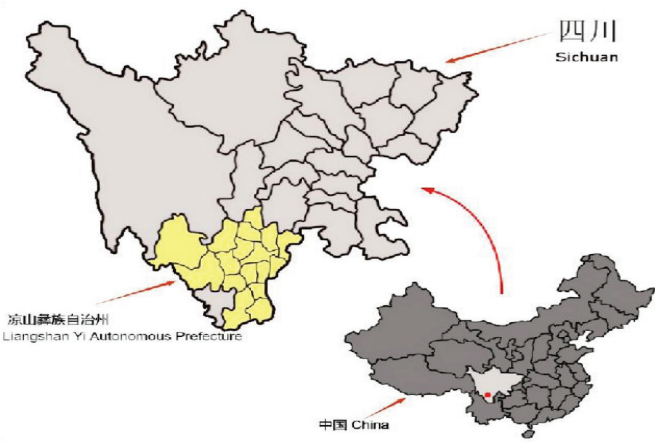


Figure 1 Location of Liangshan Yi Autonomous Prefecture in Sichuan, China.

The cultural poverty of Yi ethnic group manifests in multiple dimensions, educational barriers as Scarce resources, language gaps (Yi vs. Mandarin), and high dropout rates (due to economic pressure) keep education levels low [38]. Economic vulnerability in a traditional single-crop agricultural model with low productivity, geographic isolation which hinders market access, and natural disasters reduce income stability. Inadequate facilities, shortage of medical staff, and reliance on traditional herbal remedies or witchdoctors lead to poor health outcomes about healthcare deficits. Cultural-modernization conflict exists between traditional practices like costly funerals may deplete savings, and younger Yi lose cultural identity, failing to convert heritage into economic benefits Top-down poverty alleviation measures lack cultural sensitivity, and weak community self-help capacity result in the policy ineffectiveness.

This study attempts to understand the characteristics and the relationship of cultural poverty among the Yi ethnic group. It also explores the effects of modernization on cultural poverty and its subsequent impact on the values, education, and behavior patterns of the Yi ethnic group. The study focuses on Liangshan Yi Autonomous Prefecture, with a temporal scope of 1978–2024 (post-China's reform and opening-up) to contextualize historical and dynamic causes of cultural poverty. It examines tensions between Yi tradition culture such as language, religion, customs and modernization, and uses qualitative methods on fieldwork and in-depth interviews to explore cultural poverty's multifaceted nature.

Eventually, this study enriches cultural poverty discussion by contextualizing it in China's multiethnic setting, addressing gaps in minority-focused research. It also provides actionable insights for poverty alleviation in Liangshan Yi Autonomous

Prefecture, with lessons for other multiethnic developing countries in practice. Upon policy recommendations, it highlights the need for culturally responsive policies, balancing economic development and cultural preservation.

In the study of Liangshan Yi Autonomous Prefecture, there is a dearth of comprehensive and precise statistical data on some impoverished villages, existing literature tends to focus more on educational or economic issues rather than cultural poverty, limiting the depth of contextual analysis. Language hurdles, cultural differences, or mistrust may arise during fieldwork, may cause subjective bias in the study. The influence of cultural determinants about cultural poverty is not a standalone occurrence but rather is intimately linked to economic poverty, social prejudice, educational inequality, and other elements, which may be challenging to distinguish from economic poverty dimension. Thus, this study is important in highlighting the dual roles that culture plays in those and offer fresh insights to the area's prevalence of ethnic diversity, or other multiethnic developing nations can learn from the study experience, particularly in poverty alleviation and cultural preservation.

6.2 Literature Review

6.2.1 Cultural Poverty

"Culture of Poverty" refers to a subculture of values, attitudes, and behaviors (e.g., short-term orientation, fatalism, powerlessness) that perpetuate poverty across generations. Unlike economic poverty, it emphasizes how cultural traits—shaped by structural deprivation reinforce disadvantage [12; 29] [20] foundational theory argues that long-term poverty fosters a distinct subculture: low aspirations, lack of planning, and learned helplessness, which are transmitted intergenerationally. Critics (e.g., [29] emphasize that structural factors like inequality could interact with cultural traits to sustain poverty—an integrated perspective adopted in this study.

6.2.2 The Yi Ethnic Group

The Yi ethnic group is a major Chinese ethnic minority with a unique culture in their own Yi language, Bimo ritual tradition, and family branch systems. In Liangshan Yi Autonomous Prefecture, Yi culture shapes values of family honor and behaviors on the ritual spending, which may hinder adaptation to modernity [38] "Cultural poverty" for the Yi people refers to constrained access to education and modern culture, and erosion of traditional practices that could support development [11].

6.2.3 Underpinning Theories

The study is grounded in the Culture of Poverty Theory [20], which identifies four key variables influencing cultural poverty, values like conservative or short-term orientations that prioritize ritual over education: beliefs of fatalism reducing motivation for self-improvement of the poor. Forming behavior patterns of Intergenerationally transmitted

habits; access to opportunities while structural barriers like geographic location and poor social networks exacerbating disadvantages. Complementary literature supports these variables, [31] links community culture to socioeconomic status; [15] highlight how family culture shapes Yi consumption behaviors. Cuthrell et al. (2009) note that hostility to education in disadvantaged cultures widens inequality. [11] find Yi folk beliefs (e.g., Bimo rituals) undermine poverty alleviation policies.

6.2.4 Conceptual Framework

Existing literature confirms the role of culture in Yi poverty but lacks depth in cultural-structural interplay and up-to-date empirical data. This study addresses these gaps by using qualitative data (2023–2025) and an integrated framework. The framework integrates four independent variables (Values, Beliefs, Behaviour Patterns, Access to Opportunities) with mediating (Character Defects) and dependent (Cultural Poverty) variables. It illustrates how values shape education and income choices; Beliefs like fatalism tend to reduce opportunity-seeking; Behaviour patterns coul deplete resources; and uneven access to opportunities reinforces poverty.

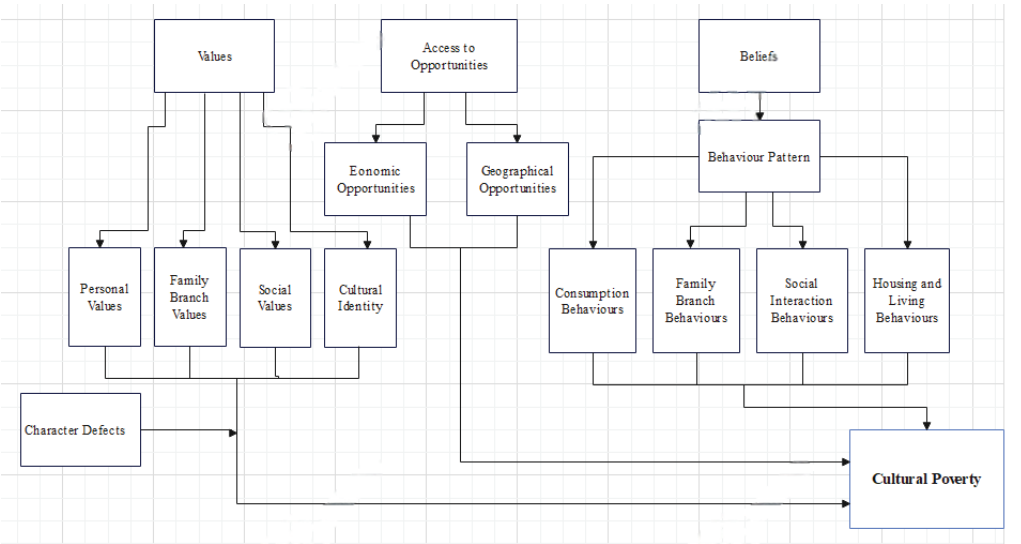


Figure 2 Development of the Conceptual Framework (Author Derivation Based on the Culture of Poverty Theory).

Most studies focus on economic and sociological aspects of Yi poverty, ignoring intrinsic cultural factors leading to the narrow research perspectives. This research has produced many insightful findings and established a strong basis for further theoretical development and empirical investigation. However, given the shortcomings of the current body of literature, it is imperative that future research expand its scholarly scope, incorporate multidisciplinary theories and methodologies, and develop a sophisticated research paradigm.

6.3 Methodology

A qualitative case study design was adopted to capture nuanced lived experiences of the Yi ethnic group. Key methods involve in-depth interviews: primary data source (20 interviews) to explore values, beliefs, and behaviors, thematic analysis: using NVivo 15 to identify patterns, guided by the conceptual framework. Qualitative methods were preferred over quantitative approaches to avoid oversimplifying cultural complexity. This study guide by the Culture of Poverty Theory particularly on variable selection including values, beliefs, while social capital theory [9] informed analysis of Yi social networks such as the reliance on family branches.

6.3.1 Population and Sample

Participants were Yi residents of Liangshan Yi Autonomous Prefecture, living in Meigu, Yuexi, Zhaojue counties with diverse social roles of students, farmers, teachers, village officials, and migrant workers. Inclusion criteria are Yi ethnicity, 5+ years of Liangshan residency, and direct experience with education and cultural poverty.

6.3.2 Sampling

Purposive sampling to select participants relevant to research objectives (e.g., teachers for educational insights), and snowball sampling to expand sample via participant recommendations. The total sample are 20 participants (10 male, 10 females; aged 16–54), ensuring diversity in age, education, and occupation (Table 1).

Table 1 The Sample Demographic Information Table.

Sample No.	Age	Gender	Social Role	Monthly Income (Yuan)	Residence	Education Level
P01	17	Male	High School Student	0	Meigu County	High School In Progress
P02	16	Female	Junior High School Student	0	Yuexi County	Junior High School In Progress
P03	18	Male	Vocational School Student	800	Zhaojue County	Secondary Vocational School In Progress
P04	35	Female	Farmer	1500	Leibo County	Primary School
P05	42	Male	Odd Job Worker	3000	Butuo County	Junior High School
P06	47	Female	Housewife	1200	Meigu County	Illiterate
P07	52	Male	Village Officer	3200	Jinyang County	High School
P08	37	Female	Village Officer	3500	Puge County	Junior College
P09	40	Male	Primary School Teacher	3800	Zhaojue County	Undergraduate
P10	31	Female	Middle School Teacher	4200	Yuexi County	Undergraduate
P11	25	Male	Migrant Youth Worker	5000	Ganluo County	High School
P12	21	Female	Vocational School Graduate	3200	Xichang City	Secondary Vocational School
P13	29	Male	Village Hygienist	3500	Huidong County	High School
P14	54	Female	Elderly	1000	Meigu County	Primary School
P15	26	Male	Young Entrepreneur	6000	Dechang County	Junior College
P16	19	Female	College Student	0	Yuexi County	Undergraduate In Progress
P17	44	Male	Village Party Secretary	4500	Butuo County	High School
P18	33	Female	Education Bureau Officer	5800	Xichang City	Undergraduate
P19	39	Male	Farmer	2500	Puge County	Primary School
P20	22	Female	Social Worker / Public Welfare Project	4000	Xichang City	Undergraduate

6.3.3 Data Collection

The in-depth interviews mode conducts via telephone online due to Liangshan's geographic dispersion and have 45–90 minutes per interview. Using Language in Mandarin or Yi (with translation support) to ensure authenticity. Interview guide with open-ended questions (e.g., "How do traditional rituals affect your family's finances?") to explore values, education, and opportunities. Verbatim transcription within 48 hours, stored in encrypted files.

Cultural Poverty is assessed via subjective experiences (interviews) and cultural poverty indicators like limited education access.Values are measured through views on success, education, and family branch values. Beliefs are captured via fatalism and traditional beliefs like Bimo rituals. Access to Opportunities is evaluated via economic (job access) and geographic (infrastructure) indicators. Behaviour Patterns are observed through consumption behaviours and social interaction habits.

6.3.4 Analysis

Thematic analysis were used in the study. Secondary data as NVivo node matrices, sample demographic tables were used to cross-validate interview findings, ensuring thematic consistency. Thematic analysis in NVivo 15 followed four steps: familiarization of multiple readings of transcripts to identify initial patterns. Initial Coding in assign labels to meaningful text segments, and thematic development that group codes into six main themes. Saturation Assessment is confirmed after 18 interviews and no new codes emerged in the final 2.

6.3.5 Reliability and Validity

Reliability is manifested in standardized interview protocols, inter-coder agreement (20% of transcripts coded independently), and audit trails of coding decisions. Triangulation on interviews and document analysis, peer debriefing includes supervisor and peer review, and thick contextual description for transferability guarantees the validity. The qualitative design, diverse sample, and rigorous analysis ensure the study captures the complexity of Yi cultural poverty, providing credible and transferable insights. It enables a thorough and in-depth exploration of the complex and multi-faceted phenomenon of cultural poverty among the Yi ethnic group in the study area.

6.4 Analysis, Findings and Discussions

This study consists of 20 interviews, organized around the six main themes, and discusses findings in relation to research objectives and existing literature. Response rate is 100%, all 20 participants completed interviews, due to clear communication of research purpose. Data Coding on open coding produces 35 subthemes and axial coding produces six main themes in NVivo (Figure 3). Data Cleaning corrected transcription errors, anonymized data and standardized terminology.

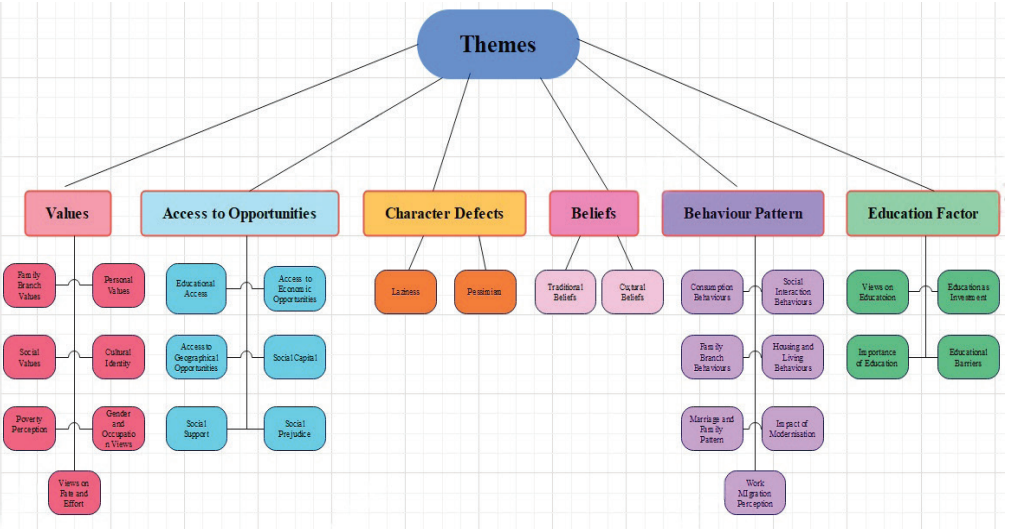


Figure 3 Development of Main Themes and Subthemes Hierarchical Structure (Author Derivation Based on Findings).

Triangulation (interviews vs. policy documents) and inter-coder agreement (92% consistency) confirmed validity. Saturation at 18 interviews ensured data adequacy.

6.4.1 Demographic Overview

Participants spanned ages 16–54: 30% students, 25% farmers, 20% village officials and teachers, and 25% migrant workers/entrepreneurs. Education levels ranged from illiterate (10%) to undergraduate (35%), reflecting Liangshan's educational diversity. Monthly incomes varied (0–6000 Yuan), with students having no income and entrepreneurs earning the highest.

6.4.2 Thematic Findings

Values. Family Branch Values influenced elders prioritized clan loyalty and honor, as the P14, 54, female emphasized:

"*Even if poor, we must not shame our family branch*",

Leading to non-negotiable ritual spending. Youth values about younger Yi valued education and urban mobility, the P01, 17, male said:

"I want to go to college, not farm like my father",

showing generational shifts.

Beliefs. Fatalism exists among 40% of older participants, as P19, 39, male believed:

"Fate won't change, no matter how hard we try"

which attributed poverty to destiny, reducing motivation. Ritual Beliefs on Lavish funerals costs average 47,850 Yuan in Mabian County (Zhang et al., 2010) depleted savings, with 60% of participants reporting debt from rituals.

Behaviour Patterns. Consumption Behaviour can be reflected in "Drink on wine, wear on silver, spend on God" (Yi proverb) described excessive spending on rituals and festivals, with 70% of participants saving less than 10% of income. Social Interaction emphasizes reliance on family networks, 80% Yi people found jobs via relatives limited access to external opportunities.

Character Defects. The laziness and learned helplessness of the Yi people were observed, Village officials (P07, 52, male) noted some villagers "wait for government help" instead of seeking change. The pessimism makes them have short-term orientation that the farmers prioritized daily survival over long-term investments.

Educational Factors. Attitude Shifts on education, most of younger parents nowadays supported education, but still a few such as P06, 47, female:

"Girls don't need much schooling"

held traditional views. Barriers on remote distance to schools reflected by P03, 18, male:

"1-hour walk to primary school"

and language gaps that for Yi people find hard to understand mandarin teaching increased dropouts.

Access to Opportunities. Participants reported poor road and internet access, limiting market and education access on their geographic isolation. Social Capital Gaps about limited networks beyond family reduced uptake of vocational training and policy support.

6.4.3 Coding Frequency Analysis

"Access to Opportunities" (350 references) and "Educational Factors" (226 references) were the most cited themes, highlighting structural barriers. "Values" (228) and "Beliefs" (190) reflected cultural persistence, while "Character Defects" (14) were less prominent (Table 2).

Table 2 Theme Reference Frequency.

Primary Theme	Subtheme	Reference Frequency
Values	Personal Values	87
	Family Branch Values	83
	Gender and Occupational Views	38
	Social Values	13
	Cultural Identity	7
Beliefs	Poverty Perception	59
	Cultural Beliefs	56
	Views on Fate and Effort	38
	Traditional Beliefs	37
Behaviour Patterns	Family Branch Behaviours	47
	Consumption Behaviours	43
	Work Migration Perception	22
	Marriage and Family Patterns	20
	Housing and Living Behaviours	10
	Social Interaction Behaviours	10
Character Defects	Pessimism	12
	Laziness	2
Educational Factors	Educational Access	101
	Views on Education	56
	Educational Barriers	32
	Importance of Education	27
	Education as Investment	10
Access to Opportunities	Access to Economic Opportunities	111
	Social Support	103
	Social Capital	57
	Impact of Modernization	32
	Access to Geographical Resources	27
	Social Prejudice	20

6.4.4 Key Findings and Discussions

Characteristics of Yi Cultural Poverty. Yi cultural poverty is a "cultural-structural trap", traditional values and beliefs drive behaviours that deplete resources, while structural barriers reinforce cultural traits. This aligns with [20] theory but adds context: Yi poverty is not just "cultural" but a response to long-term structural deprivation [29] It is characterized by an enduring interplay of traditional values, inherited belief systems, rigid behavioural patterns, and structurally conditioned psychological adaptations often sustained and reproduced through intergenerational transmission. As [31] pointed out, community culture and beliefs can significantly influence the behaviour patterns and socio-economic conditions of vulnerable groups; at the same time, [15] emphasize the role of family and community culture in consumption behaviour, analysing the cultural motivations behind the consumption patterns of disadvantaged groups. This aligns with our findings that the prevalent practice of gift-giving and extravagant rituals among the Yi people leads to household debt burdens. In addition, the study by [11] focuses on how the folk belief culture in the Liangshan Yi region affects the implementation and effectiveness of poverty alleviation measures. This perspective supports that the deeply ingrained fatalism and traditional beliefs of the Yi people often undermine the actual effectiveness of poverty alleviation policies, becoming an invisible barrier to escaping poverty.

Interplay of Structural and Cultural Factors. The interconnection between structural and cultural factors shows geographic isolation fostered reliance on subsistence farming, now a cultural norm resisting modern jobs, and low education attitudes reduce demand for schools, slowing infrastructure investment, thus, creating the cycle that poorly educated parents devalue education, leading to child dropouts. This supports [31] argument that culture and structure co-create poverty—requiring integrated interventions. [29] have criticized early poverty culture theories for isolating individual traits too much, arguing that it is necessary to analyse how structural factors constrain and shape culture. Our finding suggests that it is precisely the structural dilemmas of long-term historical isolation, market absence, and inadequate public services that have fostered the self-sufficient and insular cultural adaptations of the Yi community, thereby corroborating the view that "structure shapes culture." Similarly [12] warned as early as the last century that attributing poverty to culture while ignoring structural contexts can easily lead to cultural determinism bias. It is worth mentioning that we have observed signs of cultural transformation brought about by modernization opportunities, which have created a positive interaction between structural improvement and cultural change. This is consistent with [37] view that the formation of poverty is not a linear causal relationship but the result of dynamic interactions of multiple factors, and the cycle should be broken through a dual approach of structure and culture. Overall, existing theories generally believe that eradicating poverty requires balancing both material and cultural aspects. Our research, using the Yi community as an example, provides vivid empirical support and offers new observations in specific areas such as customary debts and ideological obstacles to policy implementation, enriching poverty research from the perspective of structural-cultural interaction.

Modernization process is shifting values: the youth prioritize education and make their effort to use online platforms to learn farming techniques. However, disparities persist that conservative families reject vocational training, and urban migrants face "cultural alienation" as P11, 25, male said:

"Friends call me 'too urban"

This echoes Cuthrell et al. (2009), who note modernization without cultural sensitivity widens gaps.t the same time, we also noticed that this change is not synchronized across different families: some of the poorest or most conservative families have not fully utilized resources such as poverty alleviation training or funds. This aligns with the social capital research by [9] they pointed out that the size and activity level of community interaction networks can affect people's ability to access development opportunities. [37] study shows that the social networks through which the Yi people access knowledge and opportunities are limited to regional and kinship ties, making it difficult for external aid and information to reach impoverished groups. This situation is precisely the continuation of the network limitations described by Zhang and others, and it is also one of the reasons we observe for the uneven distribution of modernization benefits. [9] believe that communities lacking social capital often find it difficult to fully utilize new development resources; [3] points out that unfavourable living environments can directly affect quality of life and development capacity. The reality of Liangshan confirms their assertions: the geographical conditions of remote mountainous areas have long constrained socio-economic development. Even though infrastructure has improved somewhat now, geographical barriers and information lag still weaken the effectiveness of modernization efforts.

At the same time, we found that modernization has also brought about internal cultural clashes and tensions, such phenomena of community differentiation have not yet been extensively reported in the literature, but they can be explained from the perspective of cultural adaptation. Overall, the impact of modernization on the Liangshan Yi ethnic group is complex and profound. It validates the theoretical assertion that culture can gradually change with structural improvements, as exemplified by [31]'s proposition that "culture is not a pretext for poverty, but a variable element." Our findings also enrich the literature on the negative effects of modernization—emphasizing that modernization without the support of social capital and cultural sensitivity may create new inequalities among groups. This study supports [3] argument: merely improving hardware is insufficient to solve the problem; it is also necessary to simultaneously enhance the "soft environment," including updating concepts and building community capacities, to ensure that the benefits of modernization are inclusive rather than exacerbating disparities. It is evident that for modernization to truly become a "booster" for eliminating cultural poverty, it must be accompanied by social support and cultural communication aimed at vulnerable groups; otherwise, the light of hope brought by modernization may not reach the darkest corners.

Intergenerational Transmission. Lots of parents with low education initially devalued schooling, P06,47, female said:

"Farming is for girls",

but some have changed views after seeing others' success. Beliefs like Fatalism was transmitted via family narratives, but youth exposed to migration and education challenged this. This confirms [18] finding that psychological traits drive intergenerational poverty but also shows transmission can be disrupted. Similarly, [24] suggested that attention should be paid to how the behavioural habits of impoverished groups interact with social structures; this is also reflected in our intergenerational study, behaviours formed by the previous generation in response to structural deprivation become behavioural factors perpetuating poverty when imitated by the next generation. Moreover, [26] pointed out that if a group generally doubts the value of effort, their motivation for progress will be weakened, thereby affecting their social integration and development opportunities. The elders in the Yi community's belief that "studying is useless" and "being content in the mountains" reflects this scepticism towards the returns of effort. However, we see the younger generation starting to change this by going out to study and work, which precisely validates Rein's assertion about the impact of values on social development: when traditional values are not conducive to progress, timely updating of concepts helps improve development capabilities. In addition, the research by [11] on the Liangshan Yi region emphasizes that cultural factors such as folk beliefs can affect the implementation effectiveness of poverty alleviation policies. We found examples where treatment was delayed due to ancestors' belief in folk remedies and savings were depleted due to traditional customs, which illustrate that if these inherited beliefs are not changed, policy interventions may be significantly undermined.

This is consistent with the conclusions of [11], suggesting that when formulating and implementing poverty alleviation measures, we should consider how to weaken the intergenerational impact of adverse beliefs. It is worth noting that our research also uncovered a relatively less mentioned positive aspect in the literature: intergenerational transmission is not a one-dimensional closed loop but has loosened in the context of modernization. Scholars such as [31] argue that poverty should be viewed as a dynamic process influenced by multiple factors, and cultural patterns are not immutable; they can be broken or reshaped under appropriate conditions. Our field evidence supports this view, indicating that the intergenerational chain of poverty culture is "resilient but not unchangeable." This finding injects a dimension of hope into the theory of cultural poverty: it corroborates academic discussions on the plasticity of culture. In summary, this study not only confirms the intergenerational transmission of cultural poverty but also emphasizes the possibility of change. Therefore, from a practical perspective, our results suggest that poverty alleviation efforts should focus on changing perceptions within families and communities. This can be achieved through education, role models, and media dissemination at "key exposure points" to intervene in the intergenerational cycle, thereby breaking the hereditary chain of poverty culture. Only in this way can we truly achieve a fundamental alleviation of the cultural poverty issue and intergenerational improvement.

In summary, the cultural poverty of Yi ethnic group arises from overlapping cultural and structural factors. Modernization is creating positive shifts, but cultural sensitivity is critical to avoid reinforcing inequalities. The findings reveal that cultural poverty among the Yi is shaped by a legacy of historical exclusion and perpetuated through traditional value systems, ritual practices, and psychological adaptations. However, the study also captures an ongoing cultural shift—particularly among youth and younger parents—toward education, aspiration, and self-advancement. Structural limitations continue to obstruct this shift, but modernization efforts are beginning to yield positive effects. The relationship between cultural norms and structural constraints is reciprocal, often reinforcing cycles of poverty, but also offering opportunities for transformation when aligned with inclusive policy design. Ultimately, the study underscores that effective poverty reduction in ethnic minority regions like Liangshan requires an integrative approach—addressing both tangible needs (education, health, employment) and intangible cultural dynamics (values, beliefs, trust). The insights gained here lay the groundwork for more culturally responsive development strategies and highlight the importance of engaging communities not merely as beneficiaries but as co-constructors of their own development pathways.

6.5 Conclusion and Recommendations

In conclusion, the study identified four key conclusions, the cultural poverty of Yi ethnic group is characterized by family branch values, fatalism, ritual spending, and structural isolation. Structural and cultural factors interact in a vicious cycle that isolation causing the existence of traditional norms, then leading to limited opportunities. Modernization fosters positive value shifts on education and entrepreneurship but risks cultural loss and disparities. Intergenerational transmission occurs via values and beliefs but can be disrupted by education and exposure to modernity. Theoretical implications on expanding cultural poverty theory to multiethnic contexts, emphasizing structural-cultural interplay. Practically, highlighting that poverty alleviation must honour tradition (e.g., integrating Yi culture into education) to build trust. Policy recommendations such as calling for participatory policies to align top-down measures with local needs.

6.5.1 Recommendations

Develop community-led tourism, such as Torch Festival experiences, Yi craft workshops to generate income while preserving heritage. Train locals in hospitality and small business management and invest in rural infrastructure to connect villages to markets. Project Bilingual Programs, Institutionalize Yi-Mandarin preschool education to bridge language gaps and validate cultural identity. Curriculum Reform to Integrate Yi history, crafts, and Bimo knowledge into school materials.

Increasing heritage-based income, partner with e-commerce platforms to sell Yi crafts and train artisans in modern design. Promoting digital language tools, develop Yi-language apps or websites to engage youth in cultural learning. Using Village Development Committees to establish groups consists of respected elders and officials

to co-design poverty alleviation projects. Encouraging youth engagement to create "returning youth" programs like scholarships, startup grants to attract educated Yi back to Liangshan Yi Autonomous Prefecture.

6.5.2 Limitations and Future Research

Limitations on small sample (20 participants), focus on Liangshan Yi Autonomous Prefecture exists limited generalizability, and cross-sectional data possessing no long-term trends. Future research could conduct comparative studies of Yi communities in Yunnan or Gansu province of China or have research about other minorities around the world, keeping longitudinal tracking of modernization impacts, and quantitative measurement of cultural poverty.

6.6 Conclusion

The cultural poverty of Yi ethnic group is not an "innate" trait but a product of historical structural deprivation and cultural adaptation. Alleviating it requires balancing economic development with cultural preservation, honouring the Yi's heritage while equipping them to seize modern opportunities. The recommendations proposed offer a roadmap for inclusive, sustainable development in Liangshan Yi Autonomous Prefecture and similar ethnic minority regions. The contributions of this research, therefore, lie in bridging cultural understanding with development practice, a bridge that will remain essential as academics and policymakers alike continue to strive for equitable and culturally sustainable development in the years to come.

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Chapter 7

Gendered Patterns and Motivations of Rural–Urban Migration in Bangladesh

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Abstract Rural–urban migration is central to structural transformation in Bangladesh, but aggregate gender shares can conceal important differences in why women and men move. Using nationally representative Sample Vital Registration System (SVRS) data for 2010, 2015, and 2020, this chapter describes rural–urban migration among individuals aged 18–62 and compares self-reported reasons for migration by gender. Frequencies, cross-tabulations, and two-sample tests of proportions are used to distinguish marriage- and family-related mobility from education-, environment-, income-, and other reported reasons. The descriptive evidence shows that women constitute the larger share of rural–urban migrants when all reasons are included, largely because marriage- and family-related movement is concentrated among young women. Once these social reasons are excluded, men form the larger share of the remaining migrants, while income is the dominant reported reason for both genders. The chapter argues that the apparent female majority in rural–urban migration should not be interpreted as equivalent to female labour-market mobility. By separating social from economic reasons, the analysis provides a more precise basis for gender-sensitive employment, skills, housing, and urban-service policies.

Keywords: Rural–urban migration; Gender differences; Marriage-related mobility; Labour-market migration; Bangladesh

7.1 Introduction

Internal migration is a major component of structural transformation because it reallocates labour, supports urban growth, and allows households to diversify livelihoods. Rural–urban movement is especially important in developing economies, where limited rural employment, land scarcity, and declining agricultural returns coexist with expanding urban opportunities in manufacturing and services. Migration decisions, however, are not driven by economic considerations alone; education, marriage, family formation, access to services, and environmental pressures also shape mobility (Deshingkar & Grimm, 2005; Busso et al., 2021; Alam & Mamun, 2022).
These motivations are gendered. Conventional migration accounts often portray men as autonomous economic migrants and women as accompanying family members or marriage migrants. Although women's education, labour-force participation, and financial autonomy have increased, social norms and household responsibilities continue to influence whether, when, and why women migrate. At the same time, labour-intensive manufacturing and service-sector expansion has created new forms of employment-related mobility for women, making the distinction between social and economic migration increasingly important (Thadani & Todaro, 1984; Rashid, 2013; Jones, 2020; Amirapu et al., 2022).

Bangladesh provides a particularly relevant setting. The growth of the ready-made garment sector has expanded urban employment opportunities for rural women, yet marriage, family obligations, safety concerns, and restrictions on independent movement remain influential. Aggregate comparisons of male and female migrants may therefore be misleading: a larger female share may reflect marriage- and family-related relocation rather than greater access to urban labour markets (Blanchet & Biswas, 2021; Amirapu et al., 2022).

Existing research has examined internal migration, female employment, and the consequences of migration in Bangladesh, but fewer studies distinguish systematically between the reported reasons for rural–urban movement by gender across multiple survey years. Combining marriage- and family-related moves with employment-oriented migration can obscure the extent and character of women's economic mobility. A clearer separation of migration motivations is therefore necessary for both scholarly interpretation and policy design.

This chapter addresses that gap using SVRS data for 2010, 2015, and 2020. It asks three questions: (1) how did the gender composition of rural–urban migration change over the period; (2) how did reported migration reasons differ between women and men; and (3) how did the observed gender pattern change after marriage- and family-related movement was excluded? The contribution is descriptive rather than causal: the chapter identifies differences in reported reasons and shows how the classification of migration motives affects conclusions about the gender composition of rural–urban mobility.

7.2 Conceptual framing and research expectations

Economic models of rural–urban migration emphasize expected income and employment differentials, while gendered and household-based approaches draw attention to social norms, family strategies, and life-course events. Taken together, these perspectives suggest that migration should be understood as a household and gendered decision rather than as an exclusively individual labour-market response. The chapter therefore expects income-related movement to account for a larger share of male migration, while marriage and family-related movement will account for a larger share of female migration. It also expects the apparent female majority in aggregate rural–urban migration to narrow or reverse when social reasons are excluded.

7.3 Methodology

The analysis uses individual-level records from the Bangladesh Bureau of Statistics Sample Vital Registration System (SVRS) for 2010, 2015, and 2020. The SVRS records migration direction selected demographic characteristics, and self-reported reasons for migration. The analytical population is restricted to individuals aged 18–62, corresponding broadly to the working-age population used in related studies. The three survey rounds are treated as repeated cross-sections; the analysis does not follow the same individuals over time.

7.3.1 Migration Variables and Survey Design:

This research utilized out-migration statistics from the Bangladesh Sample Vital Registration System (SVRS) to investigate rural-to-urban migration in Bangladesh. The SVRS is founded on an Integrated Multi-purpose Sample Design (IMPS). In 2020, the survey encompassed 2,012 Primary Sampling Units (PSUs) chosen according to the 2011 Population and Housing Census. Data were gathered utilizing a dual recording mechanism, wherein local registrars and supervisors autonomously documented essential occurrences. For analytical objectives, the initial residential classification was transformed into a binary variable. Rural regions (Polli) and municipal zones (Pourashava) were classified collectively and assigned a value of 0, whereas City Corporation regions received a code of 1. This categorization was employed to recognize the rural–urban out-migrants incorporated in the examination. The stated motivations for migration were reclassified into five general categories: economic, social, educational, environmental, and miscellaneous causes. These recording methods were implemented to enhance the examination of rural-urban migration trends based on gender and geographic area. The coding and recording procedures are summarized in Table 1.1.

Table 1 Coding of Variables

Variable	Coding used in this study
Place of residence	0 = Rural (Polli + Pourashava), 1 = Urban (City Corporation)
Migration direction	1=[1]Rural-urban
Migration reasons	Economic=1, Social=2, Education=3, Environmental=4, Other=5

Source: Author calculation from the SVRS questionnaire and STATA

This study used four years of nationally representative data from the Bangladesh Social Security Survey (SVRS) (2010, 2015, and 2020), collected by the Bangladesh Bureau of Statistics (BBS). The total sample comprised 1,103,326 observations in 2010, 939,530 in 2015, and 1,285,013 in 2020. The analysis focused on individuals aged 18 to 62 (Blanchet & Biswas, 2021; Boudreau et al., 2018), thus covering the labor force. STATA software facilitated data management and statistical analysis, while Excel was used to create graphs derived from the STATA results.

The original datasets contained 1,103,326 observations in 2010, 939,530 in 2015, and 1,285,013 in 2020. After removing duplicate identifiers and observations with missing information and applying the age restriction, the analytical samples contained 619,422, 551,359, and 764,597 observations, respectively. Within these samples, 43,704 migrants were identified in 2010, 49,222 in 2015, and 98,511 in 2020. Rural–urban migrants numbered 7,413, 7,161, and 11,226, respectively.

Table 1.2 Analytical sample and migrant counts by survey year, 2010, 2015, and 2020

Year	Total Observations	Filtered Observations (18-62 years)	Migrants	Percentage of Migrants	Percentage of R-U Migrants
2010	1,103,326	619,422	43,704	7%	17%
2015	939,530	551,359	49,222	9%	15%
2020	1,285,013	764,597	98,511	13%	11%

Source: Authors' calculations based on SVRS data.

The analysis proceeds in three stages. First, frequencies and percentages describe the proportion of migrants moving from rural to urban areas and the gender composition of rural–urban migrants. Second, age profiles and reported reasons for migration are cross tabulated by gender and survey year. Third, marriage and living-with-family reasons are excluded to examine the remaining pattern of education-, environment-, income-, and other migration. Two-sample tests of proportions are intended to assess whether observed male–female differences are statistically significant. Because the chapter is descriptive, the findings should be interpreted as differences in reported patterns rather than causal effects.

[1] Only rural–urban out-migrants were included in the analysis.

7.4 Results

This section reports the descriptive patterns in rural–urban migration between 2010 and 2020. To avoid ambiguity, "proportion" refers to rural–urban migrants as a share of all migrants, while "gender composition" refers to the shares of women and men within the rural–urban migrant population.

7.4.1 Overall rural–urban migration and gender composition

The proportion of migrants moving from rural to urban areas declined from 17% in 2010 to 15% in 2015 and 11% in 2020. Within the rural–urban migrant population, women consistently formed the larger share. This aggregate pattern does not, by itself, show that women were more likely than men to migrate for employment because it combines all reported reasons for movement.

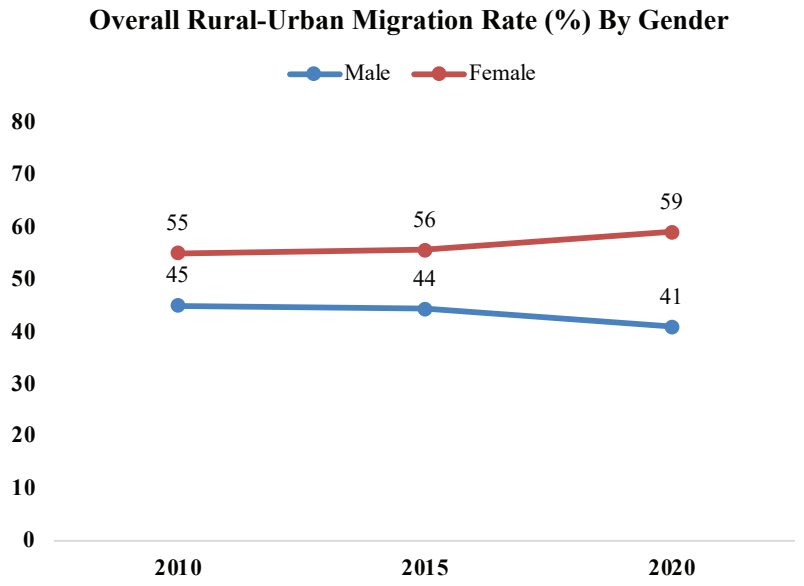


Figure 1 Widening Reversed Gender Gap in Migration rate

Women accounted for approximately 55% of rural–urban migrants in 2010, 56% in 2015, and 59% in 2020, while the corresponding male shares declined from 45% to 41%. These figures describe the composition of the migrant population and should not be labelled as sex-specific migration rates unless the denominators are the total male and female populations.

7.4.2 Reported reasons for rural–urban migration

Reported reasons reveal a sharp gender contrast. Income is the dominant reason among male migrants, whereas marriage and living with family account for the largest share among female migrants.

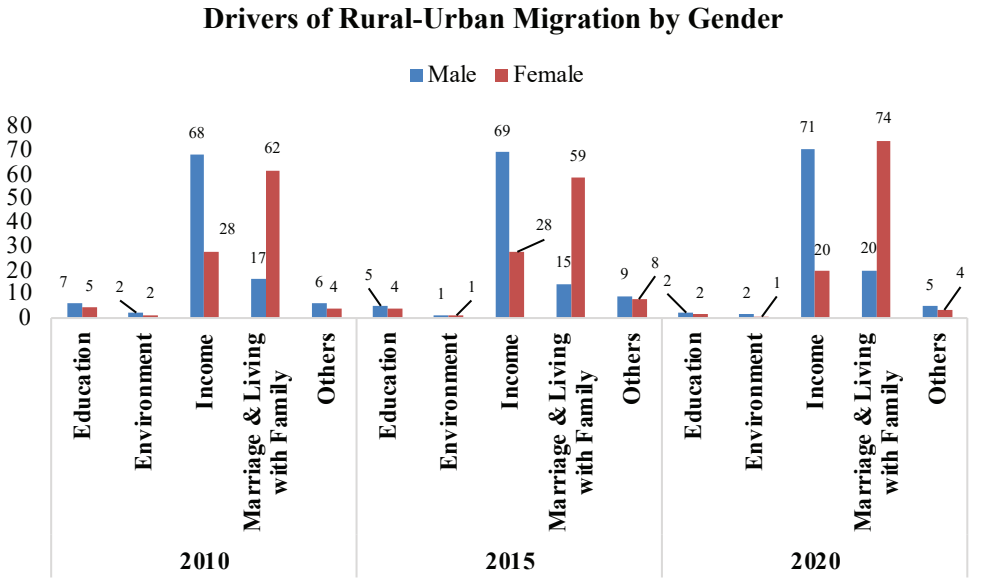


Figure 2 Widening Gender-Gap in Social and Economic Reasons of Migration

Income-related movement accounted for approximately 68% of male rural–urban migration in 2010, 69% in 2015, and 71% in 2020. For women, marriage and living with family represented about 62%, 59%, and 74%, respectively. Income remained the second-largest reported reason among women, but its share was substantially lower than among men. The figure therefore indicates that the larger aggregate female share is strongly shaped by social and family-related mobility.

7.4.3 Gender composition after excluding marriage- and family-related moves

To assess how social migration affects the aggregate gender pattern, the analysis excludes moves reported as marriage or living with family. Figure 1.3 shows that the gender composition reverses after this exclusion: men become the larger share of the remaining rural–urban migrant population.

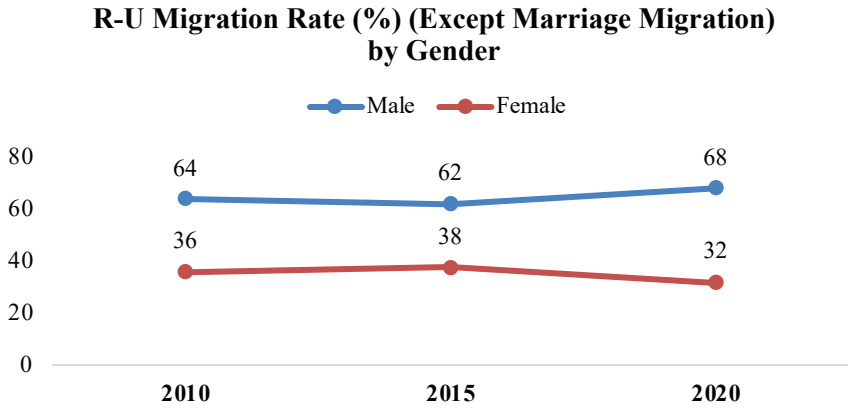


Figure 3 Reversal in gender gap: widening male-biased migration once marriage-related choices discarded

Men accounted for approximately 64% of the remaining migrants in 2010, 62% in 2015, and 68% in 2020, while women accounted for 36%, 38%, and 32%. The reversal demonstrates why aggregate gender shares should not be interpreted as measures of labour-market migration without separating the reasons for movement.

7.4.4 Reported reasons after excluding social migration

Once marriage- and family-related movement is removed, income becomes the dominant reported reason for both women and men. The share remains higher among men, indicating that economically motivated rural–urban migration is still predominantly male.

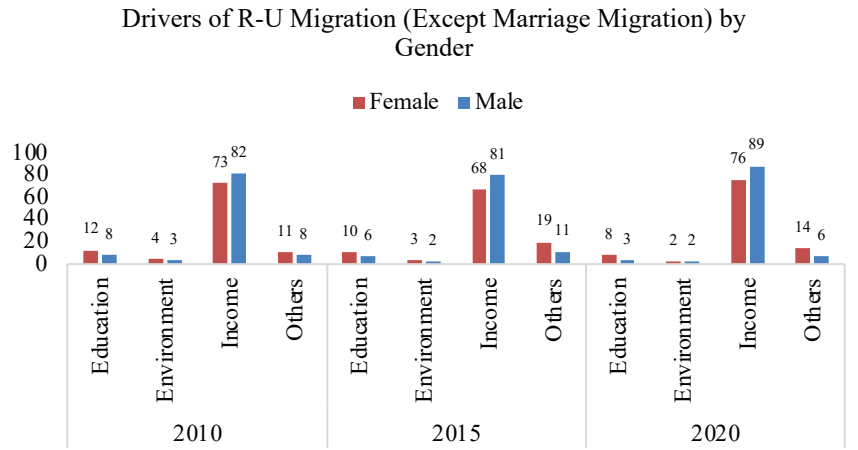


Figure 4 Widening gender-gap exclusive to economic motivates of migration

In 2010, income was reported by approximately 82% of male migrants and 73% of female migrants in the restricted sample. After a modest decline in 2015, the corresponding shares rose to about 89% for men and 76% for women in 2020. Education, environmental factors, and other reasons accounted for comparatively small shares. These results show that women also participate in economically motivated migration, although at lower levels than men.

7.4.5 Tests of differences in proportions

Table 1.3 is intended to test whether the male–female differences in rural–urban migration is statistically significant when all reported reasons are included and when marriage- and family-related reasons are excluded. Table 1.3 Two-sample tests of proportions comparing male and female rural–urban migration, 2010–2020.

Table 3 (a Panel A. Including all reported migration reasons

Year	Male proportion	Reported error	Female proportion	Reported error	Male − female
2010	0.174	0.003	0.167	0.002	0.007
2015	0.140	0.002	0.151	0.002	−0.011***
2020	0.106	0.001	0.120	0.001	−0.014***

Table 3 (b) Panel B. Excluding marriage and living-with-family reasons

Year	Male proportion	Reported error	Female proportion	Reported error	Male − female
2010	0.016	0.001	0.270	0.003	−0.254***
2015	0.017	0.001	0.178	0.002	−0.161***
2020	0.008	0.000	0.197	0.002	−0.189***

Notes: Difference = male proportion − female proportion. The entries labelled "reported error" must be verified as standard errors or standard deviations. *** $p < 0.001$.

The inferential results cannot be interpreted confidently until Table 3 has been regenerated and reconciled with the descriptive figures. In the final chapter, this subsection should report the verified difference in proportions, confidence intervals, and survey-adjusted p-values, followed by a concise statement of whether the gender reversal remains statistically significant.

7.4.6 Discussion

The descriptive evidence supports the argument that gender composition and migration motivation are analytically distinct. Women form the larger share of rural–urban migrants when all reported reasons are counted, but this pattern is largely explained

by marriage- and family-related movement. Men dominate once those reasons are removed, while income is the main remaining reason for both genders. The age profile reinforces this interpretation: female migration is concentrated at younger ages, whereas male migration is more concentrated in prime working ages. These findings are consistent with gendered migration research showing that social norms, marriage, household responsibilities, and labour-market opportunities jointly structure mobility (Thadani & Todaro, 1984; Donato & Gabaccia, 2015; Amirapu et al., 2022). The chapter's contribution is to show how conclusions about a "female majority" change once migration reasons are disaggregated. It also cautions against treating all non-economic movement as passive: marriage- and family-related migrants still require access to housing, services, safety, and opportunities in urban destinations.

7.4.7 Policy implications and limitations

Policy should respond to the different circumstances under which women and men move. Employment-oriented measures should expand women's access to market-relevant skills, safe transport, job-placement services, secure workplaces, and affordable urban accommodation. Urban planning should also recognize marriage- and family-related migrants in the provision of health care, childcare, legal documentation, and social protection. BBS should report internal migration statistics by gender, age, destination, and reason so that family mobility is not conflated with labour migration. The analysis has several limitations. It relies on self-reported primary reasons, which may simplify multi-causal migration decisions; it is descriptive and does not identify causal determinants; and the current draft does not document the use of survey weights or the treatment of the complex survey design. The 2020 round may also reflect pandemic-related disruptions. These limitations should be acknowledged explicitly, and the proportion tests must be verified before publication.

7.5 Conclusion

This chapter examined gender differences in the reported reasons for rural–urban migration in Bangladesh using SVRS data for 2010, 2015, and 2020. Women formed the larger share of rural–urban migrants when all reasons were included, but marriage and family-related movement accounted for much of this pattern. After those social reasons were excluded, men formed the larger share of the remaining migrants and income was the dominant reported reason for both genders. The findings demonstrate that aggregate migrant shares can obscure important differences between social mobility and labour-market migration. A gender-sensitive migration policy must therefore support women's access to economic opportunities while also recognising the service and protection needs associated with family-related movement.

7.6 References

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Chapter 8

Supply Chain Management Practices and Their Impact on SME Performance in Nigeria

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Abstract Small and medium-sized enterprises (SMEs) play a critical role in Nigeria's economic growth, yet their performance is often constrained by inefficiencies in supply chain management. This study examines the direct impact of supply chain management practices (SCMPs) on SME performance in Ibadan, Nigeria. A descriptive survey design was adopted, and data were collected from 266 SMEs comprising owners and managers and top executives. Using Smart PLS structural equation modelling, the findings reveal that SCMPs significantly enhance performance across dimensions of profitability, marketing, and operational efficiency. Key practices such as postponement, information sharing, information quality, customer relationship management, and strategic supplier partnerships were identified as major drivers of improved outcomes. The study concludes that strengthening supply chain management practices is a strategic imperative for SMEs to remain competitive in Nigeria's evolving business landscape. Practical implications highlight the need for SMEs to invest in supply chain efficiency to achieve sustainable performance. This research contributes to the body of knowledge by offering context-specific insights into SCMP–performance linkages in an emerging market.

Keywords: Supply Chain Management Practices; SME Performance; Nigeria; Resource-Based View

8.1 Introduction

Small and medium-sized enterprises (SMEs) constitute a vital component of Nigeria's economy, contributing significantly to employment, innovation, and GDP growth. For instance, Okoli and Ezedebego (2025) show that SMEs in Nigeria create most new jobs, accounting for 60-70% of employment and contributing a large share to GDP through industrial output and local business activity. Similarly, Ebuka *et al.* (2024) found that MSMEs (micro, small & medium enterprises) have a strong positive effect on employment though a weaker effect on GDP per capita, indicating that while SMEs are growing jobs, challenges remain for productivity and value addition. Despite their significance, SMEs in Nigeria continue to face persistent challenges such as limited access to finance, inadequate infrastructure, and fragmented markets. Studies repeatedly identify these constraints: Okoli and Ezedebego (2025) mention that "access to finance, poor infrastructure, and corruption" are among the top impediments to SME growth. Additionally, Adanlawo *et al.* (2021) found that infrastructure deficits and a lack of government support significantly reduce SMEs' capacity to scale. Effective supply chain management practices (SCMPs), such as postponement, information sharing, and information quality, as well as customer relationship management (CRM) and strategic supplier partnerships, have been identified globally as strategic approaches to improving firm performance by reducing costs, enhancing responsiveness, and improving customer satisfaction (Oriekhoe *et al.,* 2024).

Within the Nigerian context, there is emerging empirical evidence on how specific SCMP dimensions influence SME performance, but with mixed results and some gaps. For instance, Igashi *et al.* (2023) in their study on Supply Chain Management Practices and SMEs Performance: Role of Information Technology Capability among manufacturing SMEs in Kaduna State, reported that both customer relationship management and strategic supplier partnerships significantly enhance SME performance, with these effects being further strengthened by the presence of robust IT capabilities.. Another study by Ugwu (2020), examined information sharing, and information quality; results indicated all these had positive and significant effects on financial performance of SMEs. However, not all SCMPs always show uniformly strong effects. In the telecommunication sector of Nigeria, Obisesan *et al.* (2022) found that while strategic supplier partnership and customer relationship had significant positive effects on performance, some practices like information sharing quality and postponement did not show significant influence in that case. Furthermore, a study on small and medium manufacturing enterprises in Nigeria's Southwestern region revealed that although strategic supplier partnerships, customer relationship management, and both the level and quality of information sharing were adopted to a great extent, the practice of postponement was only moderately utilized (Akinbamini *et al.,* 2025). This highlights the uneven adoption of specific supply chain management practices among SMEs.

Given these mixed findings, a clear gap remains in understanding which specific dimensions of supply chain management practices (SCMPs) are more widely adopted, which exert stronger effects on firm performance, and under what conditions such effects are realized, for instance, whether factors such as firm size, infrastructural

capacity, or the use of ICT tools like social media and e-commerce play a moderating role. To address this gap, the present study investigates the relationship between SCMPs and SME performance in Ibadan, Oyo State, Nigeria. The study specifically examines five key SCMP dimensions: postponement, information sharing, information quality, customer relationship management, and strategic supplier partnerships. In line with this focus, the research is guided by three central objectives:

1. To evaluate the level of adoption of SCMPs among SMEs in Ibadan, Oyo State.
2. To examine the impact of SCMP dimensions on SME performance.
3. To provide practical recommendations for managers and policymakers to strengthen SME supply chain capabilities.

By pursuing these objectives, the study contributes both theoretically and practically. Theoretically, it enriches the limited body of empirical research on supply chain management practices within the Nigerian SME context, offering insights into how specific SCMP dimensions influence performance outcomes. Practically, the findings are expected to guide SME managers in adopting and prioritizing supply chain strategies that enhance competitiveness, while also informing policymakers on interventions needed to strengthen SME capacities through infrastructure development, technology support, and collaborative networks. Ultimately, this research seeks to bridge the knowledge gap on SCMP adoption in Southwestern Nigeria and to provide actionable evidence that can improve the long-term sustainability and performance of SMEs.

8.2 Literature Review

8.2.1 Supply Chain Management Practices (SCMPs)

Supply chain management practices encompass a varied set of activities aimed at coordinating flows of materials, information, and finances between suppliers, firms, and customers. Key dimensions of SCMP include postponement, information sharing, information quality, customer relationship management, and strategic supplier partnerships. These practices facilitate smoother operations by reducing lead times, lowering holding and ordering costs, and enhancing responsiveness to customer demands (Okon, 2018; Richey *et al.,* 2023)this promising innovation is met with a scholarly discourse grappling with an interplay between the promising capabilities and potential drawbacks. This conversation frequently includes dystopian forecasts of mass unemployment and detrimental repercussions concerning academic research integrity. Despite the current hype, existing research exploring the intersection between AI and the logistics and supply chain management (L&SCM. Recent studies provide stronger empirical backing for these dimensions. For example, Aikor *et al.* (2025), in their study titled Digital Financial Systems and the Transformation of Nigerian Supply Chains, reported that strategic supplier partnerships and effective information sharing play a significant role in enhancing SME performance, particularly in environments

challenged by digital and infrastructural limitations. In addition, recent research highlights the mediating role of information sharing between information quality and overall supply chain performance (Salami *et al.*, 2024).

Furthermore, Sundari *et al.* (2024) investigated how supply chain collaboration, underpinned by stakeholder trust, information sharing, and strategic partnerships, impacts performance of manufacturing SMEs. They found strong positive effects, especially from strategic supplier partnerships and information sharing, though pointing out that technological constraints may limit the degree of information sharing in some cases. Overall, the reviewed literature suggests that integrated supply chain management practices are strongly linked to improvements in operational and marketing performance as well as competitive advantage, not only at the global level but also within African contexts, including Nigeria (Ojubanire & Popoola, 2022)600 at the time of this study. A questionnaire was used to gather data for this research. The data collected was analyzed using frequencies and percentages, mean, standard deviation, and Pearson's correlation. Results from the study showed that SMMEs had fairly good supplier integration (50.05%. Moreover, the impact of different SCMP dimensions appears to vary depending on factors such as firm size, technological capability, and the availability of infrastructural support (Uddin *et al.,* 2023).

8.2.2 Conceptualizing SME Performance and Its Measures

SME performance is a multidimensional construct, often defined as the extent to which a business achieves its objectives across various operational and market-oriented outcomes. Key dimensions include operational performance (efficiency, productivity, cost reduction, process improvements) and marketing performance (market share, sales growth, customer satisfaction, new customer acquisition). In addition, studies in emerging markets highlight other context-specific performance outcomes such as survival rates, access to new markets and geographical expansion, and sustainability over time (Adebiyi *et al.*, 2017; Opoku *et al.,* 2024). Recent empirical studies further reinforce the multidimensional nature of SME performance. For instance, Unegbu *et al.* (2024), in their work titled The Impact of Digital Transformation on Nigerian Small and Medium-Sized Enterprises (SMEs) in the Global Business Landscape, assessed business performance using growth indicators and found that SMEs adopting digital tools, particularly e-commerce and social media, achieved significantly higher growth rates compared to non-adopters. Their study highlights a strong relationship between digital transformation and SME competitiveness, demonstrating how digital adoption amplifies global market reach, strengthens competitive positioning within industries, nurtures international partnerships, expands market share, and enhances brand visibility.

Similarly, Nwachukwu and Onuoha (2023), in their study Digital Transformation Strategy and Business Performance of SMEs in Rivers State, examined the influence of market support programs and digital presence on performance outcomes. Their findings revealed that digital transformation serves as a robust predictor of improved marketing performance, operational responsiveness, and market penetration, particularly in terms of sales growth and entry into new customer segments. Furthermore, Jamaludin *et al.*

(2022), in their study Market Orientation and SCM Strategy on SME Organizational Performances: The Mediating Effect of Market Performance, distinguished between market performance (e.g., customer satisfaction and market share) and operational performance. Their findings indicate that supply chain management strategies exert a positive influence on both operational and financial outcomes, with part of this effect being mediated through improvements in market performance.

Collectively, these studies affirm that SME performance extends beyond profitability, encompassing internal efficiency and responsiveness, market-related outcomes such as sales growth, customer satisfaction, and market share, as well as long-term sustainability through survival and growth. Adopting a multidimensional approach to performance measurement is particularly critical in Nigeria, where SMEs operate within challenging environments characterised by infrastructural deficits, regulatory uncertainties, and accelerating digital disruption.

8.2.3 Empirical Perspectives on Supply Chain Management Practices and SME Performance

Empirical evidence from both developed and developing economies indicates that supply chain management practices (SCMPs) play a vital role in enhancing firm performance. Li *et al.* (2006)but among supply chains. This research conceptualizes and develops five dimensions of SCM practice (strategic supplier partnership, customer relationship, level of information sharing, quality of information sharing, and postponement highlighted that supply chain integration contributes to competitive advantage by promoting efficiency, coordination, and responsiveness to market demands. In the Nigerian context, emerging research equally underscores the value of SCMPs. Specifically, Oyetade *et al.* (2023) revealed that dimensions such as information quality and strategic supplier partnerships are significant predictors of SME performance, with their regression analysis in Lagos State demonstrating reliable positive effects. Similarly, Omigie and Kubeyinje (2022), in their study Supply Chain Management and Performance: Evidence from Manufacturing Organisations in Nigeria, reported that procurement outsourcing, effective management of information flow, and order process management were significantly associated with improved performance among manufacturing firms in Edo State. Evidence from beyond Nigeria also reinforces these findings. For instance, in South Africa, Okoumba *et al.* (2020)similar studies on small and medium enterprises (SMEs established that the adoption of supply chain best practices strongly predicts SME supply chain performance, with risk management and agility serving as important mediating mechanisms. Nonetheless, contextual variations remain evident. In the Nigerian telecommunications sector, Obisesan *et al.* (2022) found that while practices such as customer relationship management and strategic supplier partnerships had a significant positive influence on performance, other dimensions, particularly information-sharing quality and postponement, did not produce significant effects.

These variations are frequently explained by contextual conditions such as infrastructure quality, ICT adoption, and institutional support. In Nigeria, for instance, SMEs often grapple with challenges including poor road networks, unreliable electricity

supply, and limited broadband connectivity, all of which undermine the efficiency of logistics integration and the functionality of information systems. Oyedijo *et al*. (2021), in their study Supply Chain Management Systems in Africa: Insights from Nigeria, highlight that fragmented market structures and unpredictable supply flows weaken the ability of supplier collaboration to deliver meaningful performance improvements in the absence of robust institutional or infrastructural support. Conclusively, these findings underscore that while SCMPs are generally performance-enhancing, their outcomes are highly contingent on the local business environment, reinforcing the need for context-specific investigations such as the present study.

8.2.4 Theoretical Foundation: Resource Based View (RBV)

The Resource-Based View (RBV) posits that firms attain sustainable competitive advantage by leveraging resources and capabilities that are valuable, rare, inimitable, and non-substitutable (Barney, 1991; Wernerfelt, 1984). Over time, scholars have extended this framework to emphasize that organizational processes and routines, rather than physical assets alone, are crucial for sustaining competitiveness (Teece *et al.,* 1997; Grant, 1996; Neves *et al.,* 2014). Within the supply chain domain, supply chain management practices (SCMPs) can therefore be conceptualized as higher-order organizational capabilities that facilitate the coordination of activities, integration of information, and alignment of resources across firm boundaries (Li *et al.,* 2006;but among supply chains. This research conceptualizes and develops five dimensions of SCM practice (strategic supplier partnership, customer relationship, level of information sharing, quality of information sharing, and postponement Grant, 1991; Neves *et al.,* 2014). Specifically, practices such as postponement, information sharing, information quality, customer relationship management, and strategic supplier partnerships function as dynamic capabilities that allow SMEs to enhance efficiency, reduce uncertainty, and differentiate their offerings in competitive markets (Shibin *et al.,* 2020; Dubey *et al.,* 2018). For example, information sharing and information quality provide firms with timely, reliable, and actionable data, enabling proactive decision-making and supply chain responsiveness (Jie & Gengatharen, 2019; Odiba & Yimi, 2022; Asortse *et al.,* 2023). Similarly, strategic supplier partnerships and customer relationship management create trust-based relational assets that are difficult to replicate, positioning firms for long-term competitive advantage (Thongrawd *et al.,* 2020; Olayiwola *et al.,* 2024).

In the Nigerian SME context, the RBV lens has proven particularly useful in explaining performance differentials among firms operating under infrastructural and institutional constraints. For instance, Ojubanire and Popoola (2022)600 at the time of this study. A questionnaire was used to gather data for this research. The data collected was analyzed using frequencies and percentages, mean, standard deviation, and Pearson's correlation. Results from the study showed that SMMEs had fairly good supplier integration (50.05% highlighted that SMEs that strategically invest in supplier collaboration and customer-focused practices outperform peers who lack such relational and informational capabilities. More recent studies confirm that SMEs that align SCMPs with ICT tools such as e-commerce platforms and social media marketing

enhance their competitiveness by converting intangible capabilities into measurable market and financial outcomes (Igashi *et al.,* 2023; Aikor *et al.,* 2025). Thus, from an RBV perspective, SCMPs are not merely operational tools but represent bundles of strategic capabilities that are valuable (improve efficiency and responsiveness), rare (not all SMEs adopt them consistently), inimitable (built through relational trust and knowledge exchange), and non-substitutable (difficult to replace without significant trade-offs). This underscores their centrality in achieving sustainable competitive advantage for SMEs in Nigeria and similar emerging market contexts.

8.3 Methodology

This study adopted a descriptive survey research design to empirically examine the relationship between supply chain management practices (SCMPs) and the performance of small and medium-sized enterprises (SMEs) in Nigeria, with Ibadan, Oyo State, serving as the study location. Ibadan was chosen because it represents one of the largest SME hubs outside Lagos and Abuja, hosting enterprises across diverse sectors such as agribusiness, retail, manufacturing, healthcare, ICT, transportation, and fashion. According to SMEDAN and NBS (2020), Ibadan accounts for a substantial share of SMEs in Southwestern Nigeria, contributing significantly to regional employment and trade. Its unique business ecosystem combines traditional market structures with emerging digital adoption, offering a balanced representation of the challenges and opportunities SMEs face. Infrastructural bottlenecks such as irregular power supply and logistics inefficiencies coexist with increasing uptake of ICT tools like social media and e-commerce, making Ibadan an ideal context for examining how supply chain practices operate under mixed conditions of constraint and innovation.

The descriptive survey design was considered appropriate for this study because it allows for the collection of cross-sectional data from a large sample, thereby providing a snapshot of current supply chain practices and performance outcomes (Hair *et al.*, 2017). This approach has been widely used in SME and supply chain research to capture real-time business dynamics in developing contexts (Creswell & Creswell, 2018). The population comprised of registered SMEs across multiple sectors, including agriculture and agribusiness, retail and wholesale trade, manufacturing, food and beverage, construction, furniture, ICT (hardware-focused), healthcare and pharmaceuticals, renewable energy and power generation, transportation and logistics, and fashion and beauty. These sectors reflect the diversity and economic significance of SMEs in Nigeria, where SMEs contribute approximately 48% of national GDP and employ over 84% of the workforce (SMEDAN & NBS, 2020). To ensure proportional representation across sectors, stratified random sampling was employed. This technique reduces sampling bias and provides a more representative dataset (Bougie & Sekaran, 2019). Using the G-Power calculator, which is widely recommended for social science research to determine optimal sample size (Taherdoost, 2018), a sample size of 266 respondents was targeted. Participants included SME owners, managers, and top executives who are directly involved in supply chain and strategic decision-making.

A structured questionnaire was developed, drawing from validated scales in prior supply chain management literature. The SCMP dimensions (postponement, information

sharing, information quality, customer relationship management, and strategic supplier partnerships) were measured using items adapted from Li *et al.* (2006), Ojubanire and Popoola (2022), Gawankar *et al.* (2017), Qalati *et al.* (2021), Salim (2021), and Ajao *et al.* (2018). SME performance was assessed multidimensionally, including profitability, growth, customer satisfaction, and operational improvements, based on frameworks established by Qalati *et al.* (2021) and Stekelorum *et al.* (2021). Responses were recorded on a five-point Likert scale ranging from 1 ("Strongly Disagree") to 5 ("Strongly Agree"), which is widely considered appropriate for capturing perceptions and attitudes in management research (Benidiktus *et al.*, 2022). To enhance validity, the instrument was pilot-tested with 30 SMEs in Ibadan, ensuring clarity and contextual alignment (Bougie & Sekaran, 2019).

Furthermore, data were collected through physical distribution, reflecting the growing digital orientation of SMEs in Nigeria. Ethical considerations, including informed consent and assurances of confidentiality, were strictly observed. Data analysis proceeded in two stages. First, SPSS v30 was used to generate descriptive statistics (means, standard deviations, frequencies) to assess the level of adoption of SCMPs. Second, SmartPLS 4.1 was employed for structural equation modelling (SEM), which is particularly effective for predictive and exploratory research involving complex models (Hair *et al.*, 2013; 2014; 2017). Reliability was tested through Cronbach's alpha and composite reliability, while validity was assessed using average variance extracted (AVE) for convergent validity and the Fornell–Larcker criterion for discriminant validity (Fornell & Larcke, 1981; Henseler & Chin, 2010). Structural model evaluation involved examining path coefficients, bootstrapped t-values (5,000 resamples), and R^2 values to assess explanatory power (Henseler & Chin, 2010). This methodological approach aligns with recent studies on SME supply chains in Nigeria, thereby ensuring both rigor and comparability of findings (Alhassan *et al.*, 2022).

8.4 Results

8.4.1 Response Rate and Demographic Profile

Out of the 350 questionnaires administered, 266 valid responses were retrieved, representing a robust response rate of 76%. This rate is considered satisfactory for survey-based studies in SME research, where response challenges are often reported (Hair *et al.,* 2014; Hair *et al.,* 2017)knowing the appropriate technique can be a challenge. For example, when considering structural equation modelling (SEM. The respondents were comprised of SME owners (31.2%), managers (36.1%), and executive directors (32.7%), ensuring that perspectives were drawn from individuals actively engaged in strategic and operational decision-making. The sectoral distribution of the participating SMEs reflected the economic diversity of Ibadan's business environment. Specifically, responses were obtained from enterprises in agriculture and agribusiness (9.0%), retail and wholesale trade (11.7%), manufacturing (14.3%), food and beverage (9.8%), construction (12.8%), furniture (7.5%), ICT (hardware-focused) (10.9%), healthcare and pharmaceuticals (6.8%), renewable energy and power generation (6.4%), transportation and logistics (5.6%), and fashion and beauty (5.3%). This

spread underscores the inclusivity of the study and provides a representative sample of the major SME sectors contributing to regional economic growth (SMEDAN & NBS, 2020).

In terms of work experience, more than half of the respondents (50.8%) indicated that they had over fifteen years of involvement in running their businesses. This reflects the presence of highly experienced SME operators in Ibadan who have successfully navigated Nigeria's challenging business environment marked by infrastructural deficits, regulatory bottlenecks, and market volatility (Nwachukwu & Onuoha, 2023). Such a concentration of long-serving entrepreneurs and managers adds depth to the analysis, as it enables the study to capture how accumulated experience shapes the adoption and sustainability of supply chain management practices over time (Ojubanire & Popoola, 2022)600 at the time of this study. A questionnaire was used to gather data for this research. The data collected was analyzed using frequencies and percentages, mean, standard deviation, and Pearson's correlation. Results from the study showed that SMMEs had fairly good supplier integration (50.05%. The insights from these seasoned respondents provide valuable perspectives on resilience, strategic adaptation, and the role of experiential knowledge in driving SME performance in a competitive landscape.

8.4.2 Descriptive Analysis of Supply Chain Management Practices

Among the examined supply chain management practices, strategic supplier partnership (SSP) recorded the highest mean score ($\bar{x}$ = 4.24), underscoring its central role in strengthening supply chain efficiency. This was closely followed by customer relationship (CR) with a mean score of ($\bar{x}$ = 4.23), while information quality (IQ) and information sharing (ISI) registered mean values of ($\bar{x}$ = 4.20) and ($\bar{x}$ = 4.15), respectively. Postponement (POS) recorded the lowest mean score ($\bar{x}$ = 4.14), though it was still significant when assessed against the benchmark of mean application levels outlined by Taherdoost (2022). The descriptive statistics therefore suggest that SMEs in Ibadan place the highest emphasis on cultivating strong partnerships with suppliers and maintaining robust customer relationships, both of which are essential for aligning business operations across the supply chain. By contrast, postponement strategies, while present, appear less emphasized. These findings imply that firms view strategic supplier partnerships and customer relationships as critical enablers of effective supply chain management, reflecting the importance of collaboration and trust in ensuring reliability and responsiveness. Moreover, the prioritization of these dimensions highlights the growing need for technological innovations, such as digital platforms and data-driven tools, to further enhance coordination, information flow, and operational performance across the supply chain.

8.4.3 Measurement Model Assessment

All the study constructs demonstrated strong reliability and validity, confirming the robustness of the measurement model. Cronbach's alpha values ranged from 0.878 to 0.947, well above the 0.70 threshold recommended by Nunnally and Bernstein,

(1994), indicating high internal consistency among the items. Similarly, composite reliability (CR) values exceeded 0.70 for all constructs, further confirming the stability and reliability of the measures (Hair *et al.,* 2021)the model imposes some daunting assumptions and restrictions (e.g. normality and relatively large sample sizes. In terms of convergent validity, the average variance extracted (AVE) values were all above 0.50, satisfying the minimum benchmark suggested by Fornell and Larcker (1981) and demonstrating that each construct explains a substantial proportion of the variance of its indicators. Discriminant validity was also established through the Fornell–Larcker criterion, which showed that the square root of the AVE for each construct was greater than its correlations with other constructs, confirming that the latent variables were empirically distinct. Together, these reliability and validity tests affirm that the instrument employed was both statistically sound and theoretically appropriate for assessing supply chain management practices and SME performance in the Nigerian context. Figure 4.1 illustrates the finalized measurement model, validated using SmartPLS V4.1. The assessment confirmed adequate reliability, convergent validity, and discriminant validity, thereby establishing the robustness of the measurement model and its suitability for subsequent structural model analysis.



Figure 1 Measurement Mode

8.4.4 Structural Model Findings

The structural model results revealed a strong and statistically significant positive relationship between supply chain management practices (SCMPs) and SME performance ($\beta = 0.924, p < 0.000$). This finding underscores the pivotal role of SCMP

adoption in driving superior organizational outcomes within the Nigerian SME sector, where firms often face infrastructural bottlenecks, financial constraints, and volatile market conditions. In line with the Resource-Based View (RBV), SCMPs serve as strategic capabilities that enable firms to transform limited resources into sustainable performance outcomes. Deeper insights emerged when examining the individual SCMP dimensions. Postponement (β = 0.911, p < 0.000), information sharing (β = 0.951, p < 0.000), information quality (β = 0.934, p < 0.000), customer relationship management (β = 0.915, p < 0.000), and strategic supplier partnerships (β = 0.956, p < 0.000) all exhibited significant positive effects on SME performance. Notably, strategic supplier partnerships and information sharing were the most influential dimensions, highlighting the importance of collaboration and transparent information exchange in creating value within supply chains. This aligns with RBV's argument that capabilities that are valuable, rare, inimitable, and non-substitutable (VRIN) provide the foundation for sustainable competitive advantage (Barney, 1991; Teece et al., 1997; Grant, 1996; Neves et al., 2014). As depicted in Figure 4.2, the model explained 86.6% of the variance in SME performance (R^2 = 0.866), indicating high explanatory power (Hair et *al.,* 2021).

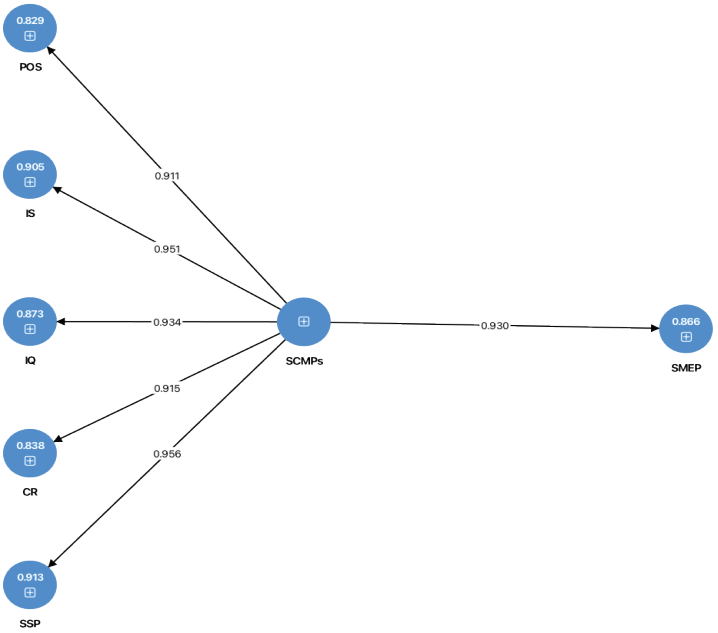


Figure 2 Structural model

This suggests that the integration of SCMPs accounts for a substantial proportion of performance outcomes, reinforcing their role as strategic resources. For Nigerian SMEs, which often operate in resource-constrained environments, these findings empirically justify the adoption of SCMPs not only as operational tools but also as core intangible capabilities that can buffer against external shocks and position firms for long-term competitiveness.

8.4.5 Discussion

The findings of this study confirm that supply chain management practices (SCMPs) exert a significant positive influence on SME performance in Ibadan, Oyo State, Nigeria. The strong relationship ($\beta = 0.924$, $p < 0.001$) highlights that SMEs that systematically adopt SCMPs are better positioned to enhance operational efficiency, customer satisfaction, and competitiveness. This outcome aligns with global evidence that supply chain integration drives performance gains by improving efficiency, coordination, and responsiveness (Li *et al.*, 2006; Thongrawd *et al.*, 2020; Olayiwola *et al.*, 2024). The individual dimension analysis revealed that strategic supplier partnerships and information sharing are the most critical drivers of SME performance. These results mirror Oyetade *et al.* (2023), who found that supplier partnerships and information quality are reliable predictors of SME performance in Lagos State. Similarly, Omigie and Kubeyinje (2022) demonstrated that managing information flows and procurement outsourcing significantly improves performance among manufacturing SMEs in Edo State. These findings underscore the importance of collaboration and trust-based relationships with suppliers in Nigeria's volatile and infrastructurally weak environment. Notably, while postponement and customer relationship management also exerted strong positive effects, their influence was relatively weaker compared to supplier partnerships and information sharing. This observation resonates with Obisesan *et al.* (2022), who found uneven adoption and varying performance effects across SCMP dimensions in Nigeria's telecommunications sector. Such variations confirm that the relative importance of practices is context-specific, shaped by infrastructure, firm size, and technological capabilities (Oyedijo *et al.*, 2021).

8.4.5.1 Theoretical Implication

From a theoretical standpoint, these results strongly support the Resource-Based View (RBV). SCMPs constitute organizational capabilities that are valuable, rare, inimitable, and non-substitutable (VRIN), functioning as strategic resources that SMEs can leverage to sustain competitive advantage (Barney, 1991; Teece *et al.,* 1997; Grant, 1996; Neves *et al.,* 2014). Strategic supplier partnerships and robust information sharing emerge as intangible assets that foster operational resilience and market responsiveness. The high explanatory power of the model ($R^2 = 0.866$) provides empirical support for RBV in the Nigerian SME context, showing how firms transform intangible resources into performance outcomes despite environmental constraints.

8.4.5.2 Policy and Managerial Implication

The findings offer important managerial insights. SME managers should prioritize long-term supplier partnerships, which enhance trust, reduce transaction costs, and stabilize procurement processes. Additionally, firms should invest in ICT platforms that facilitate timely and accurate information exchange, since information sharing proved to be one of the strongest drivers of performance. Managers are also encouraged to embed customer relationship management strategies that build loyalty,

improve responsiveness, and increase customer retention. From a policy perspective, infrastructural gaps remain the biggest barrier to effective supply chain integration. Policymakers should therefore focus on improving transportation systems, stable electricity, and broadband connectivity. Supportive policies, such as subsidized access to ICT solutions, SME-focused logistics hubs, and financial incentives for digital adoption, could accelerate SCMP uptake. Furthermore, capacity-building programs for SME owners and managers on supply chain best practices would ensure that these firms develop the strategic capabilities necessary for long-term competitiveness.

8.4.5.3 Limitations and Suggestions for Future Research

While this study provides valuable insights, several limitations should be acknowledged. First, the research employed a cross-sectional survey design, which limits the ability to establish causality between SCMPs and SME performance. Future research could adopt longitudinal designs to capture how SCMP adoption evolves over time and its sustained impact on performance.

Second, the study was restricted to SMEs in Ibadan, Oyo State, which may affect the generalizability of the findings to other regions of Nigeria with different economic, infrastructural, and institutional dynamics. Comparative studies across multiple states or countries could provide a broader understanding of contextual variations.

Third, the study focused on five SCMP dimensions such as postponement, information sharing, information quality, customer relationship management, and strategic supplier partnerships. Future research could expand the scope to include additional dimensions such as logistics integration, inventory management, and risk management, which may also play important roles in performance outcomes.

Finally, although SCMPs were shown to have significant effects, moderating variables such as social media marketing adoption, e-commerce implementation, firm size, and industry type were not directly examined in this study. Investigating these moderators in future studies could yield deeper insights into the conditions under which SCMPs are most effective.

8.5 Conclusion

This study examined the relationship between supply chain management practices (SCMPs) and SME performance in Ibadan, Oyo State, Nigeria. The findings revealed a strong and statistically significant positive association between SCMPs and SME performance, with strategic supplier partnerships and information sharing emerging as the most influential practices. Anchored in the Resource-Based View (RBV), the study demonstrates that SCMPs operate as strategic organizational capabilities, enabling SMEs to leverage scarce resources for enhanced competitiveness and sustained performance.

From a theoretical perspective, the study contributes to the RBV literature by providing empirical validation of intangible supply chain capabilities, such as postponement, information sharing, information quality, customer relationship

management, and strategic supplier partnerships as VRIN resources within SMEs, particularly in Nigeria. This expands RBV applications beyond developed economies, highlighting its relevance in emerging markets where institutional voids and infrastructural limitations are prevalent.

From a practical standpoint, the study underscores the importance of supplier collaboration, quality information systems, and infrastructural support in strengthening SME resilience and competitiveness. For practitioners and policymakers, the findings underscore the importance of prioritising digital infrastructure, building capacity for supply chain integration, and fostering supportive ecosystems that enable SMEs to effectively harness SCMPs.

In conclusion, the adoption of SCMPs is not merely a strategic option but a necessity for Nigerian SMEs striving to survive and thrive amid infrastructural deficiencies and dynamic market conditions. By reinforcing supplier networks, enhancing information quality, and embedding customer-focused strategies, SMEs can develop resilience, expand their market presence, and achieve sustainable competitive advantage in an increasingly volatile business landscape.

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Chapter 9

Do OPEC+ Commitments Matter? Evidence From Oil Market Responses to Binding and Voluntary Announcements

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Abstract This study examines how the credibility of OPEC+ supply announcements shapes oil prices, differentiating between binding commitments and voluntary pledges and assessing the moderating role of historical compliance. Addressing a gap in literature that often treats these announcements as uniform, we test two hypotheses: that binding pledges have stronger, more persistent price effects than voluntary ones, and that these effects are amplified during periods of high group compliance. Using monthly data from 2020–2025 and an ARDL–ECM econometric framework across Brent, WTI, and Dubai benchmarks, we code announcements by type and construct a compliance index from production data while controlling for macro-financial factors. Results confirm that binding announcements trigger more stable and significant price responses, while voluntary ones are often discounted or even interpreted as signals of weak demand. Crucially, compliance history conditions market reactions: voluntary pledges only influence prices when compliance is high, and binding announcements are strengthened by a track record of discipline. These effects also propagate across benchmark differentials but are subject to rapid arbitrage. We conclude that OPEC+ functions primarily as an expectation manager whose influence depends on institutional credibility rooted in verifiable compliance. The findings underscore the need for OPEC+ to prioritize discipline and transparency while suggesting the traders and policymakers incorporate compliance-adjusted credibility into oil market forecasts and risk models.

Keywords: OPEC+, Announcements, Credibility, Compliance, Oil Price Dynamics

9.1 Introduction

The crude oil market is a cornerstone of the global economy, with price dynamics critically influencing macroeconomic performance, inflation, and geopolitical stability. Global trade relies on key benchmarks of Brent, WTI, and Dubai, whereby they reflect

regional variations in quality, infrastructure, and supply-demand balances [1]. OPEC, established in 1960, evolved into OPEC+ in 2016 by incorporating Russia and other allies, shifting from direct supply management towards expectation management, particularly as U.S. shale oil eroded OPEC's structural market power. OPEC+ now influences prices primarily through informational channels, a role stress-tested by the COVID-19 demand collapse and the Russia-Ukraine war. OPEC+ announcements vary in formality, ranging from binding commitments in which enforceable under group mechanisms, to voluntary pledges reliant on reputational capital. Market reactions depend not merely on announcement content, but on perceived enforceability and historical track record.

While literature confirms OPEC+ decisions impacting prices [2,3], market reactions are heterogeneous [4,5]. A critical gap persists where studies treat announcements as homogeneous, ignoring the institutional distinction between binding and voluntary commitments. Binding decisions create enforceable obligations, whereas voluntary adjustments are discretionary and prone to coordination problems [6]. Binding acts as a verifiable signal [7], while voluntary pledges depend on sender credibility. Markets may even interpret voluntary cuts as signals of weak demand. This study addresses this empirical oversight.

Two hypotheses guide the inquiry. First, oil price reactions to binding OPEC+ announcements are significantly stronger and more persistent than reactions to voluntary ones. Second, market response is conditioned by historical compliance, with stronger price effects observed during high-compliance periods. The chapter examines the differential impact of binding versus voluntary announcements across Brent, WTI, and Dubai benchmarks, and evaluates how compliance history conditions this impact. The analysis is framed around institutional credibility and signalling theory [8,9], spanning January 2020 to March 2025, a period encompassing major demand and supply shocks, providing a natural experiment to isolate how markets differentiate commitment types under duress.

9.2 Literature Review

9.2.1 Theoretical Review

Oil markets are forward-looking, with prices shaped by expectations of future conditions [10,2]. OPEC+ announcements act as discrete informational shocks [11] influencing beliefs about supply before physical balances shift. Signaling theory [7] clarifies why binding announcements, subject to quota enforcement and monitoring through the JMMC [12], serve as credible signals, while voluntary pledges resemble "cheap talk" [6]. Credibility depends on enforcement and historical compliance [13], and post-2020 compensation mechanisms reflect attempts to restore it. Financialization further amplifies external influences, with exchange rates, equity volatility, and speculation as powerful short-term drivers [14,3]. Reactions also differ across benchmarks: Brent is globally sensitive, WTI reflects U.S. dynamics, and Dubai tracks Middle Eastern export flows [4,11]. This study is thus underpinned by four interconnected perspectives: expectation-driven price formation, signaling theory and credibility, institutional reputation and compliance, and financialization.

9.2.2 Prior Empirical Findings on OPEC+ Announcements and Market Responses

Early works [15,2,3] confirmed oil price reactions to OPEC interventions but treated decisions as homogeneous. Event studies [5] showed cut announcements significantly raise prices, while Ji and Guo [4] demonstrated heterogeneous responses depending on credibility and execution. Liu, Dong, and Failler [16] found stronger reactions from compliant members such as Saudi Arabia compared to habitual overproducers. Fattouh et al. [8] argued credibility, rather than volumes, drives price effects. Kilian and Zhou [14] highlighted speculative and precautionary demand as transmission channels, while Jensen, Mohaddes, and Raissi [17] showed stronger announcement effects during crises such as COVID-19 and the Russia-Ukraine war.

Three unresolved issues stand out. First, most studies fail to distinguish binding from voluntary announcements, leaving Hypothesis 1 untested. Second, compliance history remains underutilized as a conditioning variable despite its centrality to credibility, the concern of Hypothesis 2. Third, credibility has rarely been examined across benchmarks, limiting generalizability.

9.2.3 Benchmark Heterogeneity

Identical OPEC+ announcements can generate divergent impacts across benchmarks. Brent is especially sensitive to global supply narratives, Dubai reflects Middle Eastern policies and Asian demand, and WTI is shaped by U.S. production and storage dynamics [4,14]. Benchmark spreads thus provide insights into regional arbitrage and credibility effects. Yet most research centres on Brent alone, with Dubai underrepresented despite its significance in Asian markets, and benchmark heterogeneity has rarely been linked explicitly to the credibility dimension of announcements.

9.2.4 Parallel Literatures and Theoretical Convergence

Insights from adjacent fields enrich this analysis. Central bank communication research emphasizes reputation and consistency in shaping market reactions [18,19], and Ritz and Tille [9] compare OPEC+ to a "central bank of oil." Geopolitical risk and uncertainty magnify dependence on credible signals [20,21], weak enforcement erodes institutional credibility [13], and behavioral finance suggests ambiguous signals heighten volatility [22]. Collectively, these literatures confirm that institutional announcement effectiveness is contingent on credibility, reputation, and enforcement capacity.

9.2.5 Research Gaps and Relevance to the Current Study

Despite extensive research, key omissions persist. Most studies group binding and voluntary commitments as simple "cuts" or "increases" [4,5], compliance history has rarely been quantified, and existing methodologies such as event-study or SVAR

approaches [3,23] underestimate institutional and reputational effects. This study extends Ji and Guo [4], Loutia et al. [5], Kilian and Zhou [14], and Fattouh et al. [8] by differentiating binding and voluntary announcements, incorporating compliance indices as credibility measures, and examining effects across Brent, WTI, and Dubai. These refinements establish the foundation for the methodological framework set out in Section 3.

9.3 Data and Methodology

9.3.1 Data Description

The study utilizes a multi-dimensional monthly time-series dataset covering January 2020 to March 2025 (t = 63), integrating crude oil benchmarks, OPEC+ production and announcement data, and macro-financial controls. All series were converted to monthly frequency and log-transformed where appropriate.

9.3.1.1 Dependent Variables: Crude Oil Benchmark Prices

The dependent variables are monthly average prices of three benchmarks sourced from S&P Global Commodity Insights: Platts Dated Brent, Platts WTI Cushing, and Platts Dubai. Brent represents the dominant global waterborne benchmark, WTI reflects U.S. inland supply and storage conditions, and Dubai is critical for Asian crude imports and Middle Eastern export policies. Together, these benchmarks capture geographically distinct trading ecosystems

9.3.1.2 Response Variables I: OPEC+ Announcement Coding Framework

OPEC+ announcements were compiled from official communiqués, JMMC reports, and verified industry sources including Bloomberg, Reuters, and Platts. Each monthly observation was classified by commitment type and directional intent. Announcements were distinguished between binding decisions, subject to quota enforcement, and voluntary pledges, which are discretionary and unenforceable, then further categorized by whether they signalled a production cut, increase, or maintenance.

For Hypothesis 1, four mutually exclusive dummy variables are employed: *BindingCut, BindingIncrease, VoluntaryCut,* and *VoluntaryIncrease* (Table 1). For Hypothesis 2, binding and voluntary announcements are each collapsed into single indicators (*AnyBinding* and *AnyVoluntary*), with directional intent captured by a signed variable (*Direction_Signed*) taking values of -1 for cuts, 0 for maintenance, and +1 for increases. Interaction terms with compliance then test whether announcement credibility is reinforced by group-level discipline.

Table Coding of OPEC+ Announcement Dummy Variables

Variable Name	Code
BindingCut	=1, for mandatory output cut; = 0, otherwise;
BindingIncrease	=1, mandatory output hike; = 0, otherwise
VoluntaryCut	=1, voluntary output cut; = 0, otherwise
VoluntaryIncrease	=1, voluntary output hike; = 0, otherwise

$$\text{Total Target}_t = \text{Quota}_t + \text{Voluntary Pledges}_t \quad (1)$$

$$\text{Compliance}_t = \frac{\text{Total Target}_t - \text{Actual Production}_t}{\text{Total Target}_t} \quad (2)$$

9.3.1.3 Response Variable II: OPEC+ Production Data and Commitment Indicators

Production, quota, and voluntary pledge data are drawn from Platts to construct a compliance measure. Compliance is operationalized as the deviation of actual production from the assigned target, where the target equals official quotas plus voluntary pledges, following Equations (1) and (2). A positive value indicates overproduction, a negative value signals underproduction, and values near zero reflect close adherence. The compliance series reveals significant overproduction episodes in 2020 and 2024-2025, contrasted with underproduction during 2021-2022. This measure enters Hypothesis 2 through interaction terms to test whether binding commitments are reinforced by group-level discipline.

9.3.1.4 Control Variables: Macroeconomic and Financial Indicators

The model incorporates macro-financial controls to isolate OPEC+ effects from broader global shocks: the ICE U.S. Dollar Index (*USDYX*) for exchange rate influences; the Global Economic Policy Uncertainty Index (*GEPUI*) [24] for macroeconomic uncertainty; the CBOE Volatility Index (*VIX*) for financial risk sentiment; the U.S. Producer Price Index for Crude Petroleum for upstream cost pressures; and the OECD Industrial Production Growth Rate as a proxy for global demand conditions.

9.4 Methodological Framework

The econometric strategy follows a multivariate time-series approach consistent with established energy economics literature [2,3,15]. Model selection depends on the integration and cointegration properties of the variables. Where variables are I(1), Johansen cointegration tests [25,26] determine long-run relationships, with confirmed cointegration supporting a Vector Error Correction Model (VECM) and its absence defaulting to a VAR in first differences [27]. Where mixed integration orders exist, the

bounds-testing ARDL approach of Pesaran, Shin, and Smith [28,29] is applied, allowing simultaneous estimation of short-run and long-run dynamics. OPEC+ announcements are incorporated as exogenous dummy variables throughout, following Fattouh, Kilian and Mahadeva [30] and Kilian and Murphy [23].

9.4.1 Stationarity and Unit Root Testing

Three complementary procedures are applied: the Augmented Dickey-Fuller (ADF) test [31], the Phillips-Perron (PP) test [32], and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test [33]. The ADF and PP tests adopt the null hypothesis of a unit root, while KPSS assumes stationarity. This complementary approach minimizes Type I and Type II errors, consistent with best practice in energy economics [34,35].

9.4.2 Cointegration Analysis

Where variables are I(1), the Johansen maximum likelihood procedure [25,26] is used to detect cointegration vectors, supporting VECM estimation when confirmed [36,37]. In the absence of cointegration, a VAR in first differences is employed [27]. Where mixed integration orders preclude Johansen testing, the ARDL bounds-testing framework [28,29] is applied, increasingly favored in energy economics for its flexibility under mixed integration orders [38,39].

9.4.3 Model Specification

OPEC+ announcements enter each model as exogenous dummies representing binding or voluntary commitments, disaggregated by directional intent. Short-run impacts are reflected in coefficients on contemporaneous and lagged dummies, while long-run effects are captured through equilibrium correction terms. Dynamic responses are further assessed through Impulse Response Functions (IRF) and Forecast Error Variance Decomposition (FEVD) [23,42]. IRFs trace benchmark adjustment paths to announcement shocks, while FEVD quantifies their relative contribution to total forecast variance. In ARDL-ECM models, a negative and statistically significant error correction term (ECT) confirms a stable long-run relationship and quantifies the speed of disequilibrium correction [40,43].

9.4.4 Robustness checks and diagnostic procedures

Lag order selection is guided by the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC), balancing explanatory power with parsimony. Diagnostic tests include the Lagrange Multiplier test for serial correlation, the Jarque-Bera test for residual normality, and White and Breusch-Pagan procedures for heteroskedasticity. These checks ensure that inference rests on statistically valid assumptions. For ARDL-ECM models, the ECT coefficient additionally validates long-run stability and the persistence of announcement effects, aligning with the insights of Engle and Granger [40] and Banerjee, Dolado and Mestre [43].

9.5 Results and Discussion

9.5.1 Descriptive Statistics

Brent (LnBrn), WTI (LnWTI), and Dubai (LnDbi) exhibit comparable volatility, with means clustered around 4.21 to 4.27 and standard deviations of 0.33 to 0.35. Price extremes reflect the April 2020 COVID-19 collapse and the 2022 peaks following supply disruptions from the Russia-Ukraine conflict. The compliance index fluctuates between -0.10 and 0.09, reflecting meaningful variation in adherence to production agreements. Macro-financial controls capture relevant demand and cost dynamics across the sample.

9.5.2 Unit Root Tests and Econometric Framework Selection

Stationarity tests confirm that most level series are non-stationary I(1) processes, while their first differences achieve stationarity. Results are corroborated across ADF, PP, and KPSS procedures [31-33]. OECD industrial production and the compliance index show stationarity in levels, while *LnVIX* and *LnGEPUI* display mixed evidence. Given this mixture of I(0) and I(1) series, ARDL bounds testing [28,29] is adopted as the primary framework, allowing estimation of both short- and long-run relationships while avoiding spurious regression concerns.

9.5.3 Hypothesis 1: Binding versus Voluntary Announcement Effects

9.5.3.1 Model Specification and Estimation

The baseline ARDL model regresses log Brent prices on the four announcement dummies (*BindingCut, BindingIncrease, VoluntaryCut, VoluntaryIncrease*) and macro-financial controls, following the treatment of supply announcements as discrete exogenous shocks [23,30]. BIC-guided lag selection yields an ARDL (1,0,0,0,2,2,1,0,0,0) specification, with long-run coefficients estimated using Newey-West HAC standard errors.

Results in Table 3 reveal a persistent divergence between theoretical expectations and observed market behavior. *BindingIncrease* shows marginal significance (β = 0.026, p = 0.060), but its effect is transitory. Both *VoluntaryCut* (β = -0.029, p = 0.352) and *VoluntaryIncrease* (β = -0.007, p = 0.840) remain insignificant. Macro-financial indicators dominate: *VIX* exerts a robust negative effect (β = -0.069, p = 0.003) and *LnPPI* demonstrates near-unitary elasticity (β = 1.053, $p < 0.001$), surpassing all announcement variables in magnitude.

Table 2 Variables ARDL Model Estimates for Hypothesis 1 (BIC-Optimized Specification)

Variable	Lag	Coefficient	Std. Error	t-stat	p-value
Intercept	-	-1.937	0.500	-3.875	0.000***
LnBrn (Dependent)	1	-0.110	0.035	-3.152	0.003***
BindingCut	0	-0.018	0.015	-1.184	0.242
BindingIncrease	0	0.026	0.014	1.925	0.060*
VoluntaryCut	0	-0.029	0.031	-0.940	0.352
VoluntaryIncrease	0	-0.007	0.037	-0.203	0.840
LnUSDYX	0	0.128	0.306	0.417	0.678
LnUSDYX	1	-0.738	0.448	-1.648	0.106
LnUSDYX	2	0.822	0.283	2.904	0.006***
LnVIX	0	-0.069	0.022	-3.125	0.003***
LnVIX	1	0.078	0.023	3.383	0.001***
lnGEPUI	0	0.019	0.029	0.680	0.500
LnPPI	0	1.053	0.032	32.716	<0.001***
OECD	0	-0.001	0.001	-0.828	0.412

Note: *, **, *** denote significance at 10%, 5%, 1% levels respectively

9.5.3.2 Cointegration and Error Correction

The Pesaran-Shin-Smith Bounds F-test ($F = 104.68$, $p < 0.001$) confirms cointegration [29], supporting reparameterization into an ECM. Short-run ECM results in Table 4 show that neither *BindingCut* ($\beta = -0.005$, $p = 0.571$) nor *BindingIncrease* ($\beta = 0.022$, $p = 0.246$) achieves significance. In contrast, *VoluntaryCut* is negative and significant ($\beta = -0.027$, $p = 0.047$), consistent with markets interpreting voluntary cuts as signals of underlying demand weakness. The ECT ($\beta = -0.777$, $p < 0.001$) implies that approximately 78% of any deviation from the long-run path is corrected within a single month. *VIX* ($\beta = -0.100$, $p < 0.001$) and *PPI* ($\beta = 1.02$, $p < 0.001$) continue to dominate short-run dynamics.

9.5.3.3 Diagnostic Tests

Model adequacy is confirmed. ECM residuals pass tests for homoskedasticity (White test: $p = 0.98$) and normality (Jarque-Bera: $p = 0.70$). Serial correlation is detected at the 1% level (Breusch-Godfrey: $p = 0.009$), addressed through HAC-robust standard errors.

Table 3 Short-Run ECM – HAC Robust

Variable	Coefficient	Std. Error	t-statistic	p-value
(Intercept)	-0.002	0.0049	-0.409	0.685
BindingCut	-0.005	0.0095	-0.570	0.571
BindingIncrease	0.022	0.0188	1.170	0.246
VoluntaryCut	-0.028	0.0135	-2.040	0.047 **
VoluntaryIncrease	-0.024	0.0201	-1.170	0.249
ΔLnUSDYX	-0.445	0.318	-1.400	0.168
ΔLnVIX	-0.100	0.0246	-4.070	0.000 ***
ΔlnGEPUI	0.063	0.0424	1.490	0.143
ΔLnPPI	1.020	0.0408	25.100	0.000 ***
ΔOECD	-0.0004	0.0009	-0.429	0.670
ECT(-1)	-0.777	0.139	-5.610	0.000 ***
ΔPrice(-1)	-0.058	0.0386	-1.520	0.136

Note: *, **, *** denote significance at 10%, 5%, 1% levels respectively

9.5.3.4 Benchmark Differential Analysis

Differential analysis offers sharper evidence of binding announcement credibility. For the Brent-WTI spread, binding increases exert a strong positive effect ($\beta = 2.71$, $p < 0.001$), widening the Brent premium, with binding cuts showing delayed significance at lags 1 and 2. For the Brent-Dubai spread, binding increases again produce a strong and persistent widening effect ($\beta = 2.47$, $p < 0.001$). Voluntary announcements remain economically weak and statistically insignificant across both differentials. Both ECMs confirm rapid mean-reversion, with ECT coefficients of -0.972 and -0.940 respectively. These results (Table 5) echo theoretical predictions that binding signals operate as credible commitments [6,7], while voluntary pledges lack sufficient enforceability to move regional spreads.

Differential analysis showed that binding increases significantly widened both Brent–WTI and Brent–Dubai spreads, while voluntary pledges remained weak or counterintuitive. These results echo earlier findings that binding signals operate as credible commitments [6,7], whereas voluntary pledges often lack enforceability.

Table 4 Comparative Results on Brent, Brent/Dubai, and Brent/WTI

Variable / Effect	Brent (Benchmark)	Dubai Differential	WTI Differential
Error Correction Term	−0.77*** (fast, strong)	−0.94*** (fastest)	−0.97*** (fast, strong)
Binding Increase	Positive, marginal (p≈0.06–0.12)	Positive, strong (p=0.002)	Positive, strong (p<0.001)
Binding Cut	Insignificant	Delayed positive (lags sig.)	Insignificant
Voluntary Cut	Insignificant	Insignificant	Negative, sig. (p<0.05)
Voluntary Increase	Insignificant	Insignificant	Insignificant
Global Controls	VIX (−), PPI (+), weak GEPUI	VIX (−), PPI (+), weak GEPUI	VIX (−), PPI (+), strong GEPUI
OECD Demand Proxy	Weak, negative (p≈0.06)	Weak, negative (p≈0.08)	Negative, sig. (p≈0.03)
Adjustment Speed	High, rapid correction	Highest speed, strongest correction	High speed, inertia (lag terms sig.)

Notes: Table reports main findings from ARDL long-run levels and ECM short-run dynamics. Stars indicate significance at ***1%, **5%, *10% levels.

9.5.4 Hypothesis 2: The Conditioning Role of Historical Compliance

9.5.4.1 Model Specification

The Hypothesis 1 framework is extended by collapsing binding and voluntary announcements into single indicators (*AnyBinding* and *AnyVoluntary*), capturing directional intent through *Direction_Signed* (-1, 0, +1), and introducing triple interaction terms with the lagged compliance index. This allows direct testing of whether compliance history amplifies or attenuates announcement effects.

9.5.4.2 Brent–Dubai Differentials

The specification fits well (*Adj.* $R^2 = 0.883$). Binding announcements exert a strong and persistent positive influence. The interaction term *Binding_Comply* at *L1* is strongly significant and positive ($\beta = 31.38$, $p = 0.006$), confirming that binding announcements are amplified when recent compliance is demonstrated. *Voluntary_Comply* is initially negative ($\beta = -137.7$, $p = 0.033$) but reverses to a large positive effect at *L2* ($\beta = 352.1$, $p < 0.001$), suggesting voluntary pledges are initially discounted but rewarded ex post when adherence is subsequently observed. The ECT ($\beta = -0.958$, $p < 0.001$) confirms strong and rapid adjustment.

Table 5 Compliance-Conditioned Effects on Spreads

	Brent-Dubai		Brent-WTI	
Term	ARDL Coeff.	ECM Coeff. (HAC)	ARDL Coeff.	ECM Coeff. (HAC)
Voluntary_Comply	-137.68*	-16.03	−95.49	45.35
L(Voluntary_Comply,2)	352.08***	–	319.49***	–
Binding_Comply (t-1)	31.38**	39.77***	29.92*	−3.69
ECT_L1	–	-0.96***	–	−0.62
LnPPI	5.89*	8.22**	1.89***	0.55

Note: *, **, *** denote significance at 10%, 5%, 1% levels respectively

9.5.4.3 Brent–WTI Differentials

The Brent-WTI specification also demonstrates strong explanatory power (Adj. R^2 = 0.855). Binding announcements produce a significant immediate widening effect (β = 1.15, p = 0.016) reinforced at the second lag. Compliance history proves pivotal: the first lag of the compliance index penalizes weak adherence (β = -27.10, p = 0.012) while the second lag rewards demonstrated discipline (β = 42.50, p < 0.001). The Binding Comply interaction at lag 1 remains significant (β = 29.92, p = 0.011). Voluntary Comply follows a similar pattern of initial scepticism (β = -95.49, p = 0.120) followed by delayed recognition (β = 319.49, p = 0.002). ECM adjustment is slower than for Brent-Dubai, suggesting greater inertia in U.S. market pricing of OPEC+ credibility signals.

Taking together, results from both differentials provide strong support for Hypothesis 2. Voluntary announcements are heavily discounted when compliance is weak but rewarded when subsequent adherence restores credibility. Binding announcements retain influence regardless of compliance, but their impact is significantly amplified when backed by demonstrated discipline [13,16,20]. Markets therefore price not just the type of announcement, but the reputational environment in which it is issued.

9.6 Conclusion

This study investigated how OPEC+ announcement credibility shapes oil price dynamics across Brent, WTI, and Dubai benchmarks using monthly ARDL-ECM analysis over January 2020 to March 2025. Both hypotheses received robust support. Binding commitments produced statistically significant and stable price effects, with binding supply increases consistently widening the Brent premium over WTI and Dubai. Voluntary pledges were largely insignificant and occasionally counterintuitive, with voluntary cuts sometimes depressing prices as markets interpreted them as demand weakness signals rather than credible supply restraint. Macro-financial

variables consistently dominated announcement variables in explanatory power [3,14,23], and error correction terms of 60-95% per month confirmed rapid arbitrage of announcement effects. Compliance history proved a significant moderator: voluntary announcements gained traction only during high-compliance periods, while binding announcements retained influence across regimes but were amplified by demonstrated discipline, particularly in the Brent-Dubai differential.

Credibility, rather than physical supply volumes, is the primary channel through which OPEC+ influences oil markets. Markets evaluate announcements through dual filters of institutional enforceability and reputational capital, supporting OPEC+'s characterization as an expectation manager analogous to central bank forward guidance [9,18,19]. These effects nonetheless remain secondary to broader macroeconomic forces and are quickly arbitraged away in an increasingly financialized market.

OPEC+ institutions should strengthen JMMC enforcement through third-party verification and avoid voluntary pledges during low-compliance periods. Oil-exporting states should align fiscal frameworks with production commitments to reduce overproduction incentives. Import-dependent economies should incorporate compliance-adjusted credibility metrics into energy security planning, while financial institutions should differentiate binding from voluntary signals in trading algorithms and sovereign credit assessments. The aggregate compliance measure masks member-state heterogeneity, and monthly frequency obscures high-frequency announcement dynamics. Endogeneity concerns warrant more robust identification strategies in future work. Future research could extend this credibility framework to other producer-governed commodity markets and examine how OPEC+'s expectation management role adapts under long-term demand decline driven by energy transition [48].

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Chapter 10

Monitoring Urban Air Quality in Malaysia: An Optimised MEWMA Approach for Environmental Management

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Abstract This study aimed to identify the optimal smoothing constant (λ) for the Multivariate Exponentially Weighted Moving Average (MEWMA) control chart in air quality monitoring by evaluating Average Run Length (ARL) values. Using Monte Carlo simulation, $\lambda = 0.2$ was identified as the optimal value, providing a balance between sensitivity and stability by minimising false alarms while maintaining effective detection of abnormal observations. The optimised λ was subsequently applied to 2018–2019 air quality data from Shah Alam, Cheras, and Putrajaya in the Klang Valley, Malaysia, comprising concentrations of CO, NO_2, SO_2, O_3, PM_{10}, and $PM_{2.5}$. The results indicated that all three monitoring stations were statistically out-of-control, with abnormal observations primarily driven by elevated PM_{10} and $PM_{2.5}$ concentrations associated with anthropogenic emissions, transboundary pollution, and meteorological conditions. These findings highlight the effectiveness of the MEWMA approach with an optimised λ for air quality monitoring and its potential to support environmental management and policy development.

10.1 Introduction

Air pollution has become a major environmental and public health concern across South and Southeast Asia, driven by industrial activities, transportation, construction, residential combustion, and open burning practices [1–3]. The World Health Organization (WHO) estimates that 99% of the global population is exposed to air pollution levels exceeding recommended guidelines [4]. Poor air quality poses significant health risks, particularly to vulnerable groups, and contributes to environmental degradation. Among air pollutants, particulate matter ($PM_{2.5}$ and PM_{10}) is especially harmful due to its ability to penetrate deep into the respiratory system, increasing the risk of cardiopulmonary diseases, lung cancer, and premature mortality

[5]. Other pollutants, including sulfur dioxide (SO_2), ozone (O_3), carbon monoxide (CO), and nitrogen oxides (NO_x), are also associated with respiratory illnesses and adverse health outcomes [6].

Various statistical and machine learning approaches have been employed to model and predict air pollution levels [7–10]. While these methods generally provide strong predictive performance, studies focusing on continuous process monitoring remain limited. Unlike forecasting techniques, process monitoring enables ongoing assessment of air quality and early identification of abnormal changes, facilitating timely intervention and mitigation measures [11].

Statistical Process Control (SPC) techniques, particularly control charts, have been widely used to monitor process stability and detect unusual variations [12–13]. In recent years, these methods have been increasingly applied in environmental monitoring. Among them, the Multivariate Exponentially Weighted Moving Average (MEWMA) control chart is especially suitable for air quality applications because it can simultaneously monitor multiple correlated pollutants and effectively detect small shifts in process means [14]. Its exponential weighting mechanism further enhances responsiveness by assigning greater importance to recent observations.

The MEWMA control chart has been successfully applied in various fields, including semiconductor manufacturing [15], steel production [16], aquaculture systems [17], and ozone anomaly detection [18]. Previous environmental studies have also highlighted the value of multivariate statistical approaches for analysing complex environmental datasets [19–20]. Despite these advantages, the performance of MEWMA depends strongly on the selection of the smoothing constant, λ, which governs the trade-off between sensitivity to process changes and false alarm rates [20]. Although various λ values have been commonly recommended [21], the identification of an optimal λ remains challenging, particularly for environmental datasets characterised by autocorrelation and complex pollutant interactions.

Therefore, this study aims to determine an appropriate smoothing constant for the MEWMA control chart in air quality monitoring. By optimising λ, the study seeks to improve the detection of air quality deterioration while minimising false alarms, thereby enhancing the effectiveness of statistical process control for environmental monitoring and decision-making.

10.2 Methodology

10.2.1 Control chart

Control charts were first introduced by Shewhart [22] as tools for monitoring process stability through the process mean and variability. Their implementation typically consists of two phases [23]. Phase I uses historical data to assess process stability and estimate process parameters, while Phase II applies the established control limits to future observations to detect process shifts and abnormalities [24].

10.2.2 MEWMA control chart

The MEWMA statistic is calculated recursively using a smoothing parameter, λ, which controls the influence of current and past observations. A monitoring statistic based on the covariance structure of the process is then compared against a control limit to determine whether the process remains in control. The formula is given by:

$$Z_i = \lambda X_i + (1-\lambda) Z_{i-1} \tag{1}$$

is the *i*th EWMA vector, is the *i*th observation vector, $i = 1,2,\ldots,n$, is the vector of variable values from the historical data, is the smoothing constant, and p is the number of variables. The quantity plotted on the control chart is:

$$T_i^2 = Z_i' \Sigma_{Z_i}^{-1} Z_i \tag{2}$$

Lowry et al. [14] have shown that the covariance matrix of can be written in terms of the exponential weight and the covariance matrix of the process data $\sum X$ as:

$$\Sigma_{Z_i} = \frac{\lambda[1-(1-\lambda)^{2i}]}{2-\lambda} \Sigma_X \tag{3}$$

If λ = 1, then the MEWMA chart is equivalent to Hotelling's T^2 chart.

10.2.3 Smoothing constant (λ)

The smoothing constant (λ) is a critical design parameter of the MEWMA control charts because it determines the balance between detection sensitivity and false alarm rates [25–27]. Smaller λ values place greater emphasis on historical observations and are generally more effective for detecting small and sustained shifts, whereas larger λ values respond more quickly to recent changes [26]. Previous studies commonly recommend λ values between 0.05 and 0.25 [28]. Empirical ARL results suggest that λ between 0.1 to 0.2 works best. For instance, Areepong and Chananet [29] used λ = 0.1 to study unemployment in Thailand, and Bardhan et al. [30] applied λ = 0.12 to monitor chemical processes at a mineral water plant. However, no universally optimal value exists, as the choice depends on process characteristics and monitoring objectives. For environmental applications, selecting an appropriate λ is particularly important because air quality data are highly dynamic and often autocorrelated. Accordingly, this study evaluates several λ values and determines the optimal setting based on Average Run Length (ARL) performance. The average run length (ARL) is used to assess how effectively a control chart can determine if a process is in control or out-of-control. A high ARL_0 indicates fewer false alarms, whereas a low ARL_1 indicates faster detection of process shifts.

10.3 Results and Discussion

Table 1 presents the ARL values for the six-dimensional MEWMA charts (p = 6) at three selected smoothing constants. as λ increases from 0.1 to 0.3, the ARL decreases significantly for shifts between 0 to 1. However, this decrease becomes less pronounced as the magnitude of the shift increases across all smoothing constant values. As suggested by Lucas and Saccucci [21], the optimal λ value can be determined by balancing false alarms with detection rates. In Table 1, for small shifts, a larger smoothing constant such as λ = 0.3 tends to reduce ARL_1 substantially, thereby enabling faster detection of subtle changes. However, this comes at the expense of a lower ARL_0, which increases the likelihood of false alarms under stable conditions. Conversely, for larger shifts, even smaller smoothing constants such as λ = 0.1 are capable of detecting deviations within a reasonable ARL_1, while simultaneously maintaining a high ARL_0 that ensures robustness against spurious signals. The intermediate value, λ = 0.2, demonstrates balanced performance across a range of shift sizes, offering sufficient sensitivity to moderate deviations while preserving stability in the in-control state. This is consistent with Lucas and Saccucci [21] and Montgomery [13], who emphasise balancing ARL_1 against an acceptable ARL_0 when selecting λ. In the context of air quality monitoring, where both small episodic increases such as haze events and larger sustained deviations such as seasonal pollution trends are of concern, the choice of λ = 0.2 emerges as the most appropriate compromise. It ensures timely detection of moderate shifts that are environmentally significant, while avoiding excessive false alarms that could undermine the credibility of monitoring systems. Accordingly, λ = 0.2 is selected as the optimal value for the air quality assessment in this study.

Table 1 ARL values of the MEWMA charts with p = 6 at different λ values and shift sizes.

Shift	0.1	0.2	0.3
0	164.54*	105.44	85.50
0.5	21.60	21.15*	22.49
1	13.05	11.92*	12.36
1.5	9.97	8.66*	8.66*
2	8.33	7.01	6.80*
2.5	7.29	6.00	5.69*
3	6.56	5.32	4.96*

* Indicates the optimal value at each shift. Source: Authors' Monte Carlo simulation.

10.3.1 Application of the MEWMA control chart on air quality

To evaluate the air quality process in the Klang Valley, Malaysia, the Multivariate Exponentially Weighted Moving Average (MEWMA) control chart was applied to pollutant data collected from monitoring stations in Putrajaya, Shah Alam, and Cheras. The analysis employed the optimal smoothing constant, λ = 0.2, and utilised data

provided by the Department of Environment (DOE) Malaysia for 2018–2019. Six pollutants were considered consisting of sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), carbon monoxide (CO), particulate matter (PM_{10}), and fine particulate matter ($PM_{2.5}$).

Owing to the autocorrelated nature of air quality data, a white noise-adjusted MEWMA approach was adopted following the recommendations of previous studies [31–33, 42]. ARIMA models with an AR(1) structure were fitted to each pollutant series to remove autocorrelation, and the resulting residuals were used as inputs for the MEWMA control chart. After establishing the control limits using the 2018 baseline data, the MEWMA control chart was applied to the 2019 observations for process monitoring. As shown in Fig. 1, the MEWMA charts for Putrajaya, Shah Alam, and Cheras exhibited several observations that exceeded the upper control limit (UCL), indicating statistically significant departures from the in-control state. These signals suggest that the air quality processes at all three monitoring stations were unstable during the study period, reflecting the occurrence of unusual pollution events or shifts in the underlying environmental conditions.

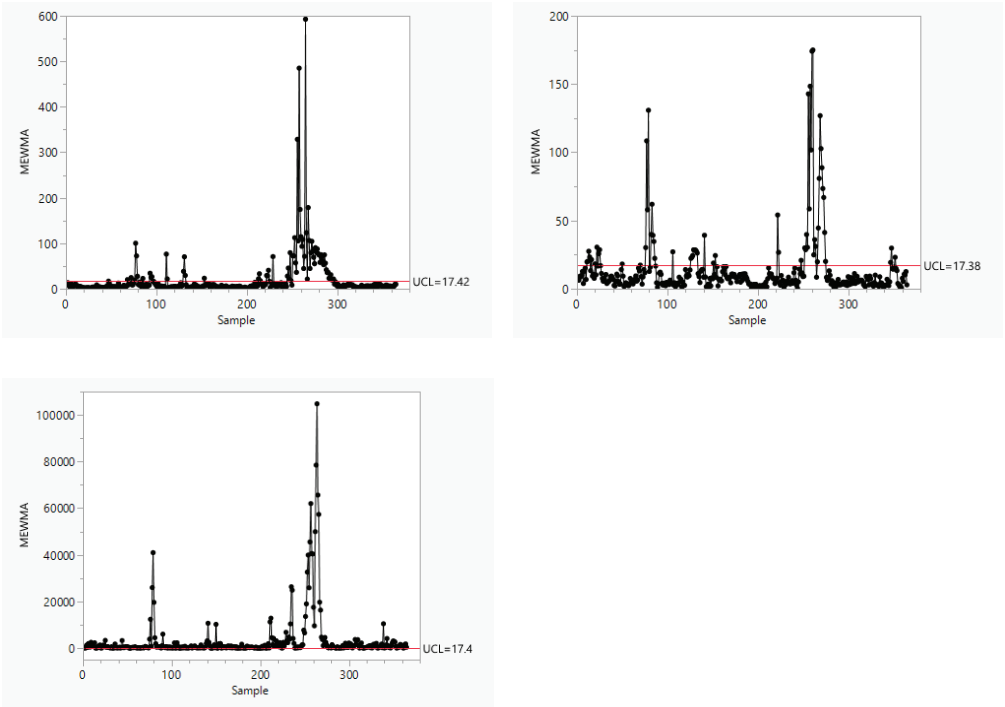


Figure 1 MEWMA control charts (process monitoring) for Putrajaya, Shah Alam and Cheras using $\lambda = 0.2$. Source: Authors' analysis of Department of Environment (DOE) Malaysia data, 2018–2019.

To identify the pollutants contributing to the out-of-control signals detected by the MEWMA chart, univariate EWMA control charts were applied to each air quality parameter [14]. Consistent with Trimardiani et al. [34], the EWMA analysis effectively isolated the sources of process instability. As shown in Figs. 2–4, particulate matter (PM_{10} and $PM_{2.5}$) was the primary contributor to process deviations across the Putrajaya,

Shah Alam, and Cheras monitoring stations. While instability in Shah Alam and Cheras was also influenced by other pollutants, ozone (O_3) showed no significant deviation in Shah Alam, whereas both nitrogen dioxide (NO_2) and ozone (O_3) remained relatively stable in Cheras. The prominence of particulate matter is consistent with previous studies identifying PM_{10} and $PM_{2.5}$ as the major pollutants affecting air quality in the Klang Valley [35–36]. Their elevated concentrations are largely associated with motor vehicle emissions, industrial activities, open burning, and the proximity of monitoring stations to heavily urbanised and industrialized areas [37–38]. Meteorological factors, including temperature and wind conditions, may also influence particulate matter dispersion and accumulation [39].

Furthermore, the MEWMA results indicated that the largest process deviations occurred between June and September 2019, coinciding with Malaysia's severe transboundary haze episode, which originated from Sumatra and Kalimantan and contributed to elevated particulate matter concentrations [35]. Seasonal patterns have also been reported by previous studies [40, 41], highlighting the influence of monsoonal dynamics on air pollution episodes in the Klang Valley.

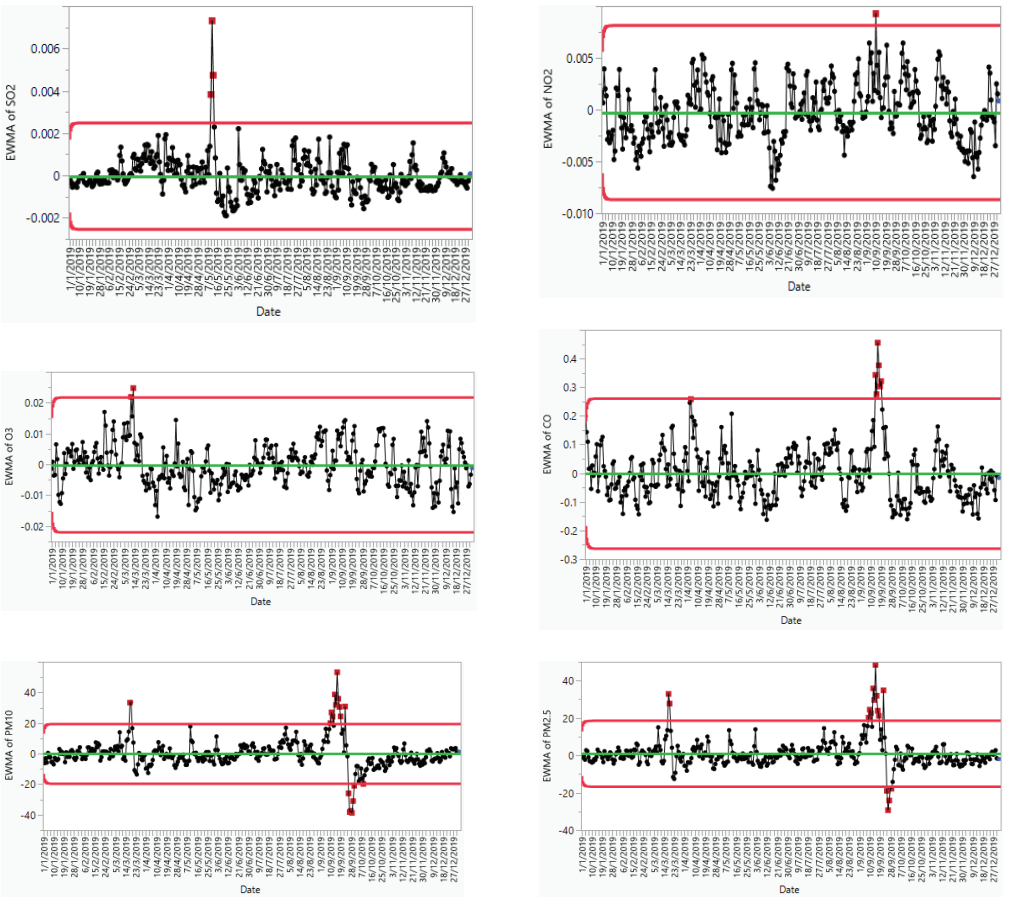


Figure 2 EWMA control charts for Putrajaya. Source: Authors' analysis of Department of Environment (DOE) Malaysia data, 2018–2019.

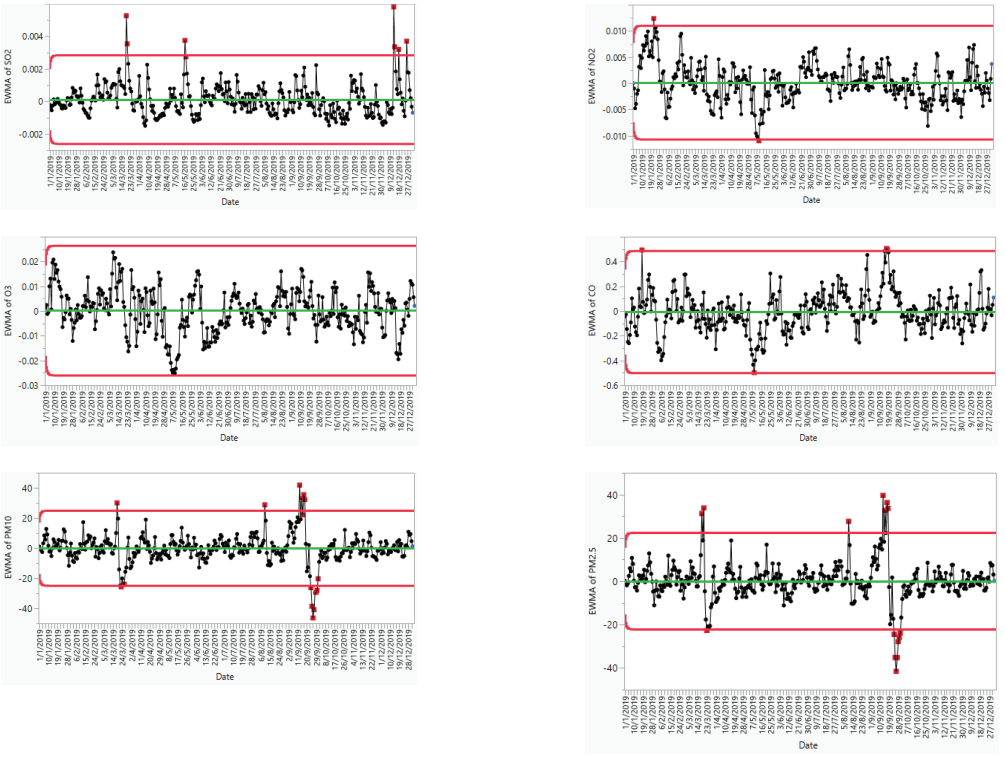


Figure 3 EWMA control charts for Shah Alam. Source: Authors' analysis of Department of Environment (DOE) Malaysia data, 2018–2019.

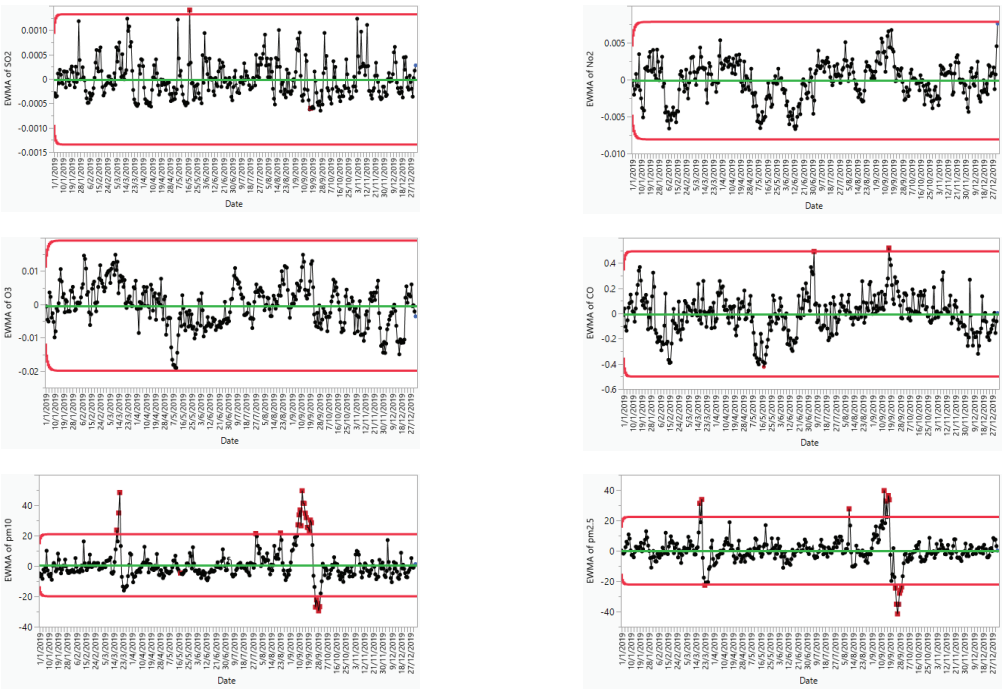


Figure 4 EWMA control charts for Cheras. Source: Authors' analysis of Department of Environment (DOE) Malaysia data, 2018–2019.

10.4 Conclusion

Air pollution remains a major environmental challenge, requiring effective monitoring tools to support timely intervention and management. This study demonstrated the application of the Multivariate Exponentially Weighted Moving Average (MEWMA) control chart for air quality monitoring, with particular emphasis on optimising the smoothing constant (λ). The simulation results indicated that $\lambda = 0.2$ provided the best balance between false alarm reduction and sensitivity to small process shifts, enabling early detection of gradual changes in air quality. This finding is consistent with previous studies that recommend relatively small smoothing constants for identifying subtle process variations.

The proposed approach was subsequently applied to air quality data from three monitoring stations in the Klang Valley, namely Putrajaya, Shah Alam, and Cheras. The results revealed that air quality processes at all stations were statistically out-of-control, with multiple abnormal signals detected during the study period. Further investigation using univariate EWMA control charts identified particulate matter (PM_{10} and $PM_{2.5}$) as the primary contributors to these deviations. The elevated concentrations of these pollutants are likely associated with traffic emissions, industrial activities, open burning, and meteorological conditions that influence pollutant accumulation and dispersion.

Overall, the findings highlight the importance of optimising the smoothing constant to enhance the effectiveness of MEWMA control charts for environmental monitoring. By selecting an appropriate λ value, the proposed framework improves the reliability of air quality assessment, supports early detection of pollution events, and provides valuable information for environmental decision-making. Nevertheless, the findings are limited to the monitoring stations and study period considered. Future studies using different locations and environmental datasets are recommended to further validate and extend the applicability of the proposed methodology.

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Chapter 11

Credit Growth, Macroprudential Policy and Banking Stability in Emerging Market Economies: Evidence from the Global Financial Crisis

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Abstract Maintaining banking sector stability is a primary objective of macroprudential policy, particularly in emerging market economies, where rapid credit expansion and financial vulnerabilities can intensify systemic risk. This study examines the role of macroprudential policies during the Global Financial Crisis in emerging market economies. Using data from 33 emerging economies over the period 2000–2022, the findings show that macroprudential policies play a significant role in enhancing financial stability and strengthening the resilience of the banking sector. The study contributes to the growing macroprudential policy literature by providing robust empirical evidence from emerging market economies.

Keywords: Macroprudential Policy; Banking Stability; Global Financial Crisis; Emerging Market Economies

11.1 Introduction

The banking sector plays a pivotal role in economic development by mobilising savings, allocating financial resources, and supporting investment through credit intermediation. While credit expansion promotes business activity and economic growth, excessive lending may weaken credit standards, increase non-performing loans, and amplify systemic vulnerabilities within the financial system [1]. Consequently, maintaining banking stability has become a major policy concern, particularly in emerging market economies (EMEs), where rapid credit growth and relatively less developed financial systems heighten exposure to financial instability. Empirical evidence shows that

excessive credit growth deteriorates asset quality, increases credit risk, and weakens banking sector resilience [2, 3].

The importance of effective financial regulation became particularly evident during the Global Financial Crisis (GFC) of 2007–2009, which exposed the systemic consequences of excessive leverage, unsustainable credit expansion, and weak regulatory oversight [4]. The crisis prompted policymakers to move beyond institution-specific supervision and adopt a macroprudential regulatory framework aimed at containing systemic risk, reducing procyclicality, and strengthening the resilience of the banking sector.

Since the Global Financial Crisis, macroprudential policies (MPPs) have become an integral component of financial regulation in both advanced and emerging market economies. Previous studies generally conclude that macroprudential measures are effective in restraining excessive credit growth, moderating asset price inflation, reducing bank leverage, and enhancing financial stability [5-8].

Despite these advances, empirical evidence on the effectiveness of macroprudential policies during financial crises remains limited, particularly in EMEs. Against this background, this study investigates the role of macroprudential policies in promoting banking sector stability across 33 emerging market economies over the period 2000–2022, with particular emphasis on the Global Financial Crisis (2007–2009). The findings provide new evidence on the effectiveness of macroprudential regulation in strengthening banking sector resilience during episodes of financial stress.

11.2 Literature Review

Agency Theory and the Financial Instability Hypothesis provide the theoretical foundation for explaining bank risk-taking during periods of rapid credit expansion. Agency Theory [9] argues that conflicts of interest between shareholders and managers may encourage banks to undertake excessive lending and risk-taking in pursuit of higher returns. Complementing this perspective, the Financial Instability Hypothesis [10] suggests that prolonged periods of economic stability foster excessive optimism among borrowers and lenders, resulting in higher leverage, relaxed lending standards, and speculative borrowing.

As credit expands beyond sustainable levels, the financial system becomes increasingly vulnerable, making even modest economic shocks capable of triggering widespread defaults and financial instability. The Global Financial Crisis (2007–2009) provides strong empirical support for this argument, illustrating how prolonged credit booms and asset price bubbles generated systemic financial distress [11]. In response to the Global Financial Crisis, Macroprudential Regulation Theory emerged as a key framework for safeguarding financial stability. Unlike microprudential regulation, which focuses on individual institutions, macroprudential policy aims to reduce systemic risk and strengthen the resilience of the financial system through borrower-based instruments such as loan-to-value (LTV) and debt-to-income (DTI) limits [12].

The Global Financial Crisis (GFC) fundamentally reshaped financial regulation by placing greater emphasis on macroprudential policy as a key instrument for safeguarding banking sector stability. Unlike conventional prudential regulation,

macroprudential policies are designed to mitigate systemic risk by limiting excessive leverage, smoothing credit cycles, and strengthening the resilience of the financial system against external shocks [12]. Since the Global Financial Crisis, these policies have become an integral component of financial regulatory frameworks in both advanced and emerging market economies.

Existing empirical studies generally support the effectiveness of macroprudential policies in promoting banking sector stability. For example, Chen et al. [13] show that macroprudential measures improve banking efficiency and stabilise credit cycles in emerging market economies. Similarly, Saif-Alyousfi [14] finds that countercyclical capital buffers are particularly effective during financial crises by reducing banks' exposure to credit risk. More recently, Vodrážka [15] demonstrates that borrower-based instruments, particularly loan-to-value (LTV) and debt-to-income (DTI) limits, effectively contain housing price booms and reduce systemic risk under normal monetary conditions. Despite these findings, important gaps remain. Existing evidence is inconclusive regarding the relative effectiveness of borrower-based and capital-based instruments, while limited attention has been given to the role of macroprudential policies in strengthening banking sector stability during financial crises, particularly in emerging market economies. Accordingly, this study examines the effectiveness of borrower-based macroprudential policies in enhancing banking sector stability during the Global Financial Crisis.

11.3 Methodology

11.3.1 Data Sources and Sample Selection

This study employs an unbalanced panel dataset of commercial banks from 33 emerging market economies covering the period 2000–2022. The sample period encompasses the Global Financial Crisis (GFC) of 2007–2009, enabling an assessment of banking sector stability during a period of heightened financial stress. The final sample was obtained through a rigorous screening process that excluded countries and banks with incomplete or missing observations. The use of an unbalanced panel is appropriate because it maximises data availability while minimising the loss of valuable information, a common feature of cross-country banking datasets.

To achieve the study's objective, data were compiled from several internationally recognised databases. Bank-level financial information was obtained from the Bloomberg Terminal, while macroeconomic indicators, such as gross domestic product (GDP) growth and inflation, were collected from the World Development Indicators (WDI) database published by the World Bank. Information on macroprudential policy instruments was sourced from the Global Macroprudential Policy Instruments (GMPI) database developed by the International Monetary Fund (IMF), which provides comprehensive cross-country data on the implementation of macroprudential measures [16]. The combination of these databases provides a consistent and reliable framework for examining the role of macroprudential policies in promoting banking sector stability in emerging market economies.

11.3.2 Variable Measurement and Construction

Banking sector stability is the dependent variable in this study and reflects the ability of banks to withstand financial shocks while maintaining their intermediation function and overall financial soundness. As the study aims to examine the role of macroprudential policy in promoting banking sector stability, two widely accepted indicators are employed: the Z-score and the non-performing loan (NPL) ratio. The use of alternative proxies enhances the robustness and reliability of the empirical findings by capturing different dimensions of banking sector stability. The Z-score is adopted as the primary measure because it combines profitability, capitalisation, and earnings volatility into a single indicator that measures a bank's distance from insolvency. It is one of the most widely used indicators in the banking and financial stability literature and has been extensively applied in studies examining bank stability and resilience [3, 17, 18]. A higher Z-score indicates greater banking sector stability and a lower probability of bank failure, whereas a lower Z-score reflects weaker financial conditions and greater vulnerability to financial distress. The Z-score is calculated as follows:

$$Z_{ijt} = \frac{ROA_{ijt} + \left(\frac{E_{ijt}}{TA_{ijt}}\right)}{\delta ROA_{ijt}} \tag{3.1}$$

where $\boldsymbol{Z}_{ijt}$ denotes the Z-score of banks i in country j during year t; $\boldsymbol{ROA}_{ijt}$ represents return on assets, which measures bank profitability; $\boldsymbol{E}_{ijt}/\boldsymbol{TA}_{ijt}$ is the equity-to-total-assets ratio, representing bank capitalisation; and $\boldsymbol{\sigma ROA}_{ijt}$ is the standard deviation of return on assets. Following the study of Soedarmono et al. [3], the standard deviation of ROA is estimated using a three-year rolling window (from t to $t–2$) to capture changes in bank risk over time and accommodate the unbalanced nature of the panel dataset.

As a robustness measure, this study also employs the non-performing loan (NPL) ratio as an alternative proxy for banking sector stability. The NPL ratio measures the proportion of impaired loans relative to total loans and serves as a direct indicator of asset quality and credit risk. A higher NPL ratio indicates deteriorating loan quality and weaker banking sector stability, while a lower ratio reflects stronger credit quality and greater financial resilience [19-21]. The combined use of the Z-score and the NPL ratio provides a comprehensive assessment of banking sector stability by capturing both insolvency risk and loan portfolio performance.

Credit growth is the main explanatory variable in this study and refers to the rate at which banks expand lending to households and businesses over a given period. It reflects the scale of banking sector credit intermediation and is widely recognised as an important indicator of financial development and economic activity [2]. However, excessive credit growth may weaken lending standards, encourage banks to extend credit to riskier borrowers, and increase leverage, ultimately deteriorating asset quality and elevating credit risk [1, 22]. Prolonged periods of rapid credit expansion may also amplify financial imbalances and increase the vulnerability of the banking sector to adverse economic shocks, particularly in emerging market economies [2, 3].

Macroprudential policy (MPP) is incorporated in this study as the moderating variable to examine whether borrower-based regulatory measures, such as loan-to-value (LTV) ratio and dbt-to-income (DTI) ratio strengthen banking sector stability by mitigating the adverse effects of excessive credit growth. Following the Global Financial Crisis (GFC), macroprudential policy has become a central component of financial regulation aimed at reducing systemic risk, containing procyclicality, and enhancing the resilience of the banking sector [12]. This study focuses on two borrower-based macroprudential instruments: the loan-to-value ratio and the debt-to-income ratio. These instruments directly limit borrowers' leverage by restricting the amount of credit that can be obtained relative to the value of pledged collateral or borrowers' disposable income, thereby discouraging excessive borrowing and improving lending standards [7]. Empirical evidence suggests that borrower-based macroprudential measures are effective in containing credit booms, reducing systemic vulnerabilities, and promoting banking sector stability, particularly during periods of financial stress [6, 15].

This study incorporates a comprehensive set of bank-specific, macroeconomic, institutional, and regulatory control variables to improve the robustness of the empirical analysis and reduce potential omitted variable bias. These variables have been widely adopted in the banking and financial stability literature [23, 24]. The bank-specific control variables include bank size (total assets), liquidity ratio (liquid assets relative to total assets), return on assets (ROA), and loan quality (loan loss reserves to total loans), which capture differences in banks' financial characteristics and risk profiles. To account for the influence of the macroeconomic environment, the study includes gross domestic product (GDP) growth and inflation, as both variables affect credit demand, borrowers' repayment capacity, and overall banking sector performance.

11.3.3 Empirical Model Specification

To examine the role of macroprudential policies during the Global Financial Crisis, this study incorporates an interaction term between credit growth (CG), macroprudential policies (LTV and DTI), and the Global Financial Crisis (GFC), into the empirical model. The interaction specification enables the analysis to determine whether macroprudential measures strengthen banking sector stability by mitigating the adverse effects of excessive credit growth during periods of financial stress. The empirical models are specified as follows:

$$BSS_{ijt} = \alpha_0 + \alpha_1 BSS_{ijt-1} + \alpha_2 CG_{ijt} + \alpha_3 GFC_t + \alpha_4 MPP_{jt-1} + \alpha_5(CG_{ijt} \times MPP_{jt-1} \times GFC_t) + \beta BLCV_{ijt} + \theta MLCV_{jt} + \lambda_i + \varepsilon_{ijt} \quad (3.2)$$

Where i, j, and t denote the bank, country, and year, respectively, while α, β, and θ represent the estimation parameters of the empirical model. The dependent variable, ***BSS,*** denotes banking sector stability, measured by the natural logarithm of the Z-score (lnZ-score) and the NPL ratio, whereas the explanatory variable ***CG*** represents the credit growth. The variable ***GFC*** is a dummy variable capturing the Global Financial Crisis, while ***MPP*** represents borrower-based macroprudential policies, namely the loan-to-value (LTV) and debt-to-income (DTI) ratios. The vectors ***BLCV*** and ***MCV***

represent the bank-level and macroeconomic control variables, respectively. The interaction term ***CG*×*MPP*×*GFC*** evaluates the moderating role of LTV and DTI in shaping the relationship between credit growth and banking sector stability during the Global Financial Crisis.

11.4 Empirical Results and Discussion

The primary objective of this study is to examine the role of macroprudential policies (MPPs) in promoting banking sector stability during the Global Financial Crisis (GFC). The analysis is based on the premise that borrower-based macroprudential instruments enhance financial stability by restraining excessive credit expansion and mitigating the adverse effects of financial stress on the banking sector. The Global Financial Crisis provides an appropriate setting for evaluating the effectiveness of these policies, as it exposed significant weaknesses in banking systems worldwide and underscored the importance of regulatory interventions in preserving financial stability. To investigate this relationship, the study focuses on two borrower-based macroprudential instruments, namely the loan-to-value ratio and the debt-to-income ratio. The empirical analysis employs the two-step System GMM estimator [25], which addresses endogeneity, unobserved heterogeneity, and the dynamic nature of banking sector stability [26].

Table 1 GMM estimation: moderating role of loan-to-value (LTV) during the Global Financial Crisis.

Model	**(1)**	**(2)**	**(3)**	**(4)**
Variable	**lnZ-score**	**lnZ-score**	**NPL ratio**	**NPL ratio**
Lag DV	0.3501***	0.3180***	0.0667***	0.0666***
	(0.0160)	(0.0165)	(0.0210)	(0.0110)
Credit growth	-0.0002***	-0.0002***	0.0056***	0.0033***
	(0.0001)	(0.0001)	(0.0017)	(0.0012)
Global Financial Crisis	-0.1102*	-0.1521***	1.7216***	1.9029***
	(0.0544)	(0.0426)	(0.4051)	(0.3639)
Loan-to-value	0.0622	0.0053	-1.3006*	-2.2958***
	(0.0565)	(0.0446)	(0.7625)	(0.6979)
CG × LTV × GFC		1.9075**		-35.0863***
		(0.8653)		(8.3845)
Liquidity ratio	0.0003***	0.0003***	0.0000	0.0001*
	(0.0000)	(0.0000)	(0.0001)	(0.0001)
Return on assets	0.1956***	0.3250***	-0.4158***	-0.3584***
	(0.0766)	(0.0340)	(0.1496)	(0.0895)
Bank size	0.0323	0.0403***	-0.8876***	-0.4356***
	(0.0122)	(0.0351)	(0.2455)	(0.1045)
Loan quality	-0.012***	-0.021***	0.4846***	0.4908***
	(0.0035)	(0.0040)	(0.0270)	(0.0234)

Continue... (Table 1)

Model	**(1)**	**(2)**	**(3)**	**(4)**
Variable	**lnZ-score**	**lnZ-score**	**NPL ratio**	**NPL ratio**
GDP growth	0.0287***	0.0203***	0.1143***	0.0927***
	(0.0022)	(0.0041)	(0.0339)	(0.0205)
Inflation rate	-0.0121***	0.0075	0.0443*	0.0810***
	(0.0033)	(0.0036)	(0.0258)	(0.0242)
Constant	3.5906***	2.8545***	24.3251***	23.9354***
	(0.7053)	(0.6370)	(6.0995)	(2.8443)
Observations	4326	4326	4988	4988
Hansen	64.4063	63.5550	78.5442	96.2239
p-value	0.2659	0.4738	0.1650	0.2259
AR(1)	-6.2481	-5.8458	-3.2479	-3.1612
p-value	0.0000	0.0000	0.0012	0.0013
AR(2)	-0.1050	-0.0226	1.1432	0.9834
p-value	0.9133	0.9930	0.2531	0.3220
No. of groups	420	420	440	440
No. of instruments	80	82	80	82

Note: Standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Source: Authors' calculations.

Tables 1 and 2 report the System GMM estimates for the moderating roles of the LTV and DTI ratios during the Global Financial Crisis, presented separately to identify the effect of each policy. Credit growth is statistically significant across all reported specifications: it is negatively associated with the lnZ-score and positively associated with the NPL ratio, indicating that rapid credit expansion weakens bank resilience and loan quality. The direct GFC coefficient is negative in the lnZ-score models and positive in the NPL models, although its statistical significance varies across specifications.

Table 2 GMM estimation: moderating role of debt-to-income (DTI) during the Global Financial Crisis.

Model	**(1)**	**(2)**	**(3)**	**(4)**
Variable	**lnZ-score**	**lnZ-score**	**NPL ratio**	**NPL ratio**
Lag DV	0.3459***	0.4757***	0.0558***	0.0671***
	(0.0165)	(0.0059)	(0.0108)	(0.0113)
Credit growth	-0.0003***	-0.0002**	0.0047***	0.0070***
	(0.0001)	(0.0001)	(0.0013)	(0.0013)
Global Financial Crisis	-0.0644*	0.0139	0.3753	0.6021*
	(0.0384)	(0.0213)	(0.2704)	(0.3159)
Debt-to-income	-0.0202	-0.2942***	-4.5736**	-3.5956***
	(0.1356)	(0.0942)	(2.0093)	(1.2075)
CG × DTI × GFC		1.6946***		-4.4562
		(0.5341)		(8.2421)
Liquidity ratio	0.0003***	0.0002***	-0.0001	-0.0001
	(0.0000)	(0.0000)	(0.0001)	(0.0001)
Return on assets	0.1963***	0.1263***	-0.4442***	-0.4323***
	(0.0434)	(0.0180)	(0.1633)	(0.1324)
Bank size	0.0546**	0.1225***	-0.6231**	-0.5221*
	(0.0269)	(0.0130)	(0.2632)	(0.2721)
Loan quality	-0.0164***	-0.0067***	0.4986***	0.3867***
	(0.0043)	(0.0015)	(0.0302)	(0.0362)
GDP growth	0.0243***	0.0383***	0.0662*	0.0944***
	(0.0026)	(0.0024)	(0.0346)	(0.0347)
Inflation rate	-0.0156***	0.0089***	0.0723***	0.0694
	(0.0059)	(0.0021)	(0.0237)	(0.0468)
Constant	3.5344***	0.4932	19.7654***	21.1768***
	(0.6977)	(0.4327)	(6.1599)	(6.5561)
Observations	4326	4326	4988	4988
Hansen	66.0629	145.8227	69.1062	84.1866
p-value	0.3388	0.2313	0.2496	0.2136
AR(1)	-5.9620	-6.3438	-3.3156	-3.1468
p-value	0.0000	0.0000	0.0008	0.0014
AR(2)	-0.3132	0.1663	1.4294	1.3940
p-value	0.7533	0.8673	0.1524	0.1631
No. of groups	420	420	440	440
No. of instruments	80	82	80	82

Note: Standard errors are in parentheses. * p < 0.10, ** p < 0.05, *** p < 0.01. Source: Authors' calculations.

The interaction terms provide more differentiated evidence on borrower-based macroprudential policy during the crisis. For LTV, the CG × LTV × GFC coefficient is positive and statistically significant in the lnZ-score specification and negative

and statistically significant in the NPL specification. For DTI, the CG × DTI × GFC coefficient is positive and statistically significant for the lnZ-score, while the corresponding NPL coefficient is negative but not statistically significant. The results therefore indicate that both instruments are associated with stronger bank resilience during the crisis, while the evidence for limiting NPL deterioration is stronger for LTV.

The diagnostic tests support the adequacy of the System GMM specifications. The Hansen J-test is statistically insignificant, indicating no rejection of the validity of the selected instruments. The Arellano–Bond [25] serial-correlation tests show significant first-order autocorrelation, AR(1), and insignificant second-order autocorrelation, AR(2), consistent with the standard diagnostic requirements for the estimator.

The findings reveal that excessive credit growth significantly undermines banking sector stability by reducing banks' resilience and increasing credit risk. The negative relationship between credit growth and the lnZ-score, together with the positive relationship between credit growth and the NPL ratio, confirms that aggressive lending weakens financial soundness during periods of financial stress. These results are consistent with Agency Theory [9], which argues that banks may pursue excessive lending to maximise shareholder returns despite the accompanying increase in financial risk, and with the Financial Instability Hypothesis [10], which suggests that prolonged credit expansion increases financial fragility. The empirical findings are also consistent with previous studies documenting that excessive credit growth deteriorates asset quality and increases banking sector risk [1, 2, 27-29]. Furthermore, the moderating effects of the loan-to-value and debt-to-income ratios support Macroprudential Regulation Theory [12] and are consistent with empirical evidence demonstrating that borrower-based macroprudential instruments are effective in containing excessive credit growth, reducing systemic risk, and strengthening banking sector stability [5-7, 13-15].

11.5 Conclusion

This study examines the relationship between credit growth and banking sector stability and evaluates the moderating role of borrower-based macroprudential policies in emerging market economies (EMEs) over the period 2000–2022. Using an unbalanced panel dataset from 33 EMEs, the study provides empirical evidence on how excessive credit expansion affects banking sector stability and whether macroprudential policies remain effective during the Global Financial Crisis (2007–2009). The analysis employs the two-step System GMM estimator to address endogeneity and capture the dynamic nature of banking sector stability.

The empirical results consistently demonstrate that excessive credit growth weakens banking sector stability. Across the reported specifications, rapid credit expansion is associated with a lower Z-score and a higher non-performing loan (NPL) ratio, indicating that aggressive lending practices reduce bank resilience, deteriorate loan quality, and increase credit risk. These findings suggest that while credit growth is essential for supporting economic activity and financial development, excessive lending without adequate regulatory oversight can generate financial vulnerabilities and undermine banking sector stability.

The study further finds that borrower-based macroprudential policies play an important moderating role during the Global Financial Crisis. Both LTV and DTI interactions are positive and statistically significant in the lnZ-score models, indicating stronger bank resilience. For the NPL ratio, the LTV interaction is negative and statistically significant, whereas the DTI interaction is negative but not statistically significant. These results suggest that the effectiveness of borrower-based instruments varies by policy tool and stability measure.

This study contributes to the macroprudential policy literature by providing cross-country evidence from emerging market economies on the moderating role of borrower-based measures. From a policy perspective, the findings support the integration of LTV and DTI instruments into financial regulatory frameworks, while also indicating that their effectiveness can vary across risk outcomes. Careful calibration can help contain excessive credit expansion, strengthen banking-sector resilience and safeguard long-term financial stability in emerging market economies.

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Chapter 12

Conclusion

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12.1 Synthesis of Chapters

The chapters compiled throughout this book demonstrates a fundamental realignment in the global economic growth paradigm. The long-standing framework is defined by unconstrained trade liberalization, reliance on fossil fuels, and capital accumulation concentrated primarily in traditional industrial dimensions is no longer sufficient to sustain long-term macroeconomic stability in the face of ongoing geopolitical shifts, environmental imperatives, and domestic social inequalities. Across diverse economic settings, from the advanced and emerging powers of the G20 to the dynamic structures of Southeast Asia, East Asia, and Sub-Saharan Africa, this book highlights how economic growth is increasingly driven by internal market strength, structural diversification, clean energy transitions, and targeted social policy.

The chapters in this book examine different actors, institutions and policy fields, but converge on a common problem. Governments can create organisations, recruit personnel, establish insurance programmes, regulate care systems and open participation channels without ensuring that these arrangements will function as intended. Governance is therefore not only a matter of formal design. It is the continuing work through which authority, resources, knowledge and relationships are organised to produce practical effects [1].

The analysis of G20 economies confirms that renewable energy consumption (REC) functions not merely as an environmental compliance mechanism, but as an active catalyst for economic expansion. By fostering technological innovation, creating green jobs, and insulating domestic production from volatile fossil fuel price shocks, clean energy adoption supports durable capital formation and structural industrial upgrading.

A central theme across several chapters is the altered role of international trade. In both the G20 econometric panel and the Chinese provincial study, trade openness failed to exhibit its historically expected positive impact on real GDP growth. Tariff conflicts, supply-chain disruptions, and strategic economic nationalism have introduced friction into global value chains. Consequently, internal demand measured through GNE, and domestic circulation has increasingly taken over as a vital stabilizer against external volatility.

Malaysia's trajectory provides concrete evidence that structural transformation within exports remains essential. Expanding the range of exported products specifically transitioning toward high-value-added manufacturing sectors like electrical and electronics and broadening destination markets creates a critical long-run buffer against sector-specific demand collapses and global market instability.

In addition, the evaluation of Kenya's Standard Gauge Railway demonstrates the dual nature of capital-intensive infrastructure investments. While the SGR generated immediate short-term growth through direct capital injection, employment, and improved transit logistics for the East African Community, it also highlighted severe structural constraints. Managing public debt burdens, ensuring local technology transfer, maintaining operational capacity, and avoiding spatial imbalances determine whether infrastructure acts as a sustainable growth engine or a fiscal strain.

Sustainable aggregate growth cannot be achieved without addressing labour market distortions, regional wealth divides, and cultural dimensions of poverty. China's domestic circulation and rural revitalization initiatives illustrate that rising unemployment directly undermines output potential. Furthermore, the qualitative investigation of Liangshan Yi Autonomous Prefecture shows that entrenched poverty is neither purely economic nor purely cultural. It is a structural-cultural trap where geographic isolation, limited social networks, and traditional practices interact. Overcoming these barriers requires educational access, economic opportunities, and culturally responsive governance.

12.2 Key Policy Implications and Recommendations

To translate these empirical findings into actionable strategies, policymakers, international institutions, and development practitioners should focus on three interconnected areas. For example, fostering green energy and building domestic expenditure buffers, advancing export diversification and sustainable infrastructure management, and enhancing labour markets, TVET, and culturally responsive social policy.

Capitalize on clean energy subsidies require governments to expand incentives, carbon pricing frameworks, and targeted subsidies to accelerate the integration of renewable energy into domestic industrial processes. Replacing imported fossil fuels with locally generated clean energy enhances national energy security and shields domestic industries from geopolitical supply disruptions. While domestic spending serves as a vital indicator, demand-side policies must be paired with supply-side improvements. Investments in public infrastructure, education, and health are needed to prevent inflationary pressures and maintain fiscal stability.

Developing and emerging economies should implement targeted industrial policies to move beyond primary commodity reliance. Strengthening trade diplomacy, entering new regional trade agreements, and diversifying product portfolios into high-tech, knowledge-intensive manufacturing will safeguard export revenues. In addition, for mega-projects like the SGR, governments and international investors must adopt transparent, hybrid financing structures to prevent debt distress [3]. Projects should incorporate explicit mechanisms for local workforce training, operational technology transfer, and cross-border customs integration to ensure long-term utility.

To address youth and structural unemployment, education systems must be modernised. Expanding TVET along with active labour market programs, ensures that the labour force can adapt to green energy shifts and modern manufacturing needs. Deploy On the other hand, in multi-ethnic and isolated regions, poverty alleviation programs must move beyond top-down material assistance [5]. Policy interventions should integrate local cultural contexts, support bilingual education, encourage community-led heritage initiatives, and improve digital connectivity to foster inclusive development without eroding cultural identity [5].

12.3 Concluding Remarks

The insights compiled in this book emphasize that the path toward sustainable economic growth is no longer linear or uniform. In a world marked by environmental pressures, shifting global trade patterns, and complex domestic socio-economic structures, national prosperity depends on adaptability and integration [1,3,5]. By aligning green technological investments with robust internal economic demand, diversifying trade capabilities, managing infrastructure strategically, and implementing inclusive, culturally responsive social policies, nations can build resilient economies capable of delivering long-term, equitable prosperity.

The global economy stands at a critical juncture. Contemporary development issues such as geopolitical fragmentation, poverty and persistent socio-economic inequalities have exposed the limitations of unidimensional growth models. Today, economic progress can no longer be measured solely by economic growth, it must be assessed by how equitably income and opportunity is distributed and how resiliently societies withstand unpredicted shocks. Although it seems appealing to discuss a problem that is nearly complex, there is a good justification to attend to it if only the issues are examined from a multidimensional perspective. Rethinking Development and Social Transformation: Growth, Poverty and Economic Resilience was conceived to address these complex imperatives by bringing together empirical investigations from Asia, Africa, and the Global Economy. One cannot be confidently claim that rethinking development and social transformation is replicable. Instead of generalising, we offer readers these interconnected themes to rethink the relationship between growth, poverty, and economic resilience.

First, Chapter 1 to Chapter 3 explores the primary catalysts of national and international expansion. The chapters examine how renewable energy adoption, domestic expenditure, trade diversification, and major physical infrastructure investments such as Kenya's Standard Gauge Railway serve as critical foundations for sustained economic

growth. Second, transitioning from national aggregate measurements to human-centered outcomes, Chapter 4 to Chapter 6 investigates structural disparities and social inclusion. The chapter highlights labour market dislocations amidst regional economic reforms, multidimensional poverty within ethnic minority groups, and persistent gender disparities in economic participation. The final section Chapter 7 and Chapter 8 focuses on durability in the face of global uncertainty. Through empirical analyses of supply chain operational strategies among Small and Medium Enterprises in Nigeria and global energy market reactions to OPEC+ policy decisions. These chapters offer insights into building micro- and macro-level resilience against external shocks.

This book owes its genesis from scholarly exchanges at the Universiti Malaya International Transdisciplinary Research Conference (INTRACT 2025). Serving as a global platform for multidisciplinary dialogue, INTRACT 2025 convened postgraduate students, academics and industry practitioners to share ideas, foster collaboration and shape the new future of connecting research in the new digital era. The realization of this book was made possible through the collaboration and technical support of the Faculty of Business and Economics, Universiti Malaya for their technical support and institutional leadership. We cannot thank the book's contributors enough. Despite long delays, they bore them without complaint.

It is our hope that Rethinking Development and Social Transformation serves as a valuable reference for scholars, graduate students, policy analysts, and practitioners. By linking policy with macro level realities across diverse regions, this volume aims to inform actionable policies that foster not only higher economic growth, but a more inclusive and resilient global society.

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