IMPACT OF RESEARCH AND DEVELOPMENT EXPENDITURES ON ASEAN-5 AND SOUTH ASIAN-3 COUNTRIES' ECONOMIC GROWTH

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OCTOBER 2024

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By

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This thesis submitted to the Faculty of Accountancy and Management,
Universiti Tunku Abdul Rahman,
In partial fulfillment of the requirements for the degree of
Doctor of Philosophy
Date: October 2024

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ABSTRACT

IMPACT OF RESEARCH AND DEVELOPMENT EXPENDITURES ON ASEAN-5 AND SOUTH ASIAN-3 COUNTRIES' ECONOMIC GROWTH

Muhammad Khalid Shahid

In response to the standings of R&D expenditures for economic growth, this thesis aims to examine the impact of R&D expenditures and macroeconomic indicators: foreign direct investment, trade balance, exchange rate, employment rate and inflation rate, on the GDP growth rate of Asian economies. Based on regional representation, growth and technological disparities, GDP volume, and availability of data, this study selected Indonesia, Malaysia, the Philippines, Singapore and Thailand (ASEAN-5) from ASEAN region while, Bangladesh, India and Pakistan (South Asian-3) were selected from South Asian region. Panel data analysis was conducted using annual data while vector error correction model (VECM) was applied on monthly data ranging from 1990 to 2019. The intent of this data range was to delimit the bumpy effects of COVID-19 on the robustness of the results. For data stationarity, this study applied Levin-Lin-Chu and Im, Pesaran and Shin on yearly panel data while the Augmented Dicky-Fuller (ADF) and Philip-Parron tests on time series monthly data. In the panel data selection process, this study applied a rigorous procedure and found the period fixed-effect model appropriate for ASEAN-5, the cross-section and fixed-effect for SA-3 and the cross-section fixed-effect model for a combined data model. Results of the panel data model show a positive and

substantial effect of R&D and macroeconomic indicators on the GDP growth rate for ASEAN-5, a significant effect on South Asia-3's GDP growth rate and a substantial positive effect on the GDP growth rate for the combined panel data model. This way, it rejects null hypotheses for regional and combined data. At the economy level, the outcomes of the VECM model present a different story rejecting null hypotheses for the Philippines, India and Pakistan in examining the influence of R&D expenditures. For Indonesia, Malaysia, Singapore, Thailand, and Bangladesh, VEMC results showed the significant impact of R&D expenditures on the GDP growth rate resulting in the rejection of null hypotheses for these countries. Further, the results of Granger's Causality confirmed the bidirectional and unidirectional causality among GDP growth rate, R&D expenditures and macroeconomic indicators. In the end, model accuracy for ex-post forecasting revealed that R&D results in enhancing the economic growth at the regional as well as at the country level which favours the endogenous impact of R&D for economic growth as presented by Romer's model of economic growth considering the recent heightened economic situation. Practically, ex-post forecasts of the study help policymakers of these countries to make R&D-intensive policies to boost economic activities which, in turn, will favour the macroeconomic environment for sustainable economic growth.

Keywords: Economic growth, R&D expenditure, macroeconomic indicators, panel data model, model evaluation, error correction model, ex-post forecast.

JEL Classification: E6, O3, O4

Subject Area: HG4900-5993 Investment, By region or country

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ADB	Asian Development Bank
ADF	Augmented Dickey-Fuller
ASEAN	Association of Southeast Asian Nations
ASEAN-5	Indonesia, Malaysia, Philippines, Singapore and Thailand
ASEAN-5 x	Indonesia, Malaysia, Philippines, Singapore, Thailand,
SA-3	Bangladesh, India and Pakistan
FEM	Fixed Effect Model
GDP	Gross Domestic Product
EMR	Employment rate
EXR	Exchange Rate
FDI	Foreign Direct Investment
NX	Exports minus Imports (Trade balance)
ILO	International Labour Organization
IMF	International Monetary Fund
INF	Inflation rate
IRF	Impulse Response Function
CPI	Consumer Price Index
MAE	Mean Absolute Error
MAPE	Mean Absolute Percentage Error
OECD	Organization for Economic Cooperation and Development
POLS	Pooled Ordinary Least Square
R&D	Research and Development
REM	Random Effect Model
SAARC	South Asian Association for Regional Cooperation

SDGs	Sustainable Development Goals
South Asian-3	Bangladesh, India and Pakistan
VECM	Vector Error Correction Model
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
VAR	Vector Auto-Regression
WDI	World Development Indicator by Work Bank
WTO	World Trade Organization

CHAPTER 1: INTRODUCTION

1.0 Introduction

This chapter provides an instantaneous summary of the study. The chapter starts with understanding the research background related to economic growth and discusses its influencing factors. In light of this discussion, the research problem has been discussed followed by the prospected gap in the field of economic growth related to the countries under study. Further, the research objective, research questions, and the significance of this study have been discussed in detail. At the end of this chapter, the organization of this study has been provided.

1.1 Research Background

Economists have asserted that economic growth is the foundation of sustainable development and is strongly associated with research and development (Gallo, 2002). In recent years, we have witnessed remarkable examples of countries achieving significant economic growth while effectively enhancing societal well-being (Borowy & Schmelzer, 2017). However, many nations continue to struggle with challenges in both economic growth and social welfare. Helpman (2009) posits that the difference between economic growth and the corresponding lack of extending this success to society remains a confusing phenomenon for developing countries. This situation is more

observant among Asian developing economies despite their immense potential for economic growth with abundant resources (Gatto & Sadik-Zada, 2021; Headey et al., 2010). Notably, the countries of the Association of Southeast Asian Nations (ASEAN) and South Asian Association for Regional Cooperation (SAARC) exhibit greater disparities in economic growth terms, development levels, and technological advancements (Amar & Pratama, 2020; Fang et al., 2022). This divergence highlights the necessity to understand the macroeconomic dynamics that reinforce their respective paths to economic growth. Particularly, the varying degrees of technological advancement within these regions reinforce the urgency of dedicating resources to research and development (R&D) expenditures because they are crucial for the continual evolution of technology and thereby enhancing production capabilities by ensuring competitiveness in the international market (Sahin, 2019).

In light of the current economic challenges developing nations face, they often need foreign aid, which can take the form of debts, assistance, and foreign direct investment. This support is crucial in boosting production levels, thereby, creating more employment opportunities and fostering a favourable trade balance through increased net exports. However, to successfully achieve these goals, economies must possess a clear understanding of macroeconomic indicators. This understanding ensures that the increase in development expenditures aimed at fostering economic growth does not inadvertently trigger issues like inflation and the widening of income gaps. It has been proved that factors; like, foreign direct investment (FDI), exchange rates (EXR), net exports (NX), employment rates (EMR) and inflation rates (INF) are crucial for

economic growth (EG) in the form of increased gross domestic product (GDP). Considering the importance of technology and innovation, it is essential to recognize the economic role of R&D expenditure in the broader macroeconomic context in cultivating a conducive economic growth environment which, in turn, strengthens the way for sustainable economic growth. Hence, this study endeavours to investigate the economic role of R&D expenditures, the synergy between R&D expenditures and macroeconomic variables, and their impact on GDP growth rate from regional and country perspectives. By doing so, it aims to delineate the reliefs of a favourable economic environment that will facilitate economic growth and regional cooperation among the countries of ASEAN and South Asian regions.

1.2 Economic Growth vs Economic Development

Before probing further, it is worthy to understand the connection between economic growth and economic development. Numerous studies stated that economic growth is an initial phenomenon in attaining economic development, chiefly representing the overall production and often, associated with average marginal productivity (Ahmed & Shimada, 2019; Law, 2016; Spyros, 2020). This change in production level results in increased income levels, resulting through increased levels of expenditures and consumption which ultimately contribute to improved living standards and quality of life which are parts of economic development. The United Nations (UN) (2015) confers emerging nations to urge for the Sustainable Development Goals (SDGs) in the form of “Decent Work and Economic Growth (SDG-8)” as an

important step in directing the World to achieve sustainable development through "Partnership in Achieving these Goals (SDG-17)". For sustainable development, economic growth lays the foundation for an economy to advance towards economic development which needs to be achieved first (Harris, 2007; Henry, 1987; IMF, 2022). A nation must initially attain economic growth through the efficient utilization of resources and a profound understanding of the macroeconomic environment (Marino & Pariso, 2020).

Table 1.1: Economic Growth and Economic Development

	Economic Growth	**Economic Development**
Meaning	Economic Growth is a positive quantitative increase in the actual production of goods in an economy.	Economic development is the combined effect of quantitative and qualitative changes in saving, spending, investment, and the rise in socioeconomic structure within an economy.
Functionality	It describes a rise in a nation's real gross national product (GNP) or real output per person over time.	Economic development refers to the procedures and regulations that a nation uses to enhance the social, and economic well-being of its citizens.
Focus	It emphasizes on production of goods and services.	The emphasis of economic development is on the distribution of resources.
Position	It serves in 1st position for economic development as its component.	It comes after economic growth as it is due to the advances in economic growth.
Period	It is relatively short-term and can be measured for a definite period.	It is generally an ongoing procedure because there is no time frame for its measurement.
Government Intervention	It is a process that passes automatically and may or may not need government involvement.	Given that the government creates all the development policies, government intervention is necessary.
Relevance	It is relevant to the rise in production level.	It is relevant to an upsurge in productivity.
Relevance to the economy	Economic growth deals with an increase in the economy's output level.	Economic development = Economic growth + standard of living
Role in Gini index	Poverty and economic inequality can persist during economic growth.	It is associated with the end of poverty and economic inequality.

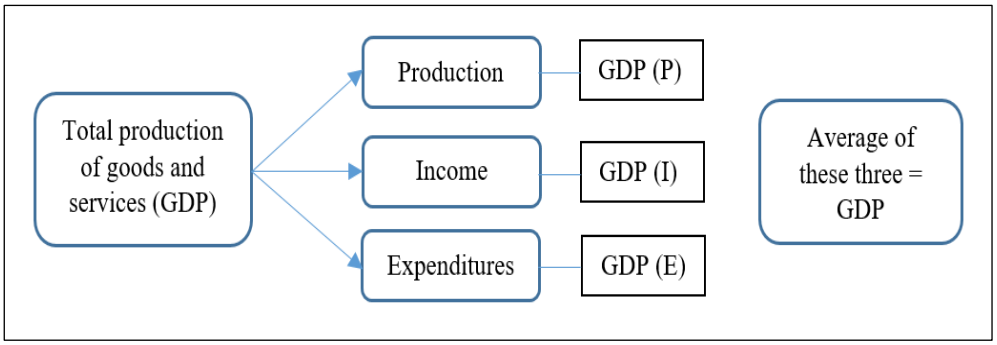
Source: Adapted from Har et al. (2008), Henry (1987) and IMF (2022)

To understand the economic growth concept in a better way, Table 1.1 elaborates on the distinction between economic growth and economic

development. The table outlines the significant distinctions and features that economic growth serves as the initial stage in achieving economic development, which comprehends increased income, enhanced purchasing power, higher living standards, and improved quality of life. Consequently, prioritizing economic growth becomes a pivotal step in pursuing economic development which needs to be discussed as to how we can measure economic growth before discussing the impact of other factors.

1.3 Relevance of GDP for Economic Growth

Among manifold criteria used to assess the overall health of an economy, the most prominent one is the Gross Domestic Product (GDP) (Petrakis, 2020, p. 31). It offers a quantifiable overview of the production of goods and services within an economy (Batrancea et al., 2022; Coscieme et al., 2020; Fioramonti et al., 2019). Typically, GDP can be measured from three distinct perspectives: 1) the Production approach, 2) the Expenditure approach, and 3) the Income approach, as illustrated in Figure 1.1 below. The average of these three perspectives presents the GDP of an economy, a practice endorsed by several global groups such as European Commission (EC), International Monetary Fund (IMF), Organization for Economic Cooperation and Development (OECD), World Bank, and the United Nations.



Source: Adapted from (Callen, 2022)

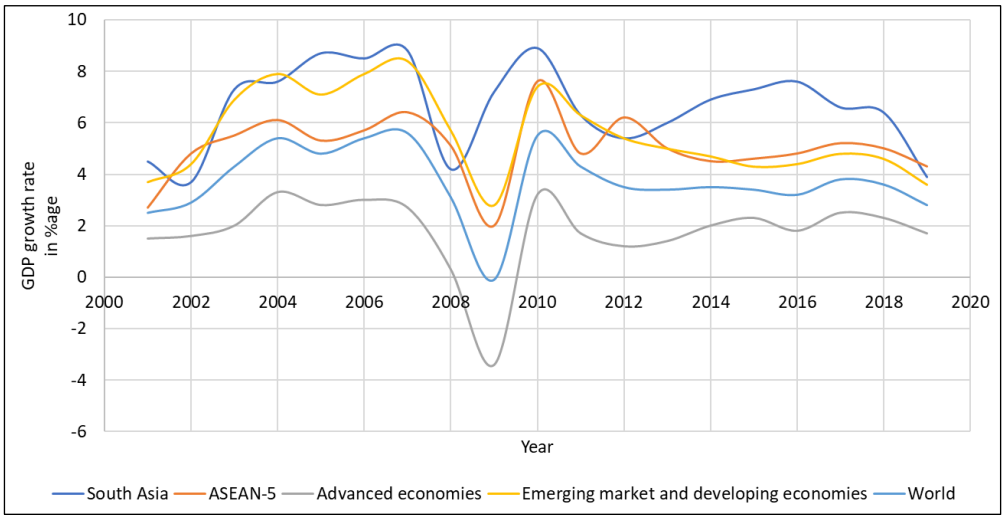
Figure 1.1: Approaches to measure GDP

As discussed in the figure, GDP may be calculated using production, income and expenditures which have also been considered the principal components of accelerated economic activities for economic growth (Ganti, 2023). The determination of GDP through production level increases the income level of countrymen which further surges the consumption patterns in the economy (Baloch et al., 2020; Callen, 2022; Zhang, 2021). This way, increased production and employment levels result in changes in the inflation rate and trade balance. Keeping the importance of GDP in view for economic growth in maintaining the macroeconomic environment, this study intends to use the GDP growth rate as a proxy of economic growth as suggested by Korinek et al. (2021).

1.4 R&D, Macroeconomics and the Economic Growth

Recent economic shifts including increased inflation, declining industrial output, and environmental changes have profoundly affected the global economy (Hu & Yao, 2019; Nawaz et al., 2021). Despite this,

technological advancements fueling the service sector that has been instrumental in supporting global GDP. However, emerging nations must prioritize R&D investments to sustain this growth and elevate GDP further to make a place in the international market (Khan et al., 2019; 2022). Analysis of growth lines indicates that developing Asian economies are yet to fully unleash their growth potential compared to developed countries (Hu & Yao, 2019; Nawaz et al., 2021).

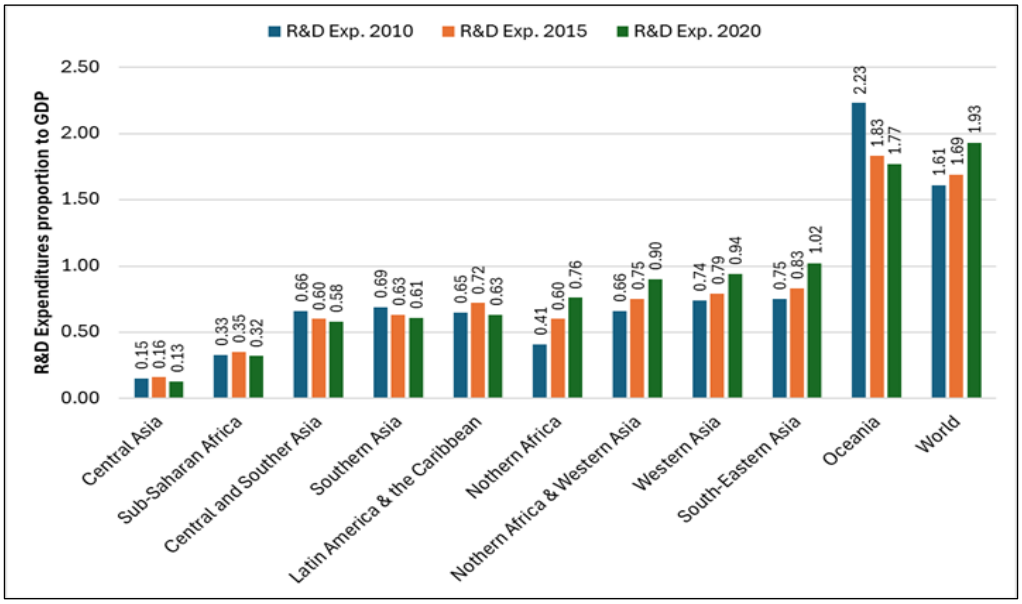


***Source**:* Authors presentation based on IMF (2023) data

Figure 1.2: Real GDP Growth by Group of Economies

Figure 1.2 illustrates growth comparisons among groups of economies. Advanced economies witnessed a 2.6% growth, while developing Asian countries, led by ASEAN nations, achieved a stronger 4.5% growth. However, this falls short of UNCTAD's benchmark of 7% growth for developing economies to support SDGs. Additionally, these nations are struggling with high inflation and unfavourable trade balances. In this context, it involves exploring new frontiers of knowledge and technology, driving progress, and catalyzing innovation across sectors to boost economic growth (Mulaydinov,

2019; Olaoye et al., 2020; Wei et al., 2023) which is possible through R&D activities. R&D includes proactive initiatives by institutions or governmental bodies to foster innovation in processes, products, or services (Guellec et al., 2004). Central to this is enhancing innovation, defined as leveraging cutting-edge technology to create innovative products or services and presenting them distinctively in the market (Chawla, 2020). R&D is anchored in four pillars: individuals, ideas, financial resources, and cultural development within an economy (Guerrero et al., 2021). Refining an R&D-centric culture necessitates policymakers and management to drive innovation, leading to enhanced competitiveness globally (Tulchynska et al., 2021). Previous studies have established a correlation between R&D investment, innovation, and economic growth (Haseeb et al., 2019; Zafar et al., 2019; Zhang et al., 2021) which highlights a need for greater emphasis on government investments among developing economies.



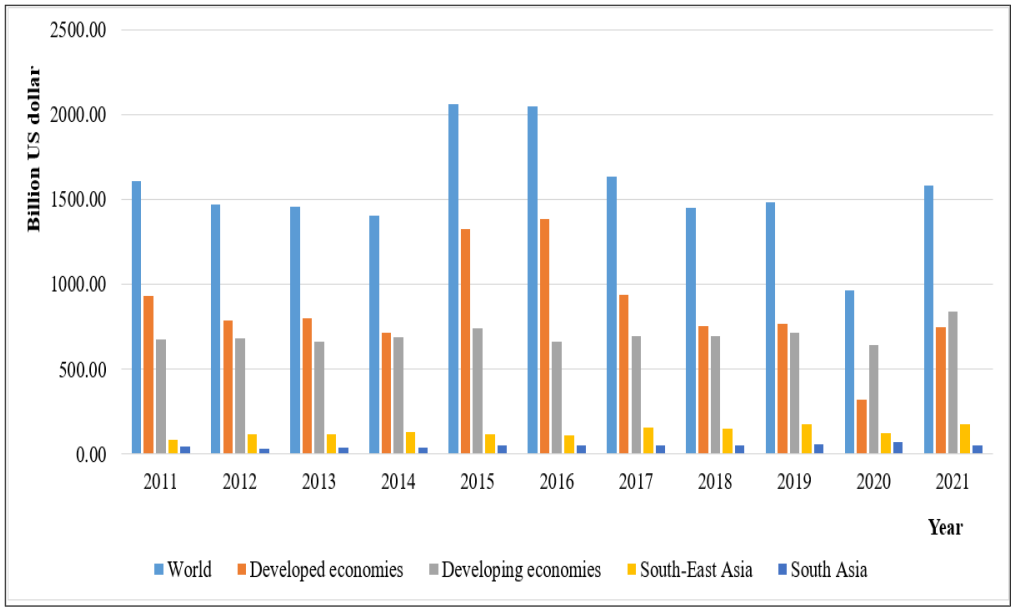
Source: UNESCO Institute of Statistics (2022)

Figure 1.3: Regional Trends of Research & Development

Figure 1.3 illustrates the global R&D investment trends showing the regional investment towards R&D. We can observe that North America and Eastern Asian regions are investing in R&D more than other regions and resultantly, countries from these regions like Japan, Korea and Taiwan among developed countries of the world. Specifically, North American countries allocated 2.65% and 3.30% of their GDP to R&D for 2010 and 2020, respectively. In contrast, South Asian countries allocated a lower proportion, with 0.69% and 0.61% for the same periods. Southeast Asian nations invested relatively more, allocating 0.75% and 1.02% of their GDP to R&D expenditures, surpassing the proportion seen in South Asia.

1.4.1 Macroeconomic and the Economic Growth

Along with the important part of R&D expenditures pursuant economic growth, developing parts of the world are facing financial difficulties which minimize their ability to invest in R&D (Asiedu & Esfahani, 2001). So, they need to look for alternative sources to fund R&D initiatives and FDI is one of these sources (Miyamoto, 2003). Government policies stimulating FDI can boost reserves, production, employment, and long-term consumption, fostering economic growth. In 2021, direct investment into advanced economies totaled $1,582,310 million, compared to $745,739 million in developing economies. ASEAN and South Asia received $175,314 million and $52,417 million respectively, underlining significant FDI gaps between developed and developing regions (Li et al., 2020; Hobbs et al., 2021; Zghidi et al., 2016).



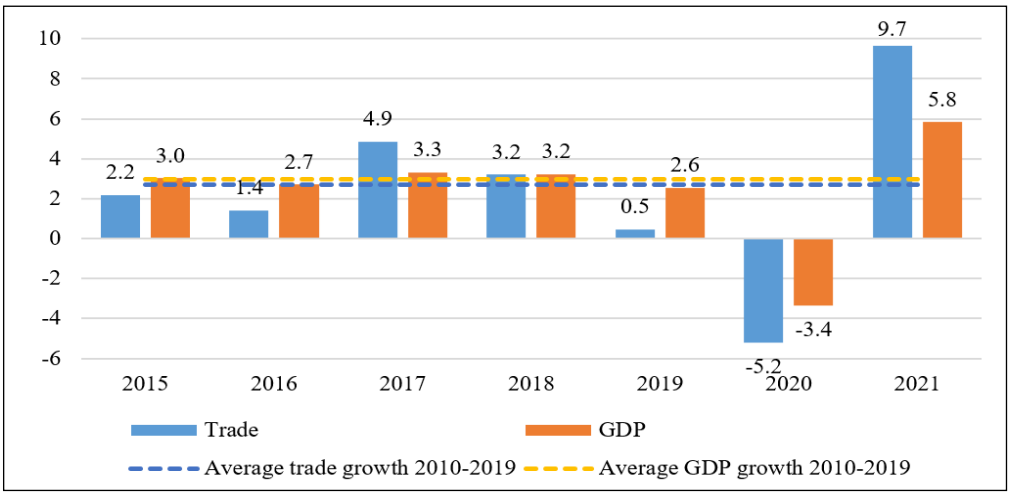
Source: UNCTAD Word Investment Report (2022)

Figure 1.4: World FDI Inflow by Group of Economies

Above figure, 1.4, illustrates FDI inflow trends across global regions, showing an upward trajectory from 2011 to 2016, followed by a decline post-2016, impacting global economic growth. The 2019-20 economic recession further heightened growth challenges. In 2015, FDI into South Asia constituted 1.8% of total GDP, decreasing to 1.2% by 2021 (World Bank, 2022). ASEAN ranks as 2nd largest FDI recipient after China, with total inflows rising from US$120.00 billion in 2015 to US$174.00 billion in 2021. Global FDI flow among developing economies increased by 58% in the third quarter of 2022, with ASEAN experiencing a 36% rise (UNCTAD, 2022). However, despite these increases, R&D investment remains lacking in ASEAN and South Asian regions. Therefore, it is crucial to explore avenues for FDI to enhance R&D and promote growth, as recommended by Tahir et al. (2021).

1.4.1.1. Economic Growth and Net Exports

Imports and exports significantly influence GDP growth (Ruranga et al., 2020) as existing research establishing a compelling connection between trade balance and economic growth (Nguyen, 2020; Zhu et al., 2022). According to UNCTAD's 2023 Technology and Innovation Report, exports from developing countries declined from 48% to 33% in 2022, attributed to a lack of innovative products. The positive impact of exports has significant implications for FDI and Exchange Rate (EXR), aiding in the growth and development of nations, particularly those in the developmental phase (Adedoyin et al., 2020; Kalaitzi & Chamberlain, 2020).



Source: World Trade Organization (WTO, 2022)

Figure 1.5: World Trade and GDP Growth Statistics

Figure 1.5 shows the association between global trade and GDP growth rate. It is obvious from the figure that GDP growth remained positive when trade has been positive showing the direct relationship between trade balance and GDP. Further, the figure shows that GDP growth rose at 1.4% in 2016, dropped

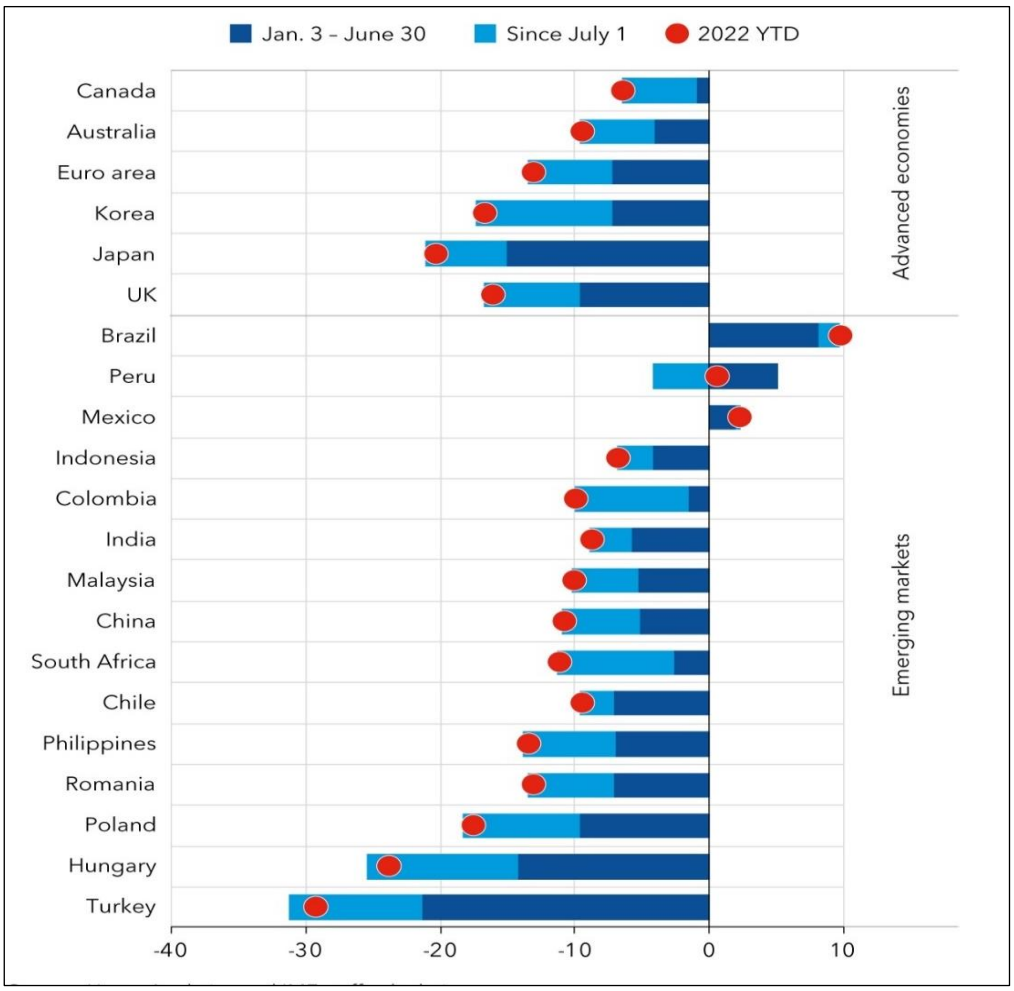
to 0.5% in 2019, and experienced a sharp 3.4% decline associated with a 5.2% decline in international trade during 2020. However, there was a robust economic rebound with a 9.7% increase in global trade in 2021. This way, we can understand that, according to the Keynesian multiplier, the export-level has a major effect on GPD growth rate.

1.4.1.2 Economic Growth and Exchange Rate

Persistent decline in currencies of developing nations correlates with unfavourable trade balance and economic downturns (Ahiadorme, 2022). The exchange rate (EXR) represents the value at which it can be exchanged with other currencies (Frieden et al., 2016; IMF, 2022). The US dollar holds a prominent position in global trade, and its appreciation often translates to a depreciation of other currencies, impacting developing economies adversely (Elson, 2021; Siddiqui & Roy, 2020).

Figure 1.6 illustrates the rise of the US currency (US dollar) compared to other currencies of the world. Except for Brazil and Mexico, currencies worldwide suffer from the US dollar's impact. Developing Asian economies like Indonesia, Malaysia, India, and the Philippines also experience adverse effects on their GDP which disrupts international trade for developing nations. The exchange rate index steadily climbed to 128.31 from 2011 to 2019, favouring the US dollar (Buchholz, 2019). This situation demands developing nations to look deeper into exchange rate dynamics to navigate international markets effectively, because failure to do so may result in further price hikes, impeding

economic well-being and growth efforts (Meyer & Hassan, 2020; Yang et al., 2022).



Source: IMF, 2022[1]

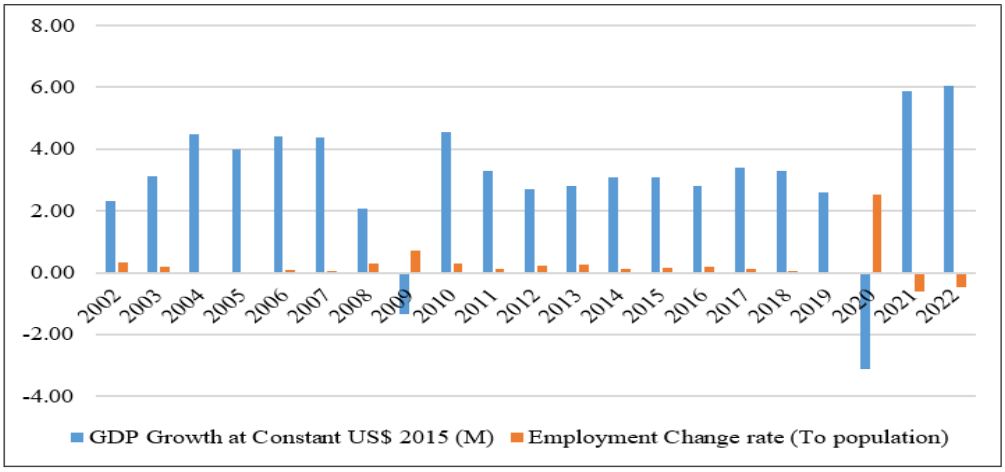
Figure 1.6: US dollar Surge against Other Currencies (2022)

1.4.1.3 Economic Growth and Employment Rate

The depreciation in the exchange rate can lead to adverse economic conditions and a decrease in the employment rate (Razmi et al., 2012). The employment rate (EMR), as defined by OECD (2023) is the proportion of

[1] Percent change in exchange rate vis-à-vis US dollar

employed individuals compared to the total labour force of an economy, reflecting the active labour force employed. Researchers like Okun (1962) and Su et al. (2022) stress the importance of EMR due to its significant relationship with GDP growth.



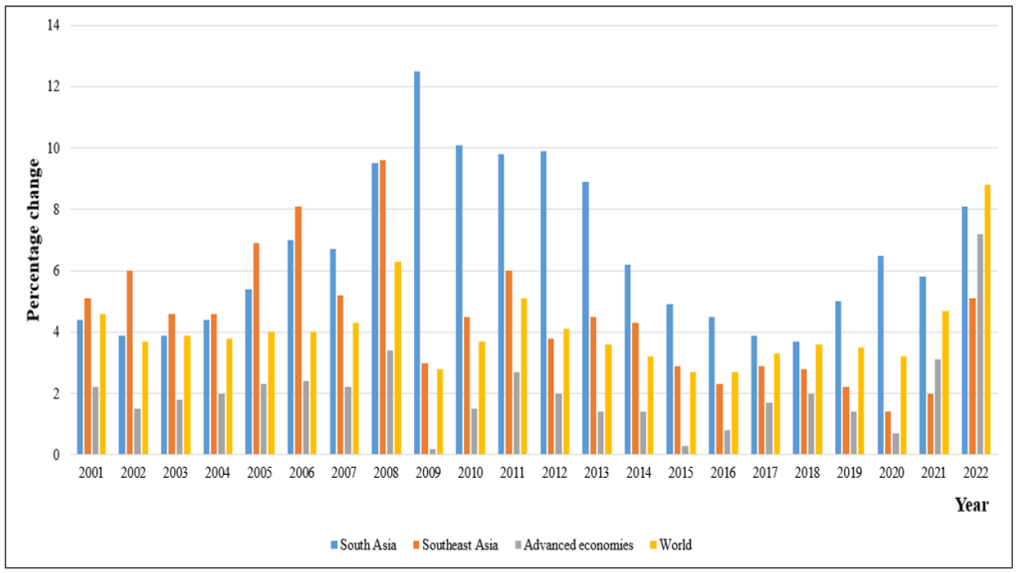
Source: Author's own development using World Bank data

Figure 1.7: GDP Growth Rate and Employment Rate

Figure 1.7 illustrates that EMR and GDP growth rates globally show fluctuations in GDP growth. However, a notable downturn occurred in 2020, persisting into 2021 and 2022, showing concerns for policymakers for future policies. Previous research suggests that governmental bodies need to increase employment levels to enhance economic growth and ultimately achieve SDGs (Altunoz, 2019; Hashmi et al., 2021). Global debates, particularly among developing economies, underscore the controversial situation regarding employment levels and economic growth. Given the significant relationship of macroeconomic factors in promoting economic growth, this study considers the EMR to examine its relationship and impact on GDP growth rates, emphasizing the necessity for corrective measures to foster a favourable macroeconomic environment.

1.4.1.4 Economic Growth and Inflation Rate

Inflation (INF) has been considered as the paramount macroeconomic factor having a significant impact on economic growth (Eggoh & Khan, 2014). It denotes a widespread surge in goods and services prices (IMF, 2022). A study conducted by Barguellil et al. (2018), and Nitami and Hayati (2021) highlights its adverse association with economic growth (Adaramola & Dada, 2020; Morina et al., 2021). The Prices-UNCTAD Statistics Handbook (2018) emphasized the complex interconnection between inflation, exchange rate, and economic growth, necessitating comprehensive exploration for economic advancement.



Source: Author's own development using data of IMF (2022)

Figure 1.8: Global Inflation Rate Comparison (2001-2022)

Figure 1.8 illustrates a comparative analysis of inflation across regions of the world. It shows a general increase that started in 2008 and lasted for five years till 2012. After this period, it started to decline and reached its minimum

in 2018 but after that, it again started to increase. This analysis indicates that inflation within developing economies consistently outpaces that of advanced economies. Since 2018, developing economies have exhibited an escalating inflationary trend, albeit with a marginal downturn in 2021.

1.5 Economic Growth among ASEAN-5 and South Asian-3

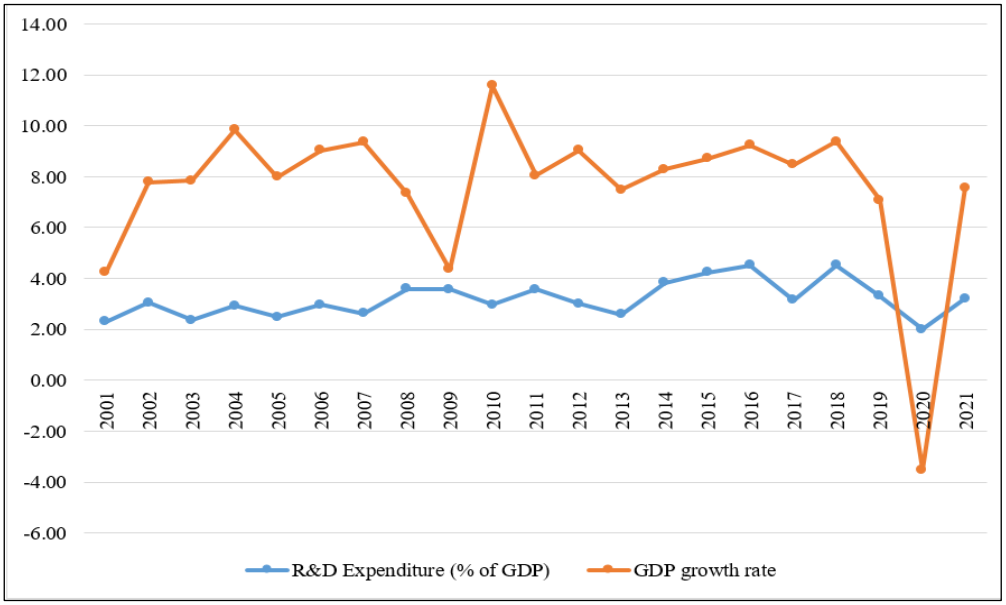
In 1967, Association of Southeast Asian Nations (ASEAN) was established aimed at fostering economic, educational, cultural, and technical cooperation among member countries. Over time, the region has grown considerably in technical and economic terms compared to other developing parts of the world. Among other objectives, ASEAN's common objective was to cooperate in science, technology, and innovation, there exists a significant growth and technology gap among member countries (Rodriguez & Soeparwata, 2012), and disparities in R&D investment contribute to unequal economic growth among ASEAN countries (Dobrzanski & Bobowski, 2020). Hence, to align with SDG-17, these nations need to make relationship ties stronger for equitable technological and economic growth patterns through global partnerships (SDG-17). To understand this postulation, let's talk about the relationship of the factors under study considering economic growth of the ASEAN region.

1.5.1 Economic Growth and ASEAN-5 Countries

The 2022 ASEAN-SDG Snapshot Report underscores a significant 4.3% decline in GDP per capita growth, coupled with a reduction in government revenue derived from production activities, dropping from 16.4% in 2016 to 15.6% in 2020. From the government's perspective, this situation highlights the importance of realigning resources toward activities fostering growth. However, despite abundant resources and growth potential, developing nations encounter difficulties on their way to modernization and innovation, resulting in lower economic progress, unemployment and development disparities (Omar & Inaba, 2020; Zhu et al., 2022). A report titled "Key ASEAN Figures," published by the ASEAN Secretariat in Jakarta (2021), disclosed that Indonesia has a Gini index of 0.38, Malaysia 0.41, the Philippines 0.43, Singapore 0.45, and Thailand 0.43, indicating relatively favourable statistics. However, there is a pressing need to prioritize innovation and economic growth to enhance competitiveness with leading global performers and narrow the growth disparities within the region. Realizing economic development requires rigorous efforts to boost productivity, employment rates, and exports through cautious resource management, an appreciation of macroeconomic dynamics, and augmented investments in R&D to effectively navigate exchange rates and inflation for sustainable growth.

Figure 1.9 (below) presents a comparison of GDP growth rates and R&D expenditures among ASEAN countries from 2001 to 2022. The GDP growth rates show inconsistency between 2001 and 2021, while R&D expenditures

remain relatively stable at a lower level, ranging from 2% to 4% of GDP during this period. One significant factor driving this deviation is the outflow of reserves resulting from imbalanced trade flows from developing to developed countries. This dynamic significantly affects spending and investment patterns within developing economies (Hartman et al., 2018; Song et al., 2021).



Source: Author's own development based on World Bank's data

Figure 1.9: GDP growth and R&D expenditure (ASEAN)

Among the ASEAN-5 economies, characterized by substantial GDPs and relatively high proportions of R&D spending, certain countries emerge as top performers within the group. Notably, Malaysia and Singapore prioritize industrial modernization and innovative economic strategies, driven by factors like urbanization, population growth, and energy demands (Haseeb et al., 2019; Maneejuk & Yamaka, 2021). However, it's important to recognize that countries such as Indonesia and Malaysia heavily rely on agricultural-based industry and mineral exports to other developing nations (UNCAD, 2022) which highlights the need for innovation to strengthen the trade relationships with developed

nations. To secure a position in the global market, these nations must transition towards producing modern, innovative products that can compete effectively in the international market. The countries under study have been investing in R&D through numerous research and development projects. For instance, Indonesia prioritizes R&D in agriculture, technology, and renewable energy, as evidenced by initiatives led by the Ministry of Research and Technology (RISTEK) and the National Research and Innovation Agency (BRIN), including the Bandung Techno Park project (ADB, 2020). Mariyono (2020) highlights Indonesia's efforts to improve agricultural research for enhanced crop productivity and sustainability. However, challenges such as funding constraints persist in the country. In Malaysia, R&D is integral to its aspiration for high-income status, with plans to increase Gross Expenditures to Research & Development (GERD) to 2.5% of GDP by 2025 and 3.5% by 2030 (MIDA, 2023). Biotechnology, information technology, and aerospace are focal areas, supported by initiatives like Iskandar Malaysia. The Philippines emphasizes R&D in agriculture, healthcare, and technology, exemplified by projects like the Philippine Genome Center and the Technology Business Incubator program (DOST, 2018). Singapore's robust R&D ecosystem, prioritizing sectors like biomedical sciences and smart cities, reflects strategic investments outlined in the Research, Innovation, and Enterprise (RIE) 2020 plan. Thailand, likewise, strengthens R&D efforts, notably through projects like the Eastern Economic Corridor (EEC) to attract foreign investment and stimulate R&D activities in various sectors (NSTDA, 2022).

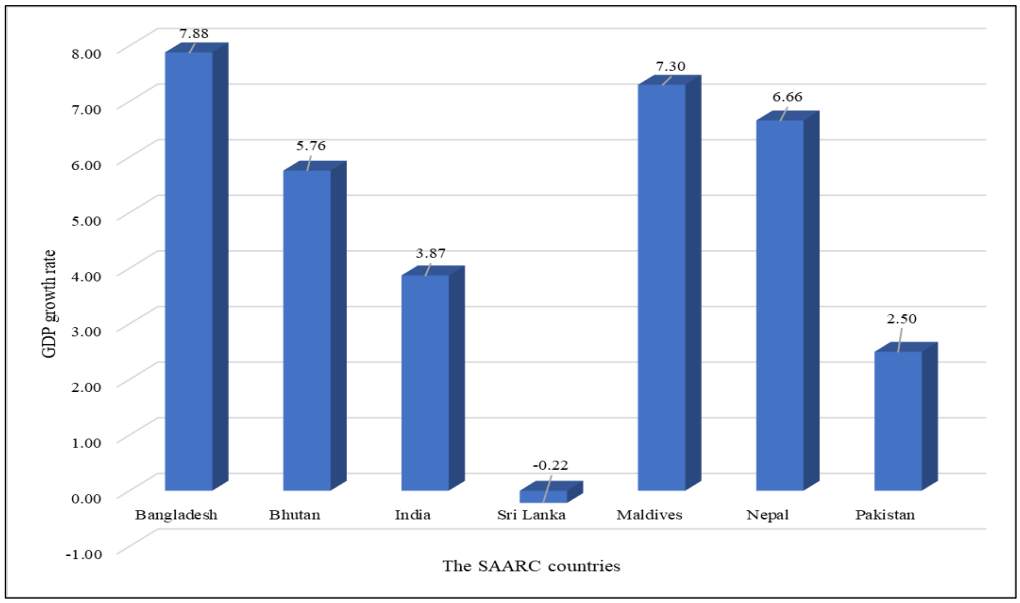
1.5.2 Economic Growth and South Asian-3 Countries

In 1985, the nations of South Asia established SAARC[2] as an inter-governmental organization. Its primary objectives were to foster welfare, enhance the quality of life, stimulate economic growth, and facilitate social development within the region. Due to geopolitical issues, this plate form could not achieve its objective and this region remains underdeveloped despite having abundant resources and witnessed a huge disparity in economic growth among the member countries. The developing parts of the world first need to achieve economic growth because it leads to economic development, creates new job opportunities, develops good infrastructure and fosters better living standards (Fukuda, 2020; Giri et al., 2021; Pandey et al., 2021). The situation in South Asian countries is more critical as compared to ASEAN countries because these countries are technologically less developed. Over-reliance on natural resources promotes inactive development rather than long-term economic growth. The only way is through technological innovation and advancement which industrialized countries have already reached this point (Abid et al., 2022; Caesar et al., 2018).

Figure 1.10 (below) demonstrates the GDP growth rates for South Asian countries. Among Bangladesh, India, and Pakistan, a GDP growth rate of 7.88%, 3.87%, and 2.50% was recorded respectively. Further, Bhutan, Maldives, and Nepal have also witnessed a commendable GDP growth rate of 5.76%, 7.30% and 6.66% while the GDP growth rate of Sri Lanka was negative

[2] the South Asian Association for Regional Cooperation (SAARC)

with a value of -0.22%. Later this period, world economies faced the Covid-19 pandemic, which had a significant impact on the global economic landscape. South Asian countries, particularly Bangladesh and Pakistan, experienced notable increases in textile industry exports during that period but after the pandemic over, this increasing trend in exports came to an end (Ahsan et al., 2022; Aijaz et al., 2022; Kim et al., 2020). This situation depicts that the GDP of these countries do not have a relative advantage of innovative products.

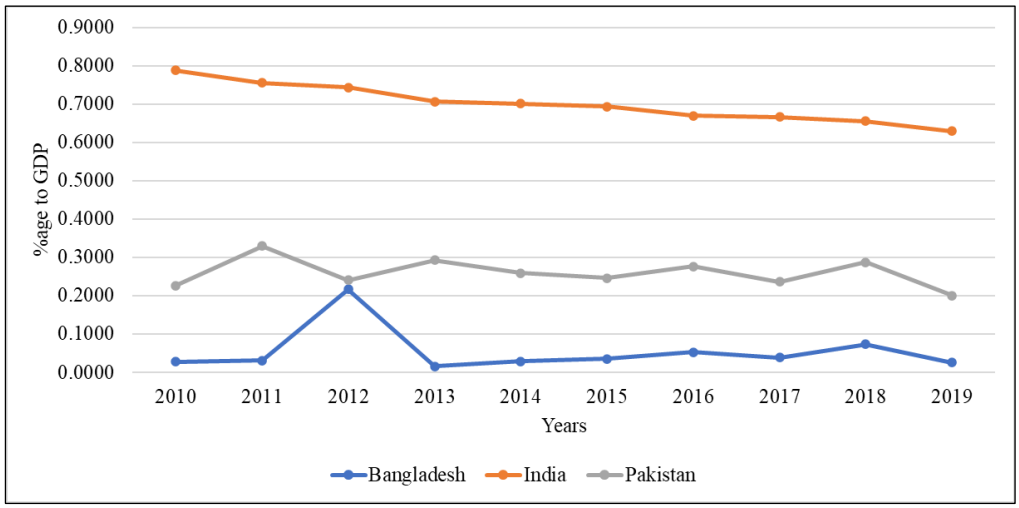


Source: Author's own development using World Bank data

Figure 1.10: SAARC Countries GDP Growth Rate

When we look at other statistics like the Gini index, the World Population Review Report (2023) published by the World Bank revealed that 32.4%, 35.7% and 31.6% people of in Bangladesh, India and Pakistan respectively have income inequality which depicts imbalanced EG and distribution of wealth which not only creating development gap among the region but also hampering UN agenda for SDGs. In order to boost the EG process, these economies need to understand the importance of R&D and

macroeconomic factors like emerging economies of the world in order to stay competitive in the international market. According to the Ministry of Electronics and Information Technology-MEIT (2023), the volume of R&D expenditures spent by India is greater than any South Asian country because of its huge GDP volume. This way, the R&D spending in money is greater in the case of Indian R&D investment.



Source: Author's own development using World Bank data

Figure 1.11: R&D Expenditure Trends among South Asian-3

Figure 1.11 shows a comparison of R&D expenditures among Bangladesh, India, and Pakistan. Bangladesh spent R&D expenditures from 0.02% to 0.20% of their GDP during from 1990 to 2022 while India spent 0.87% to the highest 1.6% during 2007. Pakistan was spending 0.62% to 0.64% of its GDP on account of R&D expenditures from 1990 to 2022 with a slight increase during 2007 and 2012. The Ministry of Foreign Affairs (2023) reports that Pakistan is allocating funds to various sectors, including education, copper and its products, agriculture (specifically wheat), minerals, and artificial intelligence in order to increase exports. However, the allocated amount for these projects is

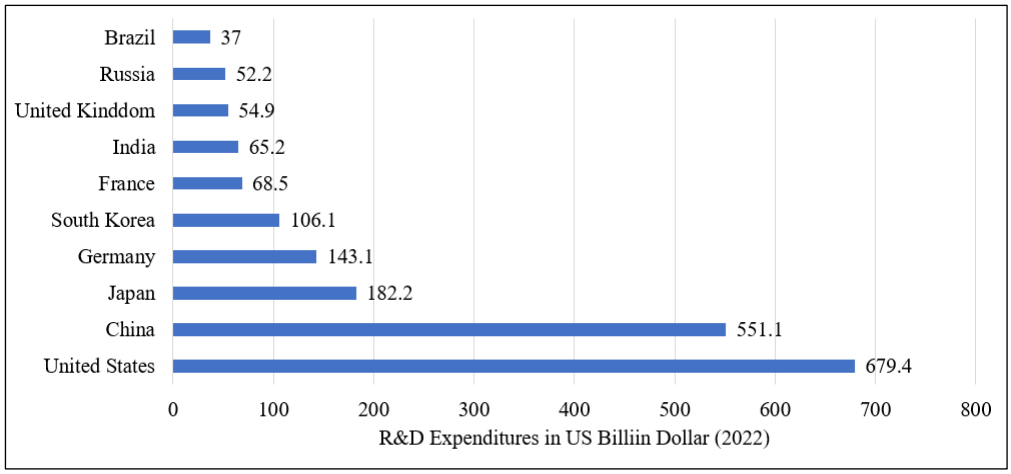
relatively low in comparison to the critical issues faced by the country, such as climate change, agricultural yield, mineral management, food processing, and the development of value-added products (PASTIC, 2022). Increased investment in manufacturing operations, for example, influences trade, leading to higher foreign reserves and elevated levels of FDI and overall investment. This, in turn, enhances GDP through increased output in the era of free trade, fostering economic development (Ahmed & Rafiuddin, 2021).

Among South Asian countries, Bangladesh is striving to develop its R&D capabilities, focusing on agriculture, textiles, and information technology (Bhuiyan et al., 2020). Government support, particularly through the Ministry of Science and Technology (MST), is evident in initiatives like the Bangladesh Research and Education Network (BdREN) and the Secondary and Higher Education Division project (MOE, 2020), aimed at enhancing connectivity and fostering R&D in education. India boasts a diverse R&D landscape, with significant contributions across sectors such as space exploration, pharmaceuticals, and information technology. Entities like the Department of Science and Technology (DST), the Indian Council of Agricultural Research (ICAR), the National Innovation Foundation (NIF), and the Indian Institutes of Technology (IITs) drive innovation and research (ADB, 2020). Pakistan is also focusing on enhancing its R&D capabilities for socio-economic development. The Higher Education Commission (HEC) and Pakistan Council for Science and Technology (PCST) lead R&D efforts, supported by projects like the National Centre for Physics and the Karachi Biennale, promoting scientific research and cultural exchange.

1.6 Motivation of the Study

Continuing from the discussion about the role of R&D and the macroeconomic environment, it has been noticed that these indicators boost the economic activities which attract foreign investors, fostering export levels (Yang & Mallick, 2014). To sustain this cycle, three crucial dimensions; innovation, inclusion, and growth must be considered (Carranza et al., 2020; George et al., 2012). These dimensions historically correlate with improved infrastructure and industrialization (Alaimo et al., 2021; Holmberg & Sandbrook, 2019; Khan et al., 2020), emphasizing the sustainable development of specific geographical areas (Adelowokan, 2019; Afolabi, 2020; Chen, 2021). Therefore, the process of industrialization and internationalization necessitates robust infrastructure and innovation supported by long-term R&D investment for sustained business growth (Alaimo & Maggino, 2020; Ozili, 2022). In ASEAN and South Asian regions, low levels of R&D, economic disparities and technological disparities have been evidenced (Amin et al., 2020; Khan, 2019; Ratnawati, 2020). Notably, the GDP of these economies is mainly composed of agricultural commodities (e.g., wheat, cotton, minerals in South Asia; palm oil, rubber, copper in ASEAN), primary industry and service sector (World Bank, 2022). Alongside this, trends of offshoring and outsourcing, stimulated by cost and skill factors, among Asian developing economies have increased for the last 5 years (Saidi et al., 2020). This situation underscores the need for prioritizing industrial growth, focusing on innovative products through skill skill-building approach to stay competitive. For this reason, continuous investment in R&D is required in R&D because it has been considered the major estimator of

economic growth and development as shown in Figure 1.12.The figure depicts that the countries that generously invest in R&D are at the top of development and growth ranking which shows that, without investing in R&D, growth cannot be achieved in the modern technological era. Top economies like the United States, China and Japan are investing 679.4, 551.1 and 182.2 billion US$ respectively which states that investment in R&D is strongly tied with growth and developing countries need to invest in R&D for speedy and sustainable economic growth (Kralisch et al., 2018; Spyros, 2020).



Source: adapted from (Shahid et al., 2024)

Figure 1.12: Top-10 R&D Investing Countries

Recognizing the macroeconomic environment and R&D's significance for economic growth, this study investigates the impact of R&D expenditures and other key macroeconomic variables on economic growth. This way, this study's motive is to help developing Asian economies re-adjust their spending pattern towards R&D with extended comprehension of the macroeconomic environment. This way, it also can abridge the economic and technological disparities among the countries under study. To hold this motive, the following

section elaborates on the problem statement to find a robust solution to the subject matter under investigation.

1.7 Problem Statement

It has been highlighted in the literature that R&D stands as crucial for growth and development. For instance, Aghion and Howitt (1992), Ali et al. (2021), Nair et al. (2020), and Romer (1990) suggested that R&D is essentially important for cost-effective and high-quality production mechanism, which contributes to increasing the employment rate, enhancing the trade balance, encouraging foreign direct investment, and stability of the exchange rate for sustainable economic growth. Although the connection between R&D and economic growth has been well-documented, there are still unexplored elements about the current heightened macroeconomic environment (Leon-Gonzalez, 2021; Mukhtarov, 2020) that were unrealized within the developing economies of Asia and that required further exploration in the given context.

Firstly, the UN established the SDGs in 2015, which requires developing economies to maintain a 7% growth rate until 2030 (UNCTAD, 2022). However, the countries under examination exhibit a deficiency in economic growth as their GDP growth rates fall below this target. Looking further, there exists a disparity in technological advancement and innovation among these nations; while Singapore is classified as developed, others are deemed emerging despite possessing sufficient resources. This careful investigation of existing studies revealed that there are rising trends of offshoring and outsourcing,

attributed to natural resource mismanagement and a lack of emphasis on R&D activities (Bottini et al., 2007; N'Dri & Su, 2023; Pradhan et al., 2024). As a result, their macroeconomic environment has become unfavourable in the form of negative trade balance, unemployment, and inflation. Particularly, investment in R&D has the potential to raise GDP growth in the form of productivity and production. Considering comparative R&D expenditures, a study integrating R&D expenditure and macroeconomic indicators can help to boost economic growth among the countries under study. Therefore, it is imperative to comprehensively examine the impact of R&D expenditures, FDI, NX, EXR, EMR and INF on the GDP growth rate among countries under study.

Secondly, the majority of the countries under study rely on primary products and traditional industries as major contributors to GDP (Huynh, 2024; Iqbal et al., 2022; Morina et al., 2021). According to Trading Economics (2024), primary and service sectors accounting for 54.40% of the total GDP of India while in Malaysia, the service sector plays a crucial role, comprising 54.15% of the GDP, underscoring the manufacturing sector substantial contribution to the nation's economy. In Malaysia, the agriculture sector accounts for 7.24% of the GDP and, in Pakistan, the agriculture sector retains a substantial share of the GDP, standing at 20.68%, highlighting the insignificance of innovative products and services to the nation's economic framework. In the same way, the agriculture sector contributes 13.7% to the GDP of Indonesia, reflecting the country's over-reliance on this sector for economic growth (Majid, 2020; Seah et al., 2021; Zhang et al., 2024). Consequently, the trade balance among these nations is continuously unfavourable due to the quality of products and services

compared to developed economies like Europe, the USA, Canada, and Japan (UNCTAD, 2022). In this context, the examination of the combined effect of R&D and macroeconomic indicators may help in a comprehensive understanding of the macroeconomic environment to foster economic growth.

Thirdly, despite efforts at structural reform over the past few decades, ASEAN countries, except Singapore and Malaysia, face economic challenges characterized by imbalanced trade, largely due to depreciating exchange rates within the international market, as indicated by DoSM (2023). Transitioning from primary sector projects to industry-based initiatives is not only proposed to boost export levels but also to stimulate overall economic activity, as advocated by Ahmad et al. (2022), Dobrzański et al. (2021), Li & Li (2022) and, Zhang et al. (2024). According to a study of Basu et al. (2024), outsourcing and offshoring activities have adverse effects on economic growth and the macroeconomic landscape of developing nations. Firms often resort to these options in response to rising production costs, high wage rates, inadequate infrastructure, and an unfriendly business environment (Dossani & Kenney, 2007). Conversely, investment in R&D can increase productivity and good infrastructure to foster a favourable macroeconomic environment in the long run through commercialization of R&D expenditures for GDP growth rate. Hence, examination of R&D expenditures among countries under study can help to understand the long-run and short-run effects which is imperative in the given context.

Additionally, institutional weakness and focus on traditional industries among the countries cause unfavourable economic and technological growth (Amin et al., 2023; Jahanger et al., 2022; Sinha & Sengupta, 2019). As such, it becomes hard for majority of these countries to maintain competitiveness in the global market since their exports are with other developing regions (Ayob et al., 2023; Bishwakarma & Hu, 2022). In addition, under-investment in R&D due to budgetary gaps is causing failure to maintain a competitive advantage for a favourable trade balance while rightly investing in R&D can contribute to the development of innovative products and services (Dobrzanski & Bobowski, 2020). The current study intends to examine the long-run and short-run impact of R&D expenditures with macroeconomic indicators. This way, results of this study can help to rightly invest limited financial resources which can be helpful in sustainable economic growth among these nations.

Finally, ex-post forecasting of the long-term impact of R&D may also help in effective policy making while models' stimulation can result in sustainable economic growth. This way, innovative products and services can help in a favourable trade balance. Therefore, a comprehensive investigation of the long-run dynamics of economic growth stimulated by R&D expenditures and microeconomic variables for ASEAN-5 and South Asian-3 countries becomes indispensable. This will also help deduce useful implications for effective policy-making that supports sustainable economic development in these regions.

By tackling these challenges head-on, the current study can play a pivotal role in steering R&D expenditures towards high value manufacturing activities, thereby fostering innovation, supporting exports, and creating more job opportunities. Such proactive measures can also serve to reduce the prevalence of outsourcing and offshoring activities by promoting a more equitable distribution of growth opportunities. Ultimately, this transition holds the potential to offer valuable insights for the countries under examination and, the combined effect of R&D and macroeconomic indicators helps in understanding the macroeconomic environment to foster economic growth (SDG-8) and mitigate the projected economic decline through strategic partnership (SDG-17).

1.8 Research Gap

Within the academic literature, numerous studies have explored the role of R&D expenditure in economic growth. Most of the existing studies used GDP and R&D in environmental studies (Shang et al., 2024), while some applied different research methods (Balsalobre-Lorente et al., 2021; Baruk, 2022) among different countries (Pradhan et al., 2024; Zhang et al., 2024). They lacked the application of the panel data model, VECM for examining the economic impact of public R&D expenditures among countries of ASEAN and South Asia (Soete et al., 2022) and macroeconomic indicators for GDP growth rate (Adedoyin et al., 2020; Charutawephonnukoon, 2020; Gruzina et al., 2021) aligned to SDGs within these countries, however, at both institutional and industrial levels. To the best of the author's knowledge, a study by Tung &

Hoang (2023) investigated the economic impact of R&D expenditures on economic growth, incorporating factors such as capital, corruption, and education. The role of R&D towards outsourcing, offshoring, and their implications for GDP growth in the current study setting is also missing in the existing literature necessitates a nuanced understanding of the dynamics behind these matters. Specifically, the following research gaps can be identified:

- While outsourcing and offshoring have become universal strategies for cost reduction and access to specialized skills, the extent and nature of these practices differ across ASEAN-5 and South Asia-3 countries. A comprehensive analysis to examine the combined impact of R&D expenditures and other macroeconomic variables on economic growth through increased productivity and innovation is needed.
- R&D expenditure plays an important role in driving economic growth, fostering competitiveness, and enhancing long-term economic sustainability through enhanced cooperation. However, the levels of R&D expenditures, modernization in output level, and technology upgradation vary significantly among these nations. Examining the impact of R&D expenditures and macroeconomic indicators at the individual country level can provide valuable insights in determining economic growth policies by providing accurate and reliable forecasting models.
- Alongside, existing studies mainly focused on single-country or regional studies using panel data models and co-integration analysis consistently applying R&D purely in technology and environmental contexts (Adedoyin et al., 2020; Gruzina et al., 2021). The proposed methods of

analysis adopted in current study help in understanding the dynamics of R&D and macroeconomics towards GDP growth rate specifically for the countries under study.

- Existing studies mainly focus on the consequences and spillover effects of economic growth in the form of environmental degradation (Shahid et al., 2024). Theoretically, it is against the role of R&D in boosting economic growth which needs to be assessed in the presence of the current heightened economic situation. Decisively, the theoretical gap has been widening and inviting scholars to contribute theoretically while assessing the role of R&D in boosting economic growth.

Abridging the gaps in assessing the economic impact of R&D expenditures, combined effects of R&D and macroeconomic indicators on economic growth among ASEAN-5 and South Asia-3 countries need a multifaceted and rigorous methodological approach. For this purpose, this study applied a rigorous scientific methodology to unravel the complex connections between R&D and macroeconomic indicators within the context of evolving regional and state economic landscapes. Alongside this, the combined impact of these factors on the GDP growth rate provides a deeper understanding of the mechanisms driving economic growth and development in diverse socio-economic contexts. This way, the theoretical role of R&D for economic growth has been examined for effective policymaking following the underpinning of the growth model. The clear understanding of R&D, macroeconomics and economic growth significantly plays an important role in mitigating the growth and technological disparities.

1.9 Research Questions

In accordance with the research problems and motivation, this study has formulated following research questions:

1. What impact do R&D expenditures, FDI, NX, EXR, EMR, and INF have on economic growth in ASEAN-5 and South Asian-3?
2. How do these factors collectively influence the economic growth process in ASEAN-5 and SA-3?
3. What are the long-run and short-run effects of R&D expenditures, FDI, NX, EXR, EMR, and INF on economic growth in ASEAN-5 and South Asian-3 at country level?
4. What are the short-run ex-post forecasts of economic growth in ASEAN-5 and South Asian-3 countries?
5. How does models' evaluation can assist policymakers in ASEAN-5 and South Asian-3 countries in the policymaking process?

1.10 Research Objectives

The principal aim of this study is to comprehensively ascertain the factors impacting economic growth in ASEAN-5 and South Asian-3 nations. This involves providing a holistic understanding of macroeconomic factors, specifically R&D expenditures, through regional, combined and country-level analyses. The study examines the influence of R&D expenditures, Foreign Direct Investment (FDI), Net Exports (NX), Exchange Rates (EXR),

Employment Rates (EMR), and Inflation Rates (INF) on economic growth through GDP growth rate for sustainable development.

1.10.1 General Objective

The general objective of this study is:

To investigate the combined, long-run, and short-run effects of R&D expenditures and macroeconomic variables; FDI, NX, EXR, EMR, and INF on GDP growth rate of ASEAN-5, South Asian-3, ASEAN-5*SA-3[3]at regional and at each country under study.

1.10.2 Specific Objectives of the Study

The specific objectives of this study are:

1. To examine the impact of R&D expenditures, FDI, NX, EXR, EMR, and INF on economic growth among ASEAN-5 and South Asian-3 countries.
2. To investigate the combined effect of R&D expenditures, FDI, NX, EXR, EMR, and INF on economic growth in ASEAN-5 and South Asian-3 countries.

[3] ASEAN-5 mean five (5) countries from ASEAN region, South Asia-3 mean three (3) countries from SAARC region, ASEAN-5*SA-3 mean combining eight countries from both the regions which have been assessed using panel data.

3. To analyze the long-run and short-run effects of R&D, FDI, NX, EXR, EMR, and INF on economic growth in ASEAN-5 and South Asian-3 countries.
4. To predict an ex-post forecast of economic growth among countries of ASEAN-5 and South Asian-3 countries.
5. To provide effective economic growth policy suggestions to policy makers among ASEAN-5 and South Asian-3 countries following the accuracy of the analysis models.

1.11 Study's Significance

The present research assesses the impact of R&D expenditures and macroeconomic indicators on GDP growth among ASEAN-5 and South Asian-3 countries. Considering the economic and technological disparities, the economic role of R&D expenditures can provide timely, well-directed results to delineate the existing gaps and provide insightful solutions to researchers and policymakers. Theoretically, this study is rooted in the crucial role of government in economic growth which results in examining R&D expenditures made by the whole economy as it is acknowledged as a significant catalyst for economic growth theories. Consequently, the study holds substantive theoretical and practical relevance within the existing scholarly discourse and stands to offer valuable insights for policymakers.

1.11.1 Theoretical Significance of the Study

Drawing from the government's influence on growth outlined in Keynesian growth model presented by Keynes (1937), later followed by Friedman (1983), and Popelo et al. (2021) confirmed a consensus among subsequent growth models. Among subsequent model, Solow-Swan model (1965) endorsed that research and development is crucial for innovation-led economic growth which was confirmed by studies of Mankiw (1992), Li et al. (1998) and, Li and Li (2022). Considering the endogeneity of human capital and R&D (Romer, 1990; Acemoglu et al. 2005; Habib et al., 2019), sustainable economic growth should be examined while keeping the macroeconomic role of R&D expenditures because it is the fundamental tool for economic growth. The point of turn midst in all the growth models and theories is the inclusion of technology for long-term sustainable economic growth. Based on the Schumpeterian economic growth theory, this study aims to add in the endogenous and exogenous roles of R&D with an intention to account for favourable economic indicators as boosters of GDP growth either internal or external. The increased R&D expenditures lead to lower costs and boost long-term growth through increased output levels (Aghion & Jaravel, 2015; Shahid et al., 2024). This phenomenon has been tested by using a panel data model for a combined effect of R&D and macroeconomic indicators and individual relationships of the R&D and macroeconomic indicators with the GDP growth rate of each country which significantly contributes to the existing endogenous role of R&D for sustainable economic growth. This way, this study opens the

novel theoretical gates for prospect studies in examining the economic role of R&D expenditure towards sustainable economic growth.

1.11.2 Practical Significance of the Study

Practically, this study has more implication as it is the first study considering the economic role of R&D expenditures for GDP growth. This way, it provides a clear understanding of harmonizing the economic and technological growth disparities among the regions and countries under study. Economic growth leads to contributing to the SDGs through the mobilization of economic resources which supports the investment in the form of FDI and tolerates decent work and economic growth (Shahbaz et al., 2022; Zafar et al., 2019. Henceforward, this study illuminates the intricate relationship between R&D expenditures and macroeconomic variables and their impact on GDP growth rates, thereby providing countries with insights to refine existing policies based on the forecasting conclusions of the VECM model as suggested by Hendry and Ericsson (2003). This way, the long-run effect of R&D can be best described through the realization of its commercialization. This approach aids in crafting development-oriented policies aimed at attaining elevated growth patterns through rightly invested R&D expenditures. Meanwhile, the findings can also be used in other developing areas around the world in the perspective of economic development, making this research even original under the Sustainable Development Goals (SDGs) proposed by the United Nations.

1.12 Organization of the Study

This study consists of five chapters which have been developed in the following ways.

Chapter 1 of this thesis presents a synopsis of the study, research background of R&D expenditures and economic growth at global as well as at ASEAN and South Asian level. This chapter identifies the research problem, research objectives, research question and a brief description of methods to pursue the study's aim. Theoretical and practical significance and organization of the thesis have been given at the end of this chapter. **Chapter 2** begins with the description and development of underlying growth theories followed by a theoretical review. Each variable's definition and its position in light of the latest literature is added to the study after defining the review process. Further, a review of proposed methods used in existing literature has been provided to develop a rigorous research method to answer the research question and fulfil the study's aim. **Chapter 3** describes the research framework, analysis procedure and data sources used for data collection. The mode specification for combined effect through panel data model, long and short-run effects of R&D expenditures and macroeconomic variables through VECM have been discussed for appropriateness of the methods. At last, model simulation methods followed by residual diagnostics of the models based on data behaviour have been described in detail in later parts of this chapter. **Chapter 4** includes the exploratory data description, and results of panel data analysis for regional and VECM at country level hypotheses testing in sections 4.1., 4.2 and 4.3 respectively. The models' accuracy for estimation and forecasting has been

provided along with the impulse response function before the summary of decisions made on the hypotheses of this study. **Chapter 5** synthesizes the results discussion in the first section. After that, the discussion and implications of the results have been discussed with reference to the relevant literature. Theoretical and practical significance shed light on the importance of this study towards effective and doable policymaking based on comparative results. In the end, the limitations of this study have been discussed with a suggestion for prospect studies.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

Current chapter begins with a synthesized examination of growth theories with respect to technology and R&D-led in section 2.1. Further, section 2.2, includes the procedure to conduct a review of existing literature considering the R&D, innovation and economic growth specifically on R&D, FDI, NX, EXR, EMR, and INF to establish a theoretical foundation for economic growth for ASEAN-5 and South Asia-3, for combined data ASEAN-5 x SA-3 and at country level. In addition, section 2.3 presents the identified gaps resulting from the empirical review of literature and methods pertaining to the economic growth phenomenon. In conclusion, section 2.4 provides an empirical summary of the review which needs to be solved by adopting a rigorous analysis procedure.

2.1 Review of the Economic Growth Paradigms

Economic growth is the prerequisite of economic development and paves the way towards sustainable development and economic well-being of the people living within a geographical boundary (Schumpeter & Backhaus, 2003). It has been a widely discussed universal phenomenon which has been under discussion since its inception into the literature. Due to its importance, governments attempt to bring good and strong economic catalogues so that their

people can get easy access to food, shelter, and basic necessities. Whenever a downturn came, economists and theorists came forward and tried to draw recovery measures for getting rid of recessions toward economic growth. It would be the 1770s UK credit crisis, 1st great depression of 1929, or the financial crisis of 2007, every time economists tried their level best to draw economic revival ideas.

2.1.1 Underlying Theories of Economic Growth

It is clear from examining the development and history of economic growth theories that production factors are crucial for economic growth and expansion. Social, technological and economic aspects are important things to consider when we talk about a country's progress towards growth and development (Boyer, 2004). In the field of economic growth, every theory has its own background and is applicable only when some assumptions have been fulfilled. For example, Keynesian theory discusses output, inflation, employment, and active government intervention (Keynes, 1937; Schumpeter, 1946; Wang & Zhang, 2021). The exogenous theory posits that technology functions as an external factor in the growth process, attributing economic growth to the collective input of labor and capital (Solow, 1956). In contrast, endogenous growth theory interprets technology as an integral factor influencing economic growth. It can be argued that the persistence associated with the endogenous growth model stems from continuous endeavors aimed at enhancing human capital through research and development as cofirmend by Mankiw et al. (1992) and, Simonova et al. (2021). In 1990, Romer founded that

R&D investment is important for sustainable economic growth which has been applied in modern authors in their studies.

It is important to note that every country has its own social, political and technological environment which needs the application of different models, strategies, and measures for economic growth (Manion & Evan, 2001; Matyushok et al., 2021). The objective of EG is a result of continuous efforts in the presence of a rapidly changing global landscape. The economies are required to offer standardized products (goods or services) which can earn a favourable balance of trade so it can further be invested to promote R&D and innovation to attract foreign investors. In order to gain economic growth, it is important that policymakers should devise policies to deploy funds in R&D investment and support the development of well-functioning fiscal systems in which information symmetries exist, letting financial institutions and firms promote innovative and modernized products from countries across the globe (Méndez-Morales & Yanes-Guerra, 2021). In the product establishment process, existing models insisted consideration of knowledge, innovations, and R&D activities for sustainable economic growth. Hence, the economies aiming to attain growth and development in the modern era need to deploy enough amount in the way of R&D expenditures.

2.1.2 Synthesized Theoretical Review

This theoretical review is designed to delve deeper into the understandings of theories of economic growth and, as such, analyze the

applicability of each particular theory in relation to the specific context, as suggested by Calero and Turner (2020), and Terluin (2003). Moreover, the availability of resources in the course of growth and development also needs to be evaluated under the assumption of principal growth theories. Based on this debate, this study upsurges conversation with a synthesized theoretical review. A synthesized theoretical review can lead to evaluating the best understanding and results-oriented concept in light of theoretical review (Maclnnis (2011). Figure 2.1 presents the synthesized theoretical review process which was developed to extract a communicative result in light of chronological and contemporary theoretical considerations. In the first stage, a summary of growth and development models has been developed to integrate growth theories. The conclusion, after the integration of growth theories, has been developed on the basis of this process.

Source: Adapted from Maclnnis (2011)

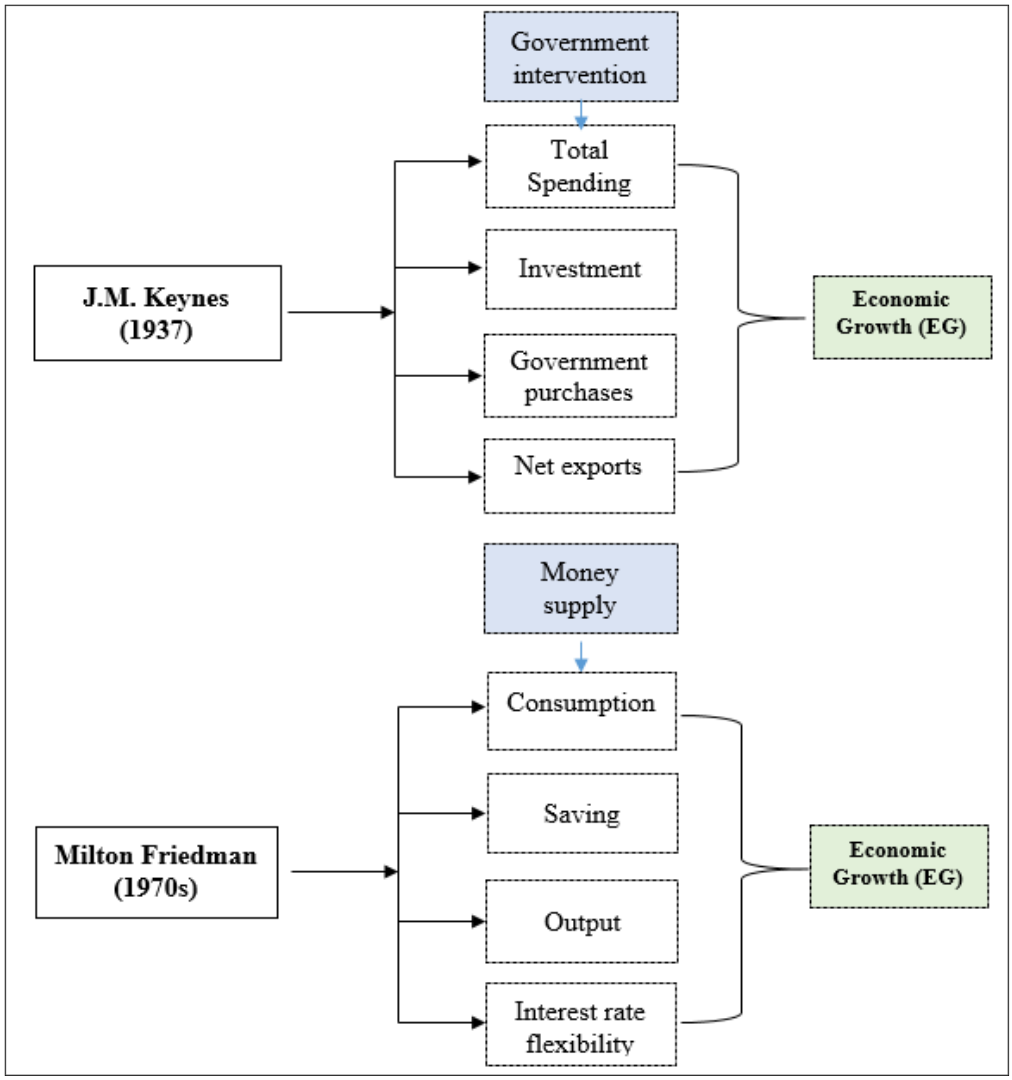
Figure 2.1: Theory Synthesization Process

The figure shows that a summary of growth theories is needed followed by integration of the relevant theories. This way, a concise and appropriate theoretical understanding can be developed according to the economic situation and requirement of the economy.

2.1.2.1 Keynesian Economic Growth Theory

In the 1930s, John Maynard Keynes, popularly known as J.M. Keynes, developed a theory concerning aggregate expenditure of an economy to achieve its full production level and its long-term consequences on economic growth and development. He idealized that public spending and policies, especially in a recession, can boost economic growth because during the recession, people's income shrinks, and they cut down their spending patterns (Keynes, 1937). In this situation, intervention from the government supports the economy by enhancing production levels and employment. He further added that an increase in output, due to government intervention, leads to a short-run increase in real output and employment which, resultantly, upholds the economy in short-run. The employment factor is more critical for economic stability compared to other factors e.g., inflation, and in order to get a higher level of employment, the government is supposed to spend more money to increase the output level. The increase in output level causes an increase in demand and employment level which makes the economy prosperous in sequence to the model of Keynesian economics which was later reformed and verified by many economists (Mankiw; 1995; Mansoor et al., 2018).

This theory first considered individual economic performance as different from extensive aggregate economics and concerned about the adjustment of income, demand, and output for economic growth. In 1946, his student Richard Kahn, in “Tariffs and the terms of trade”, added that an upsurge in government expenditures tends to a boost in business activities in the country which increases aggregate production to meet higher demand and a relative increase in income. Sequentially, the spending power of individuals increases which increases demand and output level, resultantly, the economy grows through GPD growth. Later, after the 1957 economic recession, technological advancements affected the demand side of the economy which emerged the demand for technology and innovation. After the 1970s depression, industrialized countries imposed high taxes and started spending money on R&D to produce technological products in order to stabilize the economy but adversely, it affected the people’s spending power which turned into low demand and decreased output. This pedagogy identified a flaw in Keynesian economics and created a theoretical as well as empirical gap (Aganbegyan, 2019; Friedman, 1983). In that scenario, Friedman gave a new idea of monetarism which argues that the government can intervene between consumer and business voluntarily but should not compel the economic forces to act according to the policies. He added that government intervention can stabilize the economy in the short-run only and, in the long run, it affects the economy negatively not influence output. He further added that policymakers should focus on the results of the policies and act accordingly but not interfere in the market forces. The idea of Friedman's work during the depression which added advancements in the monetarist view of economic growth.



Source: Adapted from (Keynes, 1937; Friedman, 1983; Popelo eta al., 2021)

Figure 2.2: Keynesian Economic Growth Model

Figure 2.2 depicts the developments in Keynes's ideology of economic growth identifying government intervention necessary to lessen the adverse effects of recession. The upper part of the figure portrays the Keynesian economy which involves the increase in public expenditures which in turn favour the economic activities and rise in demand (Jahan et al, 2014). Resultantly, it will help economies to recover from the trivia of inflation and unemployment and leading towards the economic growth. In the below part of the figure, Friedman's concept of government intervention is mapped. Friedman

said that government intervention can help the economy in a shorter time period so, it is better not to involve in the economic process but just to focus on the supply side of money in order to stabilize the economy. So far, the Keynesian growth model is influential and effective, especially during a crisis, but its effectiveness is questioned by many authors during stagnation and stagflation (Aganbegyan, 2022). Some critics say that the idea of total spending cannot be fulfilled during a recession because the government would not be in a position to spend extra money, so they marked a big question mark on the application of this theory in every condition. They argued that an increase in spending causes inflation which, in the long run, is not a good economic technique, especially for developing countries.

2.1.2.2 Exogenous Growth Theory

The exogenous growth model, known as Neo-Classical economic growth model and more popularly referred to as the Solow-Swan growth model, demonstrates how economic growth can be achieved through effectively applying three factors of production: labor, capital, and technology. The historical depth indicates that this model was first presented by Domer in 1946, taking much inspiration from the work of Harrod, an economist from the Keynesian school. Domer proposed that capital and output constitute significant elements of economic growth; however, his model was deemed inadequate. The theory gained prominence when Robert Solow and Trevor Swan incorporated labor as a crucial factor of production necessary for fostering growth and development in 1956 as follows.

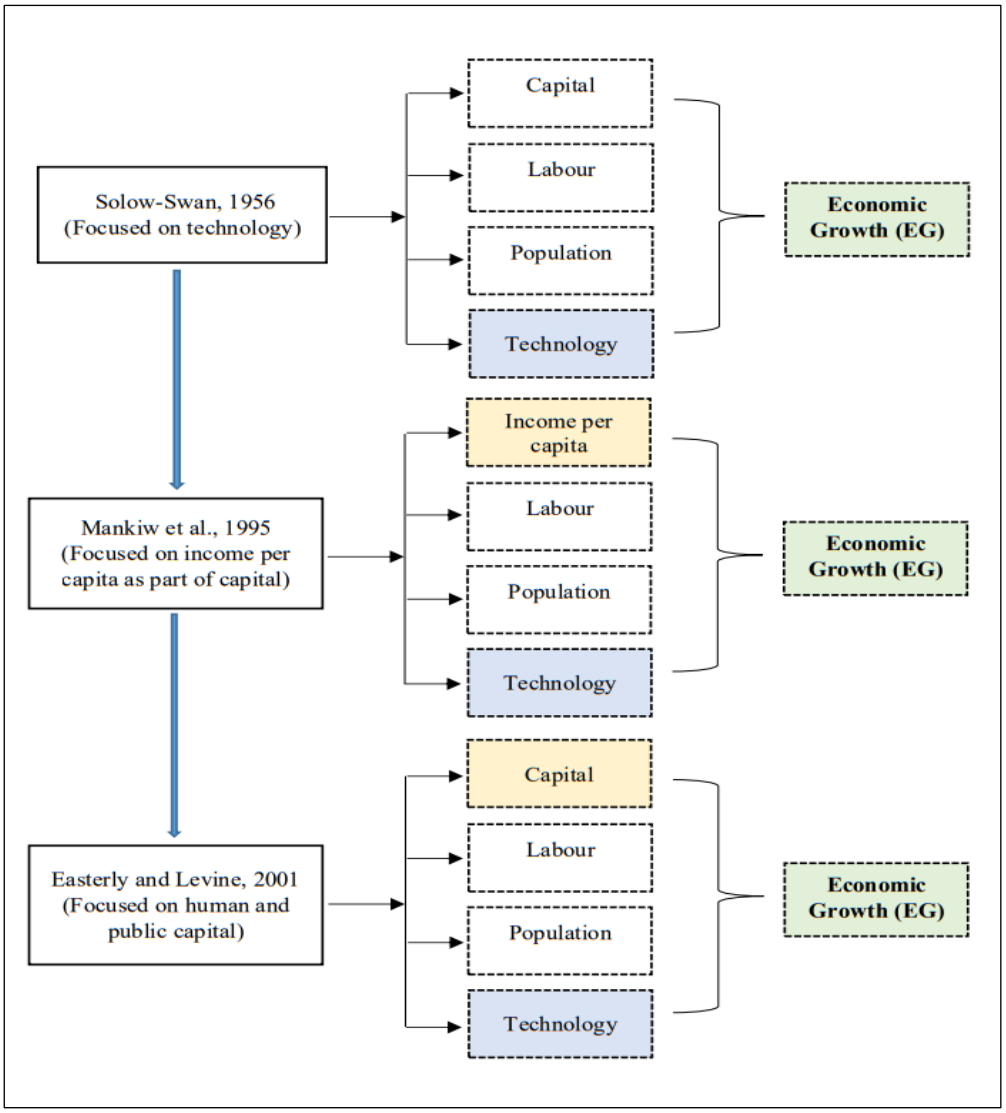
$$Y = f(L, K, A) \qquad \text{(Eq.2.1}^{4}\text{)}$$

Where, Y = Output, L = Labour, K = Capital, and A = Technology

The equation depicts that output (Y) is a function of labour (L) and capital (K) in a certain level of technology (A). This model says that exogenous factors like labour, capital, population, and technological factors play a more important role in determining economic growth through GDP (Figure 2.3) than endogenous factors as these are outside the control of policymakers. Solow incorporated technology in the model as the major driving force toward economic development. This growth model depicts that economic development is steady and exogenous because as saving increases, capital also increases which equals the output level. They further added that the increase in per capita is a result of fluctuation in human capital if no technology works properly. Thus, these economists gave importance on technology for speedy short-term growth while in long run, the factors equate to the output level which shows a steady economy. This theory was further testified by many neo-classical economists like Cass (1965) and Koopmans (1965).

This concept worked for many years, but the long-run applicability of the theory was still questioned until it was further added that people accumulate capital and when capital and labour work together, short-run economic equilibrium happens which leads to growing technology in order to get sustainable long-term economic development (Barro, 1996; Easterly & Levine, 2001) as shown in the Figure 2.3.

[4] Eq. here and hereafter means Equation



Source: Adapted from (Solow, 1956; Easterly and Levine, 2001)

Figure 2.3: Developments in Exogenous Growth Model

The long-term relationships between the determinants of long-term economic growth, such as capital, labour, population and technology made it easier to comprehend how government spending in technology can affect economic growth. Mankiw et al. (1995) added that income per capita role in economic growth is missing in this neo-classical growth model. They suggested that, in the presence of income and growth differences, the role of income per capita cannot be neglected while talking about economic growth. Increased

monetary correction, lessened inflation, innovated exports, and a focus on value addition are all necessary factors for economic growth and development (Alekhina & Yoshino, 2019; Chowdhury, 2020; Chugunov et al., 2021; Saidu et al., 2018). This process needs capital for technology replacement, so technology has been described as the major component of EG. Later, economists like Easterly and Levin (2001) added that capital, either human or public, has a major role in increasing national income and economic growth. The major consensus among the followers of the Solow-Swan model was on technology and its importance for short-run and long-term economic growth. Since technology is the primary driving force behind this hypothesis, it is evident that investment in technology is necessary to support productivity and growth among developing economies (Caminati & Sordi, 2019). This way, investment in R&D can lead to technological transfer and modernization among developing nations (Haseeb et al., 2019). In the case of South Asian countries, producers are unable to produce low-cost products which affects productivity and competitiveness. R&D expenditure leads towards technology and modernization which cause improved production processes and cut costs resulting in higher productivity. In this way, we can say that investment in R&D expenditures may help economies to achieve EG through increased productivity, increased employment level and higher level of exports.

2.1.2.3 Theory of Endogenous Growth

This framework proceeded from Schumpeter's theory of creative destruction, dating back to 1942, which focused on how innovation is important

to advance product quality to achieve higher economic growth. Based on Schumpeterian insight, product quality continuously improves with the introduction of advanced technology and leads to an increase in aggregate output at lower cost. Primarily, Schumpeterian growth model is underpinned by three fundamental doctrines: (a) The primary catalyst for sustained economic growth is innovation; (b) Innovation pertains to business investments motivated by the potential for monopolistic profits; and (c) Continuous innovations occur, leading to the obsolescence of outdated existing technologies.

The Schumpeterian growth theory, which states that an idea is the finding of how to make an innovative product, is likely the most significant part of economic growth theories. The Schumpeterian paradigm is built on "quality ladders," where an innovation is an ideal replacement for an old product, except that it is of greater quality or can be produced more affordably. Innovation is linked to creative destruction, in which a new innovator's creation pinches from the revenue chain of an earlier innovator. The idea was strong in the presence of other growth models but could not get fame as the technology was not advanced during that era, and it rapidly progressed after the 1970s. In contrast to exogenous growth theory, endogenous growth theory posits that research and development activities, the level of production, and human capital constitute the principal sources of economic growth, characterized as manageable and intrinsic factors contributing to economic advancement. Economists like; Aghion (1997), Helpman (1991), Makiw et al. (1992), and Romer (1986) were the economists who believed that an increase in R&D expenditures inevitably increases the EG through GDP growth rate. They believed that improvement in

production level is the result of higher spending in R&D and human capital. Firms need to offer modern and innovative products by improving skill and knowledge so that clear advantage can be obtained in the service as well as manufacturing sector of the economy.

First, this theory was extended by Romer (1986), who stated that endogenous factors play a primary role in economic growth then followed by other economists. Technology has been, also, considered a major contributor to EG, and enhanced investment in human development, innovation and knowledge considered factors that lead an economy toward technological advancement, but the above-mentioned economists considered that technology is an endogenous (internal) economic aspect of economic growth. They presented endogenous growth theory by the following equation:

$$Yt = AK^{a}L^{1-a}\acute{K}^{b} \quad \text{(Eq. 2.2)}$$

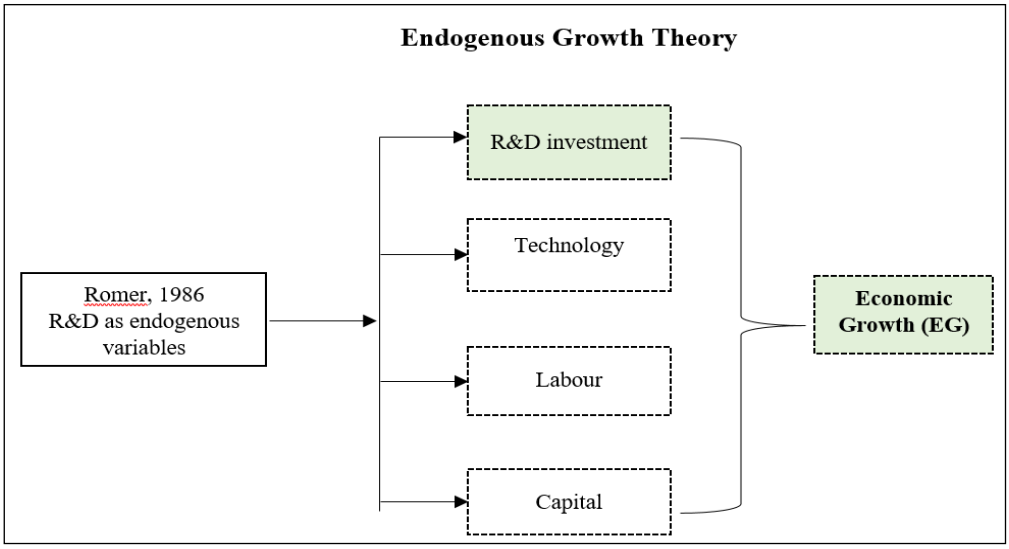
$$Y = AK^{a} + \beta L^{1-a} \quad \text{(Eq. 2.3)}$$

$$\mathrm{g} - \mathrm{n} = \frac{\beta N}{[1-\mathrm{a}-\beta} \quad \text{(Eq. 2.3)}$$

Where, Y = Output, A = Growth rate (technological), K= Capital, L = Labour, g = Output growth rate, N= Population growth, Ḱ= Change in Capital, and α and β are parameters.

Followers of endogenous school of thought argue that these factors are interlinked with each other as spending on knowledge guides the economy to innovation which raises the human development index. Further, technology emerges when these three factors work collectively for a higher level of EG.

The theory states that long-run economic growth is associated with these endogenous factors which got wide fame among economists throughout the world as stated below in figure 2.4. The theory of endogenous economic growth emphasises technological changes driven by financial rewards with the leading role of entrepreneurs and economists with novel ideas. It is clear from the figure that R&D investment had been added to the endogenous understanding of economic growth along with other factors, labour, capital and technology. Further understanding of the figure clarifies that R&D investment is different from technology and it works with other three factors for higher levels of economic growth.



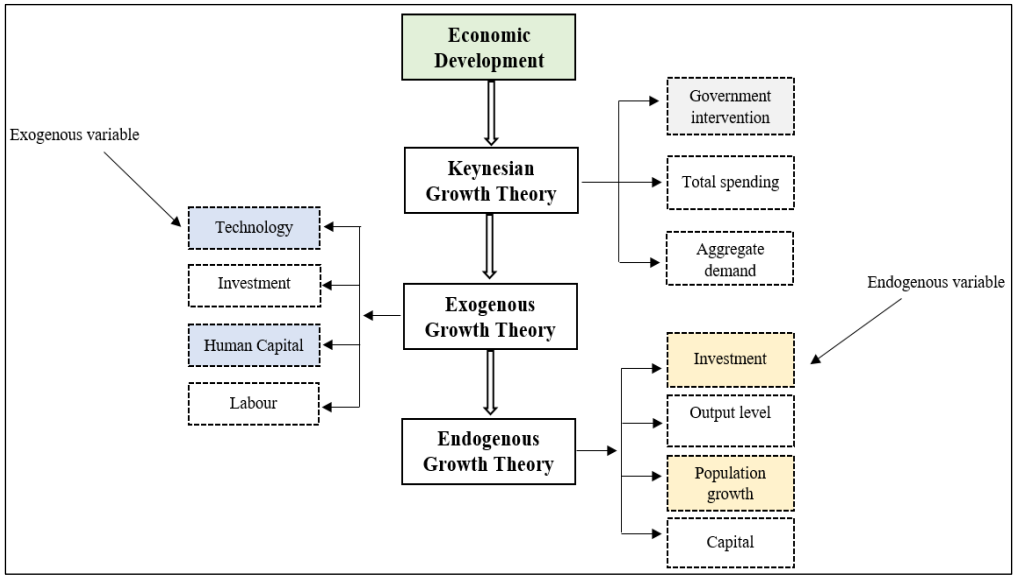
Source: Adapted from (Romer, 1986; Aghion, 1991)

Figure 2.4: Endogenous View of Economic Growth

2.1.3 Integrated Theoretical Review

It becomes clear by examining the development and history of economic growth theories that production factors are crucial to economic growth and progress. The key takeaway when discussing economic growth and

development is to take into account an economy's social, economic, and technological aspects. Each theory has its applications and shortcomings depending on the status of the economy. For example, the Keynesian theory focuses on government intervention for a higher level of economic growth (Wang & Zhang, 2021). According to the exogenous theory, economic growth comes from investment, labour and capital. Regarding the applicability of the endogenous growth model, economic growth is a result of continuous investment, population and capital for increased output level as endorsed by Musibau et al. (2019) and, Simonova et al. (2021) considering technology as an endogenous factor of economic growth.



Source: Adapted from (Habib et al., 2019)

Figure 2.5: Integrated Theoretical Review of Growth Theories

Figure 2.5 portrays the theoretical history of economic growth models. It is evident that J.M. Keynes treated economic development as a result of aggregate demand caused by full employment while exogenous and endogenous growth theories considered technology as a major factor of economic growth. The point of conflict is that, in the exogenous model, economists consider

technology as an uncontrollable factor whereas, the endogenous theory says that technology is an endogenous variable for economic growth (Akcigit & Nicholas, 2019) which is a result of continuous investment in R&D and human capital.

In today's dynamic economic landscape, we find ourselves in the midst of a modern era troubled with unique economic challenges, particularly evident in developing countries. These nations face the scary task of navigating limited funding for crucial investments in R&D, which are indispensable for sustainable growth and development. Concurrently, they must contend with the adverse effects of inflation while actively seeking FDI to strengthen their GDP growth rates. Central to addressing these challenges is the imperative for increased expenditure on R&D which is a key factor of knowledge innovation. This investment is vital for enhancing the quality of existing goods and services and augmenting the base of collective knowledge and skills. Matyushok et al. (2021) highlighted six pivotal trends driving economic development: societal, technological, economic, environmental, energy, and political factors. Among these, technology emerges as a key player among these drifts because the contemporary economy is witnessing a paradigm shift towards innovation-driven products and the widespread integration of artificial intelligence. In this context, nations dependent solely on the export of primary products find themselves ill-equipped to compete in the global marketplace. It is imperious for these countries to embrace modern technology and diversify their product offerings, incorporating innovation and modernization (David & Grobler, 2020).

2.1.4 Synthesized Theoretical Development

The modern economy is described as a globalized system, which changes the needs and methods used in tackling existing technology-based challenges as mentioned by Manion and Evan (2001) and Matyushok et al. (2021). Regarding importance of technology, as pioneered by Romer and then elaborated further by Easterly and Levine, is quite intrinsic to meeting the needs of the current economic environment. Hence, the following points are considered contemporary elements of a modern economy.

- Diffusion of technical knowledge for productivity, efficiency, and increased output level.
- Technology, infrastructure improvements and micro-computer efficiency are needed for innovative products and to stay aware of rapid changes in the market.
- Understanding the macroeconomic environment and efficient policymaking according to the situation (Soete et al., 2022).
- Competitiveness in global trade with the innovative products and services.

While discussing each element of the modern economy, a clear recognizing of the economy and its affecting forces leads to favour the exports to the international market which needs innovative products. Innovative products and services need R&D expenditures supported by both the government and industry side. In the absence of enough financial resources, FDI can help economies to enhance R&D expenditures so that the business cycle is

completely affectively in developing economies but to enhance FDI, policies should be for competitive advantage which is only possible through innovation and modern offering. Hence, the point of concern is only to understand the macroeconomic environment and enhanced R&D. In this context, the present study aims to make the situation understandable and check the theoretical viability in the following empirical way.

- The government has to get competitive advantage by improving infrastructure which will attract investors and help to increase FDI (Fernandez & Joseph, 2020). This in line with the Keynesian economic growth theory.
- Economies need to spend more on R&D in order to enhance human capital (skills and knowledge) which will affect employment level (Habib et al., 2019) which the endogenous growth phenomenon.
- In recent economic situation, developing nations need fund to invest in R&D and, for this, they need to attract foreign inflow. This way, R&D expenditures can be assumed as exogenous phenomenon.
- The increase in exports will lead to favour the exchange rate and inflation which affects GDP growth efforts which is a result of an increase in imports. This will be corrected through the means of innovation and an increase in exports and ultimately as an important source of new jobs, investment, and further innovation.

Based on the above discussion, the need for time is to evaluate the impact of R&D expenditures and macroeconomic factors on the attainment of economic growth. This study considers EG theories and models, discussed in

the previous section, stating that entrepreneurs are assigned the primary role of investing in R&D and finding alternative ways of raw material supply chain (Emami Langroodi, 2021) but here the case is with R&D expenditure at the economy level. The Schumpeterian attempt to consider occurrences like wars, political chaos, and cultural or otherworldly difficulties are of secondary importance while developing the theoretical framework for economic growth. Keynesians consider human capital a necessary factor which is abundant in developing countries, but the need of time is to effectively deploy these resources. The followers of Romer say that investment is the important exogenous factor of the economy to achieve EG but when after analysing the current situation of developing nations, it reveals that they need instant money to update the technology which can attract foreign investment (Bahrini & Qaffas, 2019; Dong et al., 2022). In conclusion, the theoretical model identifies that R&D expenditures are crucial for GDP growth in the modern era and economies need to advance FDI which will increase output and export levels. This process will greatly influence the inflation rate and exchange rate as well as employment level which is an essential measure of human capital. Some parts of this phenomenon related to R&D and its relative impact along with macroeconomic variables were discussed by Solow-Swan growth model in their famous exogenous growth theory, but R&D expenditures are the internal investment made by the government. So, to discuss growth models for suitability with the economic condition of countries under study, a chronological theoretical review has also been presented in the following lines.

2.1.5 Theoretical Development in ASEAN and South Asia

An economic factor is the element of an economy which have a direct or indirect impact on the growth and development of an economy. There is a wide range of macroeconomic factors that have a great influence on a country's growth and development. A geopolitical, environmental, or economic event that affects the whole economy of a nation or area rather than just a small segment of the population, is referred to as a macroeconomic factor. A macroeconomic factor's impact on the economy can be determined by whether it is positive, negative, or neutral. A natural disaster can have an unfavourable impact on manufacturing and the sale of output but, on the other hand, larger production brought on by increased demand can be observed as favourable macroeconomic variables. These factors have been under study for decades to evaluate the health of the economy.

2.1.5.1 Theoretical Development among ASEAN Countries

Economists applied several macroeconomic factors influencing economic growth including GDP, exchange rate, inflation rate, money supply, balance of payment, balance of trade, interest rate, R&D and so on. They applied several growth theories for assessing the impact of variables among ASEAN region countries. Following is a summary of theories used by previous researchers considering various factors of economic growth among ASEAN-5 countries considering the GDP growth rate as a proxy to measure the economic growth.

Table 2.1: Theoretical Review among ASEAN countries

Author(s)	Aim of the Study	Theoretical Viewpoint	Outcomes
Yanyun and Mingqain, 2004	To examine the impact of R&D expenditures on economic growth	Cobb-Douglas Production function	R&D expenditures have meaningful and positive role toward economic growth
Hill & Hill, 2005	To examine growth rate through trade balance, exchange rate, and inflation rate	Endogenous growth theory	Trade and exchange rate not adequately determine economic growth of Thailand and Singapore, but for Philippines, Malaysia and Indonesia, their role is important as endogenous variables
Almasaied et al., 2008	To see the influence of FDI, gross income and financial intermediaries on GDP growth rate	Borensztein cost theory	Production and export have positive effect on GDP to boost domestic as well as FDI for economic growth
Srinivasan et al., 2010	To investigate the role of FDI for GDP growth	Dependency theory	Unidirectional causality between FDI and GDP growth
Moudatsou and Kyrkilis, 2011	To examine the impact of FDI, financial cashflow on GDP as endogenous variables	Transition cost theory	A bidirectional causality was found between FDI and GDP growth for Indonesia and Thailand while, for Philippines and Singapore, unidirectional causality was found.
Delpachitra and Van-Dai, 2012	To see TFP for economic growth through trade, FDI and human capital	Exogenous growth theory	Trade balance has significant impact, FDI and human capital have invisible positive impact.
Chung et al., 2016	To assess GDP through R&D, financial liberalization and development as exogenous variables	Endogenous growth theory	Financial liberalization has positive impact on GDP while financial openness has negative impact on GDP for economic growth.
Muhamad et al., 2018	To estimate the influence of human capital, high-tech exports and patent application on GDP growth rate	Theory of Value	Authors found no short-term association between human capital, innovation and GDP growth whereas, ample long-term relationship has been found.
Haini, 2019	To evaluate the relationship of EG, trade openness, internet penetration and human capital	Romer's growth model	Relationship between human capital formation and internet dispersion was positive and substantial.

An et al, 2020	To analyze the influence of FDI on GDP growth of ASEAN countries	Purchase power disparity theory	FDI was found having positive effect while inflation and trade openness was having negative impact on economic growth.
Dobrzanski and Bobowski, 2020	To see the relationship between R&D expenditures and high-tech exports among ASEAN.	Endogenous growth theory	R&D expenditure cause high-tech exports among ASEAN nations.
Charutawe-phonnukoon et al., 2021	To assess the impact of R&D, high-tech exports, and patent application on economic growth	Schumpeter and Keynes Model of economic growth	Authors found significance impact of exogenous factors on economic growth
Ho et al., 2022	To examine the EG through trade openness and financial depth	Schumpeterian growth model	Trade openness, and financial depth's effect on economic growth of ASEAN nations was found significant
Sriyakul, 2022	To explore the relationship between innovation and renewable energy and their impact on GDP growth	Solow's growth theory	GDP growth of ASEAN countries has strong relationship among exogenous variables.

Source: Author's own development
Notes: EG=Economic growth, FCF=Fixed capital formation, GDI=Gross domestic income, HCI=Human development index, ICT=Information & communication technology, and TFP=Total factor productivity,

Table 2.1 demonstrates that, since 2001, the greatest number of scholars (5) have evaluated economic growth across regions using endogenous growth theory, leaving a significant theoretical vacuum in the context of the countries being studied. This study primarily focuses on exogenous growth theory and endogenous growth theory because both theories are likely to take into account technology (exogenous) and capital (endogenous) as production and growth functions. The table shows that in 2005, the first study conducted after 2001 among the countries study that applied R&D investment as an indicator to calculate the total factor productivity using the growth accounting (Cobb-Douglas) production function. Hill and Hill (2005) employed the term

"economic development" for the first time, which confirmed by later studies like Chung et al. (2016). It is significant that most of the studies applied trade balance, exchange rate, and inflation rate as estimators of GDP growth through industrial sector. The table further demonstrates that the concept of economic growth gained attraction post-2015 but the researcher applied GDP growth rate, human capital index, and renewable energy as proxies of economic growth completely ignoring the association of R&D with GDP as an exogenous variable. This table shows that the previous researchers used R&D expenditure to judge its impact on energy consumption, CO2 emission and technological aspects, as the studies of Charutawephonnukoon et al. (2021) Dobrzanski and Bobowski (2020) and, Yanyun and Mingqain (2004) depicting a wide gap in terms of exogenous relationship between R&D and GDP growth.

2.1.5.2 Theories Development among South Asian Countries

A profound study of previous studies related to EG among South Asian regions revealed the application of numerous growth theories that influence economic growth which has been presented in Table 2.2. The majority of the researchers used the Keynesian growth theory of EG in the South Asian region as depicted by the table. Until the near past, not even a single study used R&D as a predictor of the macroeconomic factors in the course of economic growth among the countries under study although, some researchers like Hayat et al. (2021) found a long-term bidirectional relationship between inflation, interest rate and economic growth and applied a Wavelet analysis model to see the relationship among these factors.

Table 2.2: Theoretical Review among South Asian Countries

Author (s)	Objective(s)	Theory Used	Results
Khan, 2019	To examine the effect of exchange rate, FDI and Inflation on economic growth of Bangladesh	Endogenous Growth Theory	The country's economic growth has been strongly impacted by the exchange rate and FDI. Whereas, inflation, FDI, and exchange rates have the negative effect.
Ali et al., 2020	To examine the impression of agriculture trade and exchange rate on economic growth.	Keynesian Export-led Growth Theory	Exchange rate stability supports export, foreign direct investment, foreign reserves, investment, and money supply in the nation, all of which contribute to the country's desired economic growth in Pakistan.
Jayasinghe and Selvanathan, 2021	To evaluate the influence of energy consumption, tourism, and CO^2 emission on economic growth in India	Keynesian Growth Theory	CO^2 emissions are positively influenced by energy use and tourism. There is a long-term, unidirectional causal association between CO^2 emissions, GDP, and tourist arrivals.
Khan et al., 2022	To inspect the influence of energy consumption, capital formation on economic growth in Pakistan	Keynesian Growth Theory	The findings highlight the significance of two-way relationship between energy consumption, economic growth, and capital formation for Pakistan.
Yasmeen et al., 2021	To identify the relationship between natural resources, energy consumption, gross capital formation with economic growth	Exogenous Growth theory	Natural Resources, Financial openness, REN, NREN, and FDI affect Economic Growth whereas capital formation negatively affects the Economic Growth of the country
Basantwani et al., 2021	To assess the effect of national income and public expenditure on employment in the course of growth	Employment-led Keynesian growth model	At a 0.05 probability level, the GNI time series is non-stationary, whereas public expenditure time series exhibits a downward drift that shifts in the private sector. Lagged private sector employment and private income/expenditure are used to assess employment.
Ali et al., 2021	To inspect the influence of Covid-19 on economic growth of Pakistan	Exports-led exogenous growth theory	The covid-19 pandemic rigorously impaired the economy of Pakistan and many businesses closed as they cannot tolerate the situations stirred due to the Covid-19 pandemic.
Uddin, E. 2021	To evaluate the impact of inflation on economic growth in Pakistan	Keynesian Growth Theory	He found that 1 unite increase in inflation cause 0.27 unite increase in economic development indicating a positive association between the two.

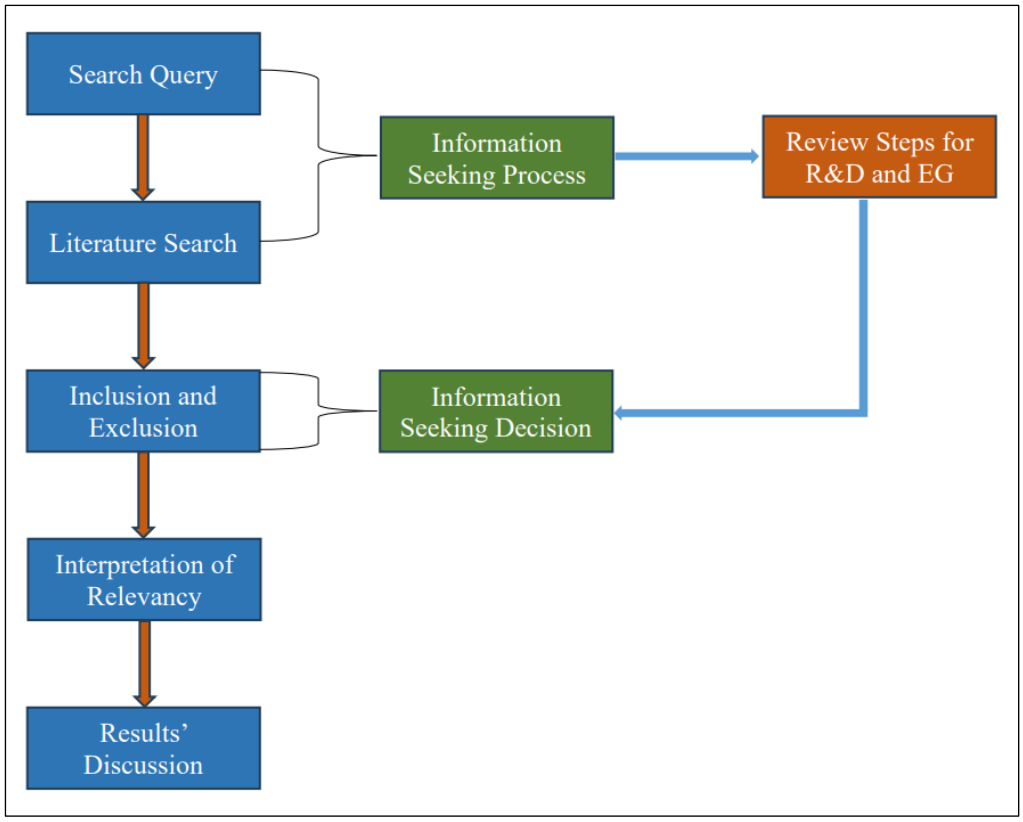
Hayat et al., 2021	To investigate the link among inflation, interest rate, and economic growth in Pakistan	KeynesianGrowth theory	Bidirectional causation in long-run while unidirectional causation in short-run analysis from the data which means to maintain a medium inflation in long run for the sake of economic development
Qamaruzzaman et al., 2021	To examine the impact of financial innovation, FDI and Exchange Rate Volatility on economic growth of South Asian Countries	Keynesian Growth Theory	Exchange rate volatility and FDI inflows move in cycle. Besides, the results of the study confirmed negative effects over time, ranging from exchange rate volatility to FDI inflows and financial innovation.

Source: Author's own development

While most of the researchers use macroeconomic variables and covid-19 impact for growth measurement which indicates that R&D expenditures in the course of EG are still missing in the literature since it is the most important estimator for economic growth. From this, it can be drawn that the need for a comparative study considering R&D's role for EG is still missing. Theories discussing R&D's importance for higher levels of EG (e.g., exogenous growth model) can provide robust and practical results considering the current state of economics among the countries under study. Table shows the application of the Keynesian growth model with many factors like; employment used by Basantwani et al. (2021), and exports used by Ali et al., 2021 but they mostly ignore the inception of R&D for economic growth. In conclusion, the researchers among ASEAN and South Asia applied all the growth models and theories. Some researchers used R&D with economic growth models but examined their role from the institutional and industry side which misses the important economic role of R&D expenditures from the government side which is an important element of modern growth models.

2.2 Literature Review Strategy

While doing review of pervious literature, the author first developed understanding about the concept which is mentioned under heading 1.2 in Chapter-1. In presence of numerous variables and extended population, this study followed the literature review process developed by Jaakkola (2020) with aim to enlighten the association among this study's constructs rather than testing them in conventional way.



Source: Author's own development

Figure 2.6: Literature Review Process

At first, the author read related research papers to understand the concept and then conducted review of the literature. After that, a total of 436 documents have used the terms, "economic growth", "research and development

expenditures", and "R&D expenditures". The research items were processed following the procedure depicted by Figure 2.6. The research items were filtered out relevant to the objective of the study and further evaluated through appropriate discussion under the literature review for this study. Due to this exclusivity, a common measure has not been drawn yet which can be applied to developing economies pursuing economic growth which revealed that, from classical to modern economists, efforts have been made to stimulate the growth process. Consequently, this study observes a number of previous studies on the interrelated indicators so that the empirical evaluation can be made for examining the growth factors among countries under study.

2.2.1 Review of the Literature

Economic growth is a key driver in converting developing economies into modern industrial economies employing quantitative improvement towards prosperity and living standards of the countrymen (Myent & Kruegar, 2016). However, it is not always incessant but must be inclusive and sustainable to make sure the equitable benefits among all corners as suggested by J.M. Keynes that it should be the "continuous increase in a nation's wealth". So, we acquire that it is the growth of wealth of a nation which leads the better quality of life and consumption pattern which further flourish the economy. This was a great achievement, especially for underdeveloped and emerging economies. While developed nations of the world continuously strived for years and then they were able to provide good comparative improvement in the living standards of their people. When we look at statistics of developed countries, we come to

know that strong and modern infrastructure is the key to growth and development which includes transportation systems, communication, education systems, sewage, and, most importantly, the wise use of water. In the presence of modern technology, infrastructure should be modernized which conserves resources and leads to economic wellbeing. All these objects need investment from the government as well as from private sector so that technology can be modernized and implemented without any barrier. Developed countries can easily manage the funds on R&D so that modernization can be brought into the production process to raise production, productivity and employment level but, the developing economies are behind in making R&D expenditures on time which restrict them to remain underdeveloped. This problem is being crucial for the countries under study so following a review of past literature will help to understand the R&D and economic growth.

Over the last decade, the world has witnessed massive growth which causes the use of energy on a large scale. Li and Ullah (2022) evaluated economic growth through renewable energy consumption using R&D, energy intensity, international trade and FDI as exogenous variables. They applied the ARDL method to analyze the data by applying the environmental Kuznet-curve (EKC) to see the impact of economic growth on the environment. They used multi-stage panel data of China, Japan and India comprised of 10-20 years and revealed that, in the short run, R&D intensity increases renewable energy, amount of energy and financial development that increase energy consumption among the three countries under study. The results reveal that the part of innovation in the study model has not been considered which opens a new aspect

that how environmental innovation affects the use of renewable energy. It is possible to conduct similar research for other modern economies contributing to environmental pollution. It is worth mentioning that when a government spends more on R&D, it will lead to increased innovation and the production of high-tech products in the country (Celli et al., 2024; Simonova et al., 2021). This ability of the production sector creates a competitive advantage which results in more exports and, consequently, an increase in GDP. So, it is found that continuous investment in R&D has become an integral source of knowledge and innovation which leads the country towards economic growth in modern economies otherwise the growth vision cannot be attained (Baruk, 2022; Shkarlet et al., 2020). It is necessary to invest in basic research so that knowledge can be created and then in applied research to know about the possible flaws in existing infrastructure. In the last stage, this knowledge accumulation works for development work which includes improvement in infrastructure, addition in existing knowledge and, development work for economic growth which is a missing area in empirical research has found by Besiroglu et al. (2024).

In an empirical study, Saidi et al., (2020) used FDI along with infrastructure growth to evaluate their impact on economic growth among 46 developing countries in Europe, Asia, and the Middle East. The authors led an infrastructure-based economic development review and applied GMM for data analysis. The results of the study showed that improved infrastructure attracts foreign investors and increases FDI which eventually adds to economic development in the countries under study. In this way, the authors found a

substantial constructive association among infrastructure, FDI and economic development. When infrastructure and FDI work together, they lead to improved production and higher exports which is the ultimate desire of modern nations (Meyer, 2021). He conducted a comparative study on imports and exports to observe the product and service diversification in international trade caused by modern technology. The author used data from African developing countries and used ordinary least square methods for the long-run and short-run causality among the variables. The results depict that merchandise exports have positive long and short-run impacts on economic development. Export is a major contributor to economic development and if the countries under study want to compete well globally, they have to invest in infrastructure so that FDI can increase in order to get higher exports.

When we talk about investment in infrastructure, studies found that emerging economies find themselves unable to make huge investment in R&D due to economic uncertainties and insufficient funds (Farooq et al., 2024). To evaluate this dilemma, Chugunov et al. (2021) steered a study to evaluate monetary and fiscal policies so that keeping in view the economic situation of the countries under study, priority areas can be set for better policy suggestions. For this purpose, they collected 23-year data from 19 emerging economies about government spending and their impact on GDP growth rate. They pointed out that institutional quality, fiscal outlay of the country and composition of expenditures differ country-wise and to achieve higher economic development, policymakers should concentrate on spending in institutional quality which leads to an increase in the growth rate. Ansari et al. (2021) used public

expenditure as a stimulus for economic development. They evaluated that, theoretically, public expenditures have a positive association with economic growth which needs to be applied in different settings. So, a global data set was used and analysed through fully modified OLS to test the hypotheses. The results revealed that the theoretical assumption is true in all cases especially when applied among developing or less-developed economies. Keynesian view public spending led to economic growth with a detrimental effect of inflation and unemployment caused by continuous spending. So, an observatory role and spending according to the situation is suggested.

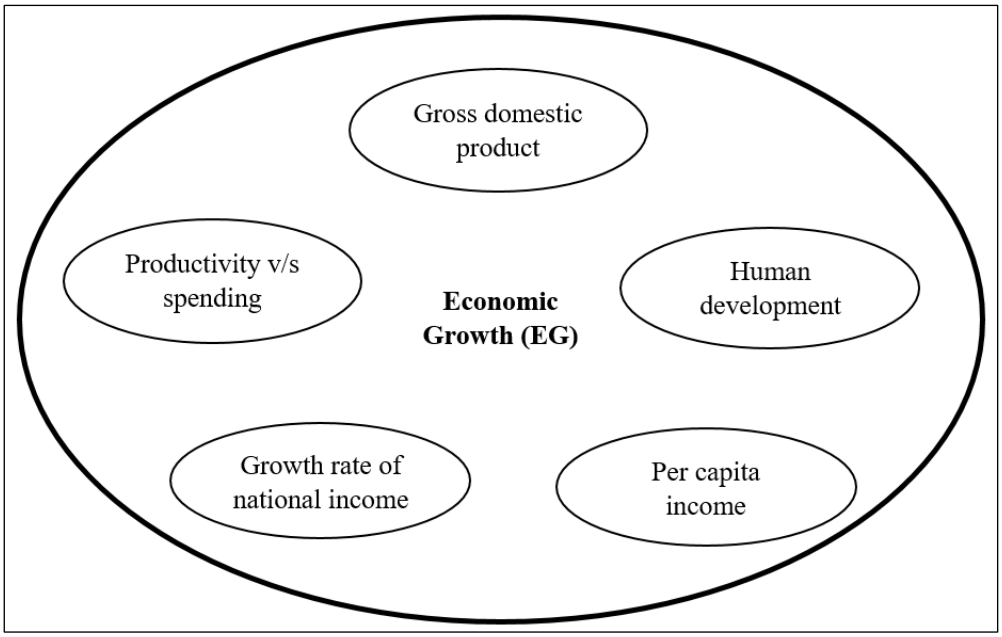
The above studies show a positive relationship between public spending in the course of R&D and economic development considering GDP as a key indicator of EG, and R&D expenditure has a direct relationship which causes improved infrastructure, increased productivity, employment level, and exports. It is worth mentioning that in developing countries; financial constraints are always there but these countries should focus on infrastructure so that FDI can be attracted for increased and modernized output levels which further enhances the favourable macroeconomic environment.

2.2.1.1 Economic Growth and GDP

The concept of economic growth has been examined by using a number of measures like GDP, human development index (HDI), and GINI index (Muo & Azeez, 2019; Wang &Zhang, 2021). An extensive study of the existing literature revealed that GDP is a common measure of economic growth when

for a study having technology objective (Ahmad et al., 2023; Anakpo & Oyenubi, 2022; Wei et al., 2023). Coscieme et al. (2020) conducted a study to suggested suitable measure of economic growth and their importance. They identified 16 indicators for measuring economic growth in a complete and productive way. They recommended GDP per capita as most suitable measure of economic growth which is the important measure to view the overall performance of economic factors. The grouping of the economic performance and economic growth is at the midpoint of controversy as Kalimeris et al. (2020) which shows that at global level, an increase in the use of resources by 96% between 1980 and 2009 induced a 153% growth in welfare in terms of GDP. In effect, economic growth seems to be feasible, given the efficient use of resources induced by suitable strategies not much dissimilar from those currently dominant.

A number of researchers used HDI as measure of economic growth (Gruzina et al., 2021; Rahman et al., 2021) while others used energy consumption as measure of economic growth (Shahbaz et al., 2021). In relation to estimators, numerous studies suggested that investment in R&D is a major estimator of GDP growth rate so that innovative products can contribute to production level and exports (Dobrzanski et al., 2021; Mahmood, 2022). In addition, many researchers find out that employment rate is the key to success in the field of growth and development (Irshad et al., 2022; Pamela & Indrawati, 2022) which has been proved theoretically.



Source: author's own development

Figure 2.7: Review of Economic Growth Indicators

Figure 2.7 represents the review of economic growth indicators used by previous researchers. The figure shows that productivity, HDI, per capita income, national income and GDP growth rate are often used by economists to measure economic development. Most of the studies related to developing countries often use GDP growth rate as an economic development indicator so this study intends to use GDP growth rate to measure and compare the EG among five countries of ASEAN, three countries of South Asia and then among the two regions with an intention of better evaluation and comparative results.

When we evaluate the economic, social, and technological situation of ASEAN and South Asian countries, it discloses that all eight countries (i.e. Bangladesh, Indonesia, India, Malaysia, Singapore, Thailand, Pakistan and the Philippines) are technologically at different stages even in India, various parts of the country are different in technological feature (Majid, 2020; Pascual et al.,

2020). Contemporary technological advancement is a major influencer of increased output which is a function of GDP so consideration of GDP growth rate for economic growth will help to understand the situation in a better way.

2.2.2 Research and Development Expenditures

Research and development (R&D) expenditure is the money a business or a country spends for improving the quality of its products and service through idea inception, improved existing processes and producing innovative products or services (OCED, 2002, p 26). The review of previous literature highlights the significant importance of R&D expenditures as a major tool to enhance economic development. It is worth mentioning that when a government spends more on R&D, it leads to growth through the production of high-tech products and services (Simonova et al., 2021). This ability of the production sector creates a competitive advantage which results in more exports and, resultantly, increases in GDP. So, it is found that continuous investment in R&D has become an integral source of knowledge and innovation which leads the country towards economic growth in modern economies otherwise the growth vision cannot be attained (Baruk, 2022; Shkarlet et al., 2020). It is necessary to invest in basic research so that knowledge can be created and then in applied research to know about the possible flaws in existing infrastructure. At the last stage, this knowledge accumulation works for development work which includes improvement in infrastructure, addition in existing knowledge and, development work for economic growth.

Economic development is the outcome of economic growth (Rajnoha & Lesnikova 2022) which is usually measured by GDP and employment rate. R&D and innovation are important factors which enhance global competitiveness (Dima et al., 2018; Farinha et al., 2018; Gavurová, 2020) so the government should increase R&D expenditures to stimulate its completion and export level. The increase in R&D means investment in higher education related to R&D and innovation (Caballero-Morales et al., 2020) which helps in increased productivity. Olaoye et al., (2021) conducted a study among four African countries to evaluate the role of R&D expenditures and the government's role in boosting growth and development. The authors used GDP as an economic growth measure and applied a correlated panel regression model to test secondary data spanning four years. The results of the study found a 29% increase in the GDP of the selected African countries due to the role of government and R&D expenditures. Importantly, the study stressed the importance of improving R&D and innovation among the countries under study. Likewise, Charutawephonnukoon et al. (2021) found a significant positive impact of R&D expenditure on economic development with the help of a comparative state of R&D spending and EG. They applied a panel unit root test with augmented Dicky-Fuller test on 26-year data collected on ASEAN countries and found that R&D along with innovation and high-tech exports play an important role in economic development among ASEAN countries. The authors added that the countries that are behind in R&D expenditures are also behind in the course of exports and EG.

When we talk about economic recession and the R&D relationship, it reveals that spending in R&D keeps economies back from the vilest effects of economic recessions (Ahmad et al., 2022). They led research to see the length of the pervasiveness of R&D expenditures among OECD countries by comparing recessions and innovation waves. The results revealed that, during the recession period, the government could not be in a position to invest in R&D. Further, the outcome of R&D expenditures during the expansion period is larger than the results of R&D expenditures during the recession period. So, if governments want to mitigate the effects of the recession on the economy, they should spend more in the expansion period.

Collins and Nguyen (2022), applied distributed lag to R&D expenditures at the macro-level to see the changes in accounting profit due to innovation caused by R&D. They used distributed lag mode to R&D and pre-R&D data components. Results confirmed model prediction and revealed that aggregate spending in R&D strongly affects innovation and advances economic growth. The increase in R&D creates innovation and modernization that provide higher demand and increase in sales, resulting, in enhanced growth and development. The role of internal and external R&D in the way of sustainable development is apparent and affirmed in contemporary literature. Sánchez-Sellero & Bataineh, (2022) highlighted that R&D are crucial for innovation. The authors used R&D intensity with R&D expenditures on Spanish firms' data and applied fixed-effect regression on panel data. The results confirmed the important role of R&D expenditures on innovation lead economic development. Despite R&D intensity and volume, it is apparent that policymakers should prioritize R&D

expenditures as they are critical for human capital through knowledge creation and innovation. In the current literature, it has been found that modern and innovative goods and services are key to success at the international level as well as help in eradicating the negative impact of economic recession for developing countries. For instance, Elfaki and Ahmed (2024) assessed the role of technology in economic growth among Asian economies (Including ASEAN and India) and the results of the random effect model suggested that technology adoption is important for sustainable economic growth. However, at the same time, the authors endorsed the presence of CO2 emission in the process of technology and sustainable economic growth. Considering current economic uncertainties, Wang et al. (2024) examined the relationship between R&D spendings and economic uncertainty and found that amplified economic uncertainty reduced economy's ability to invest in R&D which further widen the economic gaps among developing countries. They argued that policymakers desire to hold the financial resources to cover the uncertain economic situation. From this debate, this study postulates that current trends of R&D-led technology and economic growth deviate from the economic growth stimulator. Hence, it is worth examining the impact of R&D considering economic indicators among ASEAN and South Asian economies can set novel insights into R&D expenditures and economics in a developing context.

2.2.3 Foreign Direct Investment

Literature say that foreign direct investment (FDI) is the investment from outside the country which results in better policymaking and investment

in infrastructure (OECD, 2007). It is a form of foreign ownership which increases the concern and alleviates the country's relationship abroad which are key factors to increase exports. For developing countries, FDI is considered a premium source of the money supply as resilience from the bad effects of financial crisis. During the financial crisis of 1997-98, the East generally, was the ownership or investment in a company in any foreign country. The country that is receiving the money in the form of ownership of investment is the host country and for that, it is the source of inflows from another part of the world. At the global level, it is unceasingly adding up to the EG in large economies since 2005. Osei and Kim (2020) steered an empirical study consisting of 62 countries' panel data to measure the financial development caused by FDI along with private credit. They used an endogenous growth model applying the FDI-led economic development to assess the postulation. For analysis, they used the linear GMM method to evaluate financial development caused by FDI. The results revealed that foreign investment upsurges the economic growth pace but as the ratio of private credit increases concerning GDP, this adversely affects economic development. The results highlight the need for strong monetary control to seek better results caused by increased FDI. Nguyen, (2020) states FDI is an indicator of social development in Vietnam. The author used 22 years' time-series data on Consumption, Investment, Govt. expenditures, and Net exports (XM) to see the relationship of FDI among these variables. For this purpose, he applied OLS regression analysis to the data and found net inflow of FDI has a positive effect on economic development which leads to an increase in exports during the period. He further added that high economic growth can be achieved by government support and effective policymaking for exports and

FDI inflow. The role of government is found progressive in order to grow at the international level as FDI increases the output level and exports of the country which leads to a higher growth level.

According to some economists, the economic growth caused by FDI does not stay stable all the time. This hypothesis was tested by Wei et al. (2022) who used renewable energy as FDI holder and economic development. The main idea was to enjoy the long-term effects of FDI processed through renewable energy. They used data from China and applied ARDL on panel data. Results of the study showed a FDI in the renewable energy sector stayed long-term resulting in a longer effect of foreign investment on economic development. From the results of this study, we can say that in the modern global landscape, FDI can be diverted into renewable sectors in link with the sustainable development goals (SDGs) for a better economy. When we talk about developing countries and the role of FDI, a strong impact on economic development is explicit from previous studies. Saidi et al. (2020) used 46 developing countries' data and split it into three sub-panels to assess the relationship between FDI and growth & development of developing economies. The main intention behind their study was to assess the available logistics resources, by using a resource-based view (RBV), for economic development. The applied generalized method of movement (GMM) on the available data found that economic development meaningfully (0.2%) was affected by FDI but available resources (logistics, labour force, capital stock) of these countries do not appeal to FDI which is essential for modern-day economies. So, they

suggested that to attract foreign investors, the government should pay attention to upgrading its infrastructure and available resources.

A nonlinear study on African countries, conducted by Asafo-Agyei and Kodongo (2022) stated that countries must build capacity so that FDI can be utilized advantageously. The endogenous growth model was applied in the study by applying the threshold level of FDI per capita, technology gap, human capital, and government expenditures for the countries under study. They pointed out the technology gap as one of the major hindering factors for FDI and economic growth. The results of the two-step sum of square residual and OLS analysis techniques suggested a better financial policy along with trade openness so that the desired results of economic development can be achieved.

Likewise, technological advancement is attractive to international investors so policymakers should consider innovation by effectively using available resources. Handful existing studies also found a negative impact of FDI on GDP when it talks about real GDP. For instance, Ciobanu (2021), conducted a study in Romania applying VECM and causality analysis among GDP and FDI. The author found negative causality and relationship between the two factors. In recent literature, Ahmed and Kialashaki (2023) examined the linkage between FDI and labour productivity for economic growth through TFP. They found a positive spillover effect of FDI to enhance labour productivity adding to the TFP of Pacific-Asian economies. The authors concluded that the increase in FDI helps to improve labour skills, and in the long run, it adds to the economic growth of the countries under study. In a study

conducted by Amit and Kafy (2024), authors discussed role of FDI to mitigate dollar crises faced by developing countries. They found that, considering current economic situation, developing countries need foreign inflows to boost productivity and innovation which facilitate economic growth. This way, FDI can serve as a lifeline for sustainable economic growth of developing nations which needs to be realized and work for increased foreign inflows.

Based on the examination of the above empirical studies, this study intends to assess the association between R&D investment and economic growth, it is evident that economic growth is not an ordinary concept to comprehend. A profound examination of existing literature related to R&D expenditure, EXR, EMR, INR, FDI, and INF to get economic development clears the understanding that government's role is influential to bring technological changes as it has an efficient role in economic development, R&D lead innovation which increases exports (Fassio, 2018), exports lead to enhance output which increases employment rate, and moderate inflation is helpful for economic growth (Ahmed & Elfaki, 2023), especially in the case of developing countries. The major concern of this study is to examine the relationship between R&D expenditures and GDP growth rate, which is an economic development indicator, and to evaluate economic growth among the countries under study. Hence, considering this debate, it has been assumed that FDI inflow can positively influence productivity and production process which resultantly adds to the economic growth of developing economies.

2.2.4 Net Exports

Imports are the inflow of products and services from outside the country for sale to end users which causes an outflow of foreign exchange from the importing country which adversely affects the financial condition of the country (Seyoum, 2013). On the other hand, exports of the goods and services which are being provided to other countries result in an inflow of foreign reserves. This is a positive signal for an exporting country if its exports exceed the imports i.e., its trade balance is favourable. Exports provide international markets to local producers in order to grow their business but making a place at a global level is quite difficult in this technologically advanced age. Exports provide international markets for local producers to grow their business but making a place at the global level is quite difficult in this technologically advanced age (Ali et al., 2021; Liang & Tan, 2024). When a country is able to compare its exports with imports positively, it means that the manufacturing sector is progressing well in order to get the balance of payment in favour, which is important for economic growth (Irwin, 2024; Ruranga et al., 2020). In recent times, technology has become the key element for better competition and the countries involved in high-tech exports are in a better position compared to others who don't have a wide range of technology products.

Numerous previous researchers conducted studies and applied this phenomenon of economic growth with different products. Because international trade is a crucial and very important factor for economic growth, economies have to create a competitive edge for better competition at the global level.

Carrasco et al. (2021) collected secondary data from 19 developing countries to evaluate the impact of deviation from high-tech exports to general exports on economic development. They applied a generalized method of movement (GMM) on panel data and found that exports have a significant positive influence on economic growth among developing economies. It is important to note that the effect of high-tech exports is linearly associated with economic growth whereas, export divergence is not associated with economic development. Iqbal et al., (2022) organized a study to see the relationship of exports with economic development using 3 other exogenous variables among BRICS countries. They used GDP growth rate as economic development predictors using 18-year panel data and applied pool mean group (PMG) on the data for analysis purposes. The results of the study revealed that an increase in exports and FDI caused an increase in GDP which led to economic growth. To confirm the result of PMG, authors also applied ARDL on the data which also confirms the results of PMG by showing a one-way causal relationship between exports, labour, and economic growth.

Diversification of technology-led exports has a substantial and important role in economic growth which needs a growth-focused strategy for economic development (Meyer, 2021). Using ordinary least square (OLS) regression along with Granger's Causality test, he conducted empirical research on African countries and found that export outcome economic development and service exports cause exports of commodities. This dilemma is more crucial for developing countries because they already struggling for economic development and if they are able to find a gap in technology, it will help them

in export-led economic growth otherwise exports do not help such countries in boosting the EG. In a multivariate analysis of an empirical study conducted in the United Arab Emirates, Kalaitzi and Chamberlain (2020), considered total factor productivity, human and physical capital, exports and, imports to evaluate specialization's impact towards economic growth. They used DOLS regression analysis and found that exports and economic growth have a long-run relationship. So, it is implicit that, to achieve long-run economic growth, an economy must consider diversification from general methods to specialized products at the international level.

Globally, countries are diverting attention from traditional exports to technology exports because only producing agricultural products and exporting them is not helping economic growth these days (Shang et al., 2024). Nigeria is a country which traditionally exported crude oil and related products about 85% of its exports in 2020 which means they are heavily relying on oil-related exports. To empirically evaluate its exports ratio among non-oil exports, Zoramawa et al., (2020) conducted a study by using non-oil exports data from 1981 to 2019. They applied the ARDL model to agricultural exports and solid minerals, the results revealed that oil exports are negatively associated with the economic growth of the country. From this discussion, it is embedded that exports are a major indicator of the economic growth of any country. Adedoyin et al. (2021) discussed this matter about the link between exports and economic development in Malaysia. Malaysian economy has experienced rapid growth since the 1980s because they focused on specialization which creates a competitive advantage to the country’s exports. They used economic policy

uncertainty as a mediator between exports-led growth and economic development by using the ARDL model on 38-year data. The results showed a negative impact of economic policy uncertainty which hinders the export-led growth of the country.

For the studies related to the Asian context, the study of Zhu et al. (2022) found on target and well described in the sense of exports, exchange rate and economic development. The authors postulated that the economic development of developing nations is heavily associated with exports and for this purpose, they collected panel data from 1981 to 2016. The authors used VECM for analysis to see the fixed effects of control variables. The results of this export-led study revealed that the undervalued currency of the country leads to an increase in exports and economic growth. The results of the study are empirical but the applicability of the model for long-run economic development is still under question. Export is considered an important element in the sustainability of economic growth, in both developing and developed nations which draws the attention of researchers to investigate the type of association between export and economic development. Enormous studies found a positive association between imports, exports, and economic development but some found no causality among imports, exports, and economic growth in the country like Bahrain (Ali et al., 2021). The authors used Granger's causality test for their study and recommended policies to control exports to control economic growth and development.

Considering dynamics of economic growth, Saleem et al. (2023) conducted a study to examine the impact of exports on economic growth of Pakistan from South Asia. Authors used 48 years annual data applying a distributed lag approach to the data considering non-linearity in the data. Results of their study found that economic growth of the country has positive linear association with the economic growth. Considering this association authors suggested policymakers to take necessary actions to increase exports level so that it can help in sustainable economic growth. Extending this postulation to Other south Asian nations, this study postulates that exports are of much significant and directly related to the economic growth of these economies whereas, investment in R&D can help to produce innovative products and services which resultantly favour the economic growth.

2.2.5 Exchange Rate

The exchange rate (EXR) is the amount at which the currency of one country can be exchanged with some other country's currency (Murdifin & Mangkona, 2017) so, in this globalized world, it necessarily has a significant effect on international trade. The interaction between demand and supply of an economy's balance of payment determines the exchange rate (Civcir & Akkoc, 2021) which is crucial for the growth and development of the country. A study of previous literature endorsed the exchange rate as a key factor influencing international trade and has a significant impact on economic development (Bird & Choi, 2020; Bölükbaşi & Civcir, 2024; Yussif et al., 2024). The exchange rate serves as a payment tool for international economic activities and as a

current local currency rate to foreign currency rates. A decline in a currency's value indicates deprecation, while an increase in a currency's value can be defined as appreciation. Foreign currency's value has been determined by supply and demand, just like with general goods. A growing figure of research shows that the ability to ensure a competitive exchange rate in developing nations is positively correlated with long-term growth, supporting the idea that exchange rate policies can be used to promote the growth of industries linked to superior technological advancement (Chen et al., 2021b; Guzman et al., 2018).

The imports and exports are the resonant variable which affects the exchange rate. This assumption was found true in the study conducted by Ahmad et al., (2021) who used secondary data from four ASEAN countries (Indonesia, Taiwan, Thailand, and Cambodia) to see the exchange rate volatility impact on economic growth. They used path analysis on twenty-year data and found a cognitive relationship between exchange rate and economic growth with import/export variations. The same assumption can be applied to other developing nations like South Asian countries as well due to almost the same growth structure between the two regions. When we talk about the exchange rate volatility and its high amplitude on economic development, the work of Morina et al., (2021) appears to contribute to this respect. The authors used data from fourteen Central and Eastern Europe (CEE) countries and applied unit root test with regression analysis to observe the impact of exchange rate volatility and economic growth. The results revealed that an increase in exchange rate has a significant negative effect on economic growth which is crucial for under-observation countries although they controlled some traditional variables while

conducting the data analysis. The exchange rate not only affects international trade, but it also disturbs the internal growth pattern which ultimately distracts international growth policies. Bampi and Colombo (2021) conducted a study by using the Brazilian manufacturing industry's data to observe economic changes due to fluctuation in EXR. The results of their study also confirm that EXR has a negative influence on manufacturing activities within the country and subsequently, it affects the net exports negatively.

In other studies, authors used time series data to observe the impact of exchange rate on economic development and found a significant negative impact of EXR on economic growth (Gaies et al., 2020). They used a generalized method of movement (GMM) on six economic development indicators data from 72 developing countries. The authors used the exchange rate as an influencer with foreign debt's role in economic development and found that the exchange rate negatively affects economic development even when it is applied to foreign debts. He further added that if the governments of developing countries play their part actively in controlling foreign debts, the negativity of the exchange rate on EG can be mitigated. Ngiik et al. (2021), using Malaysian data spreading from 1988 to 2017, conducted a study to assess the impact of the exchange rate on economic development along with government expenditures. The results of Granger's causality test by vector error regression model on time series data exposed that the exchange rate has an important negative result on the economic growth of the country. They suggested a suitable preservation of the exchange rate to achieve the goal of economic growth.

The exchange rate has a significant influence on the trade balance of a country. If the trade balance is favorable, then the foreign reserves of the economy increase and the exchange rate is reinforced (Alsamara et al., 2024; Ogbonna & Ichoku, 2023). Further, it has been also endorsed that export-oriented businesses tempted to increase output levels have a positive connection between the exchange rate and the output level (Zhu et al., 2022). A stronger local currency is anticipated to draw foreign direct investment to the specific economy, which will lead to long-term economic development. FDI and financial innovation have a substantial effect on determining the EXR at the global level. The FDI mean the inflow of funds to the country which lowers the demand for foreign currency, consequently, it affects the EXR. Qamaruzzam et al., (2020) by representing South Asian countries spearheaded a study using time series data from Bangladesh, India, and Pakistan. The authors were determined to find exchange rate volatility and its long-run effects on FDI and economic growth of the countries under study. For this purpose, they used the ARDL method for data analysis and found that FDI, EXR and financial innovation change together which assists EXR volatility to stay persistent. From the results of this study, the importance of EXR is proven towards positive innovation and FDI as a major influencer of economic growth.

From the above debate, it is clear that the exchange rate is an integral part of economic growth through international trade and governments would pay due attention to keeping the exchange rate stable so that they can compete well in this globalized era for economic growth and development. Factors like

imports and exports, economic and political situations, supply chains, inflation, and real income have an impact on the prices of commodities in developing nations, which in turn affect the country's exchange rates. Especially, the majority of the countries under study are under domestic as well as foreign debt hence depreciation in EXR always hampers effective policymaking. Further, trade with neighbouring indebted countries affects the value of a currency, which causes unstable inflation complicating the planning and commercial activities. Further, it has also been devised from this debate that most of the existing studies only focused on the relationship between exports, business activities and exchange rate hence, examination of this correlation in relation to economic growth related to developing parts can provide a better understanding of economic indicator for higher economic growth. The reasons cause appreciation or depreciation of the local currency, pushing the market to raise prices and putting the investment break, both of these have a negative impact on the exchange rate over a longer time period so need to understand the impact and intensity of EXR on GDP growth among the developing Asian economies is pertinent.

2.2.6 Employment Rate

The employment rate (EMR) is a ratio of the overall available labour force which is currently working. Usually, a number of working-age people is termed as a labour force. Although, human capital's importance for economic development is strongly highlighted by Romer (1990) all the economists unanimously agreed that human capital is a primary and important factor for

growth and development (Hippe & Fouquet, 2024; Vladimirov et al., 2021). The wise use of human capital led to create employment opportunities in the economy which led to increased demand and supply resulting in an increase in output. Economic indicators like life expectancy, better living standards and better healthcare facilities are positively correlated with the effective use of human capital (Kuznetsova et al., 2021; Sultana et al., 2022) which leads to creating employment opportunities.

The linkage between human capital and economic growth has already been established but it lacks in examining its role in relation to R&D is missing in the given context. An existing study found that investment to enhance human capital skills is important for achieving knowledge-based economic growth (Ahmed & Krishnasamy, 2013). This way, postulation about the significance of EMR for economic growth has been confirmed which needs to examine considering the current heightened situation. Meyer and Sanusi (2019) led a study to see the macroeconomic causality between the employment rate and economic development in South Africa. The authors used quarterly data and applied a vector error correction model (VECM) to the available data. The findings of the study exposed a long-run association between employment rate and economic development indicating no permanent effect of economic growth on raising employment in the country under study. Rakhmatillo et al. (2021) used a data series from 2000 to 2020 in Uzbekistan to check the effect of the employment rate on the relationship between FDI and economic growth. For this purpose, they applied the vector auto-regressive (VAR) model to the data and found that employment has a strong relationship between FDI and economic

growth. Further, they find that in order to get a higher rate of economic development, the country should increase the rate of employment as they cause each other statistically. According to the authors, a higher employment rate leads to settling social problems as well as higher production results from employment will also attract foreign investors. This empirical study is useful for other developing countries as well to seek foreign investment.

The relationship between economic development, FDI and employment is important, and all the researchers agree on this point, but the nature of the relationship is still ambiguous. Some researchers say that there is a negative association among the three indicators (Pheang et al., 2017; Poumie & Claude 2021) while some highlighted a negative association among the indicators (Irshad et al., 2022). Irshad et al. (2022) used the generalized least square (GLS) model among ASEAN and BRICS regions to evaluate the relationship between FDI, GDP and employment. They found that FDI affects the output level in the regions under study which directly affects the employment rate. This means that employment is crucial for economic development, and in the modern economic landscape, economies need to generate employment opportunities in order to achieve economic development. From this discussion, it is explicit that employment and economic development have a direct correlation with each other and to evaluate the living standards of countrymen, we need to know about the economic development statistics of such a country. Considering this, every government tries to achieve economic development and raise the living standards of their countrymen by considering inflation, employment, and exports. In Indonesia, a study conducted by Pamela and Indrawati (2022), found

a direct relationship among these variables by using VECM on the data from Java, Indonesia. They found that the employment rate has a momentous positive influence on financial growth in the long run which means maintaining the employment rate is crucial for long-term economic development whereas another indicator only raises the development graph in the short term.

When it talks about the employment rate contribution from the institutional level to the macro level, negative statistics on the employment rate affect the industrial production index adversely which leads to a lower level of economic development at the country level (Ragmoun, 2022). The author used VCM along with Granger's causality test for the long and short-term evaluation of the data of 24 developed countries and suggested political stability for good governance which leads to better economic policies among countries. The simultaneous effect of employment and output reduces the export capacity of the economy and during this period, other competitors fill the gap in the long run.

A deeper investigation of the recent literature revealed that most of the studies tried to explore the relationship between employment rate, production levels, and economic growth often considering their environmental effects. For instance, Mitić et al. (2023) conducted a study considering employment rate role for economic growth and their spillover effects in the form of CO2 emission among eight South Eastern Europe (SEE) countries. The panel data revealed a positive causality among these variables suggesting that, to achieve economic growth, these countries should consider employment and environmental effects

to achieve sustainable economic growth. Developing countries, specifically South Asian countries, are facing critical climate change and the greenhouse effect which is not due to their activities (Chandio et al., 2023; Farajzadeh et al., 2023) but it is not area of this study. Hence, it is pertinent to examine the relationship of employment rate with GDP growth as it has been discussed in above page. it is better to increase output level in the short run. As previous studies like Fernandez and Joseph, (2020), and Mengesha and Singh (2023) endorsed that human capital does not contribute effectively to the GDP growth if it is not fully equipped with modern technology. Considering the explicit relationship between human capital and economic growth, this study intends to examine the influence of employment rate on GDP growth pursuant to enhanced understanding of macroeconomic environment for sustainable economic growth.

2.2.7 Inflation Rate

Inflation (INF) is the general increasing tendency in the price of goods and services in an economy. Inflation is caused by many reasons i.e., increase in demand, supply of currency, and increase in government expenditures but its effects on economic growth are always significant. It is a widely discussed area of public finance because of its significance and importance for economic policy effectiveness for growth and development (Mishchenko et al., 2018; Mayevsky et al., 2019; Pham et al., 2023; Saungweme & Odhiambo, 2021). The moderate increase in inflation is considered helpful for economic growth by Keynesian economists as they advocate an increase in government spending during the

recession (Eichner, 2023). But when we look at the other side of inflation, we come to know that inflation is not good, especially in the case of developing economies (Ramzan, 2021). Price increases generally in a continuous period which can be understood when society has more money, leading to a general increase in demand and price of goods and services. It is generally measured by the Consumer Price Index (CPI) in which inflation will increase the prices of raw materials. This increase in the price of raw materials increases the cost of production. This situation leads to a high-price product at the international level which, resultantly, minimizes the firm's ability to perform well globally.

Onwubuariri et al. (2019) led a researcher to evaluate the relationship between inflation, unemployment and economic growth using GDP as a growth factor in Nigeria. The authors used annual time series data for this objective. The results of the ARDL analysis technique study and found that Nigerian economic development is negatively associated with inflation and exchange rate while interest rate positively affects the economy. The authors concluded that, in order to pace economic development, policymakers should take measures to control inflation and its consequent effects. In many previous studies, three major views about inflation (monetarist view, Keynesian view, and structural view) have been discussed to evaluate the relationship between inflation and monetary policy in order to attain economic development. In this regard, the monetarist view states that it is the result of an increase in nominal income due to an increase in money supply by the government caused by deficits whereas, Keynesian economists believe that an increase in output pushes the demand high which leads to higher income and inflation. The structures economists argued

that an increase in investment leads to an unbalanced rise in output level resulting in an increase in exports and money.

In 2021, a study conducted by Saungweme and Odhiambo on data ranging from 1970 to 2019 related to inflation and economic growth discusses the above three perspectives. They applied Granger's causality test which revealed a short-term causality between inflation and economic growth. The outcomes of the ARDL model displayed an important negative effect of inflation on the economic development of the country. It is important to note that the authors were convinced from the results that unbalanced investment causes an increase in output and inflation which need effective policymaking from the policymaker's side. In developing countries like Pakistan, policymaking is not effective which leads to unbalanced investment and supply of money which depicts a strong correlation between inflation and economic growth is evident in enormous studies. Ijaz-Uddin, (2021) conducted a study on secondary data by using the ADF causality test for stationarity and then the Engel Granger Co-integration test to evaluate the short and long-run association amid inflation and economic development in Pakistan. He found that a 1 unit increase in inflation caused a 0.27-unit increase in economic development indicating a positive association between the two. In this course, we can say that inflation is good and helpful for economic development but when we see on the previous literature, reveals that inflation is good in the case of developing countries to a certain level (Hussain & Haque, 2017; Rosnawintang et al., 2021).

Another study conducted by Hayat et al. (2021) about the relationship between inflation and economic development in developing countries. They used monthly data comprised of 22 years and applied the ARDL model with two tests for causality among the variables under study. The multi-scale Granger's causality and wavelet tests revealed different relationships among the variables in the short and long run. They found bi-directional causality in the long run while unidirectional causality in short-run analysis from the data which means maintaining a balanced inflation rate in the long run pursuant to economic growth. Zheng et al. (2022), in their study conducted in the US economy, also found a medium-term effect (humped yield curve) of inflation with technological innovation and economic development using Schumpeter's growth model for the study. The authors used the OLS method for testing the Fisher equations precast for the study. They added that economic development can be achieved through medium-sized inflation, but it negatively impacts the social development in the country which means economic development does not always guarantee social development even in developed economies.

Tien (2021) conducted a study in Vietnam on the causality relationship between inflation and EG using time series annual data of 40 years. He applied the ADF unit root test and OLS assuming a nonlinear association between inflation and the economic growth of the country. After lagging the data, the results of the study also found an impact of inflation on economic development according to the Philip curve which states an intermediate-term linear association between two variables. Among ASEAN countries, Rosnawintang et al. (2021) conducted an experimental study to evaluate the effect of inflation

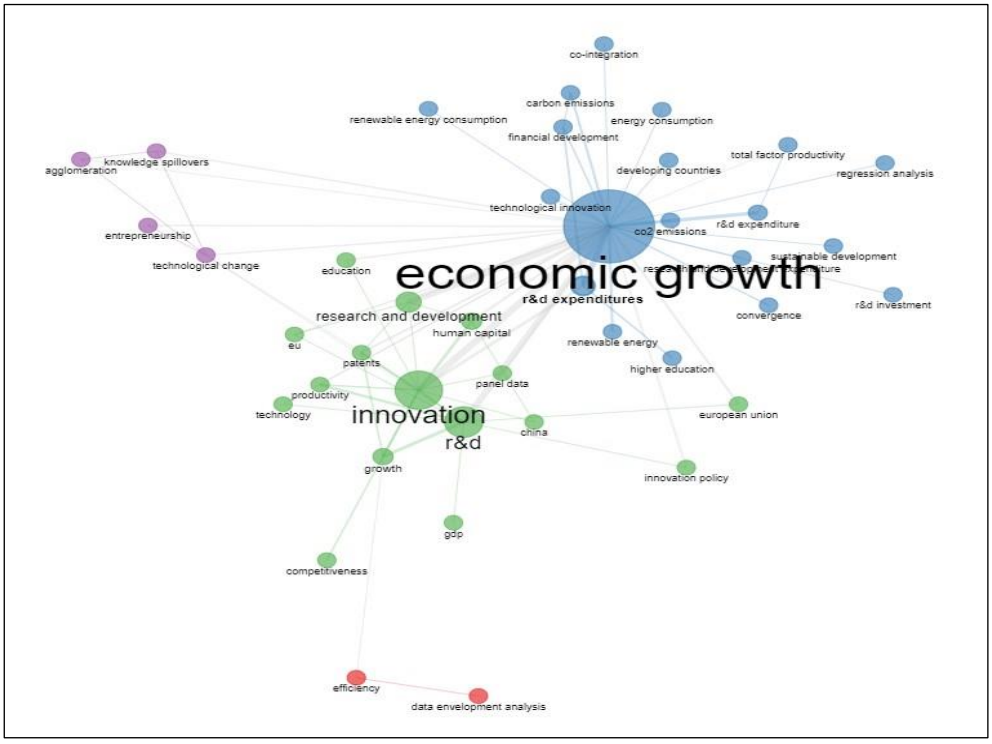
on economic development along with oil prices and internet volatility. They used panel data and applied the ARDL approach for testing the postulations. The results exhibited that inflation affects economic development only in the short run so advised the policymakers to keep inflation at a moderate level in the short run so that these countries can boost the economic growth at a regional level.

In a study about developing Asian economies, Uddin and Rahman (2023) used panel data to examine the impact of unemployment and inflation rate on GDP growth rate of 79 developing economies. The authors found positive association of inflation rate with GDP growth rate and suggested that a moderate inflation is helpful for sustainable economic growth of developing nations. As earlier endorsed, need to assess the role of inflation for GDP growth is a prerequisite in nature as it can greatly influences efforts in the way of economic growth especially among Asian developing countries (Aprilia et al., 2024; Hasran et al., 2023; Musarat et al., 2021). The unrestricted spending increases inflation which hampers economic development efforts and related policies. Inflation decreases the value of money and, resultantly, increases the outflow of foreign reserves in the long run hence, this study aims to fulfill this need while considering ASEAN and South Asian countries.

2.2.8 Conclusion from the Literature Review

A comprehensive review of existing literature economic growth reveals that it is dependent to several factors like R&D, FDI, NX, EMR, EMR and INF,

in different settings like region, country and methods. A keyword co-occurrence analysis conducted on the existing literature unveils a robust correlation among economic growth, R&D, and innovation, as depicted in Figure 2.8. This analysis underscoring the necessity for research endeavours that investigates into the economic impact of R&D, rather than merely acknowledging its traditional role.



Source: Adapted from (Shahid et al., 2024)

Figure 2.8: Keywords' Co-occurrence of Available Literature

In extension to the above analysis, the author selected the studies related to the countries under study for examination of R&D and economic growth literature which revealed the usage of economic indicators based on the regions and country level. Most of the researchers used annual data on R&D from industry and institutions to see their impact on economic growth. Table 2.3 depicts the tabular picture of the literature review of the studies related to ASEAN and South Asia considering the proposition of this study. The table depicts that only one author, Mehmood et al., (2022) used R&D expenditure to

evaluate its impact on economic development in the ASEAN region which shows the need for economic growth at country as well as at regional level.

Table 2.3: Summary of Economic Growth and Its Estimators

Variable	Author (s)	Results
Economic growth and development	Bieth, 2021; Haseeb et al., 2019	Energy consumption for economic growth leads to environmental pollution which has a significant impact on health expenditure among ASEAN countries in long-run and short-run.
Exchange Rate	An et al., 2020; Yussif et al., 2024	Economic growth rate improves with favourable change in exchange rate. Alongside, trade openness rate has a negative relationship while FDI has a positive relationship with on inflation rate.
Economic Development	Charutawe-phonnukoon, 2021	High levels of R&D investment at industry level leads to technology exports which enhance economic development.
R&D Expenditures	Mehmood et al., 2022; Saleem et al., 2023	R&D expenditures negatively associated with ecological footprints but leads to a sustainable development among Asian countries.
Exchange Rate	Ahmad et al., 2021	The volatility of currency rates and economic growth are mediated with trade which means that exchange rate volatility and economic growth will be impacted by the flow of investment into and out of the country.
Inflation	Aprilia et al., 2024; Rosnawintang et al., 2021; Uddin & Rahman, 2023	There is a bidirectional long-run while unidirectional causality in short-run of inflation with growth rate for the sake of economic development
Employment Rate	Farajzadeh et al., 2023; Irshad et al., 2022	Overall impact of FDI and employment on economic growth is insignificant. Human capital and globalization have positive impact on economic growth. The relation between FDI and employment is ambiguous

Source: Author's own development

On the basis of recent theoretical and empirical review of literature, following propositions need to evaluate in the form of current study.

- R&D expenditure is a major factor for economic growth and existing researchers used R&D investment at industry or institutional levels.

Economic role of R&D expenditures, to see their impact on economic growth investment, is rarely available in the literature which needs to be investigated.

- Macroeconomic factors are imperative for better understanding and effective policymaking considering the prevailing macro environment. This way, a study is needed that can help to accurately invest R&D for economic growth in scarce financial resources.
- The methods used in previous literature do not provide clear understanding of macroeconomic factors which highlights the need of comparative study for better planning which will further help to achieve the SDGs.

On the basis of these literature-backed gaps, this study intends to make comprehension of macroeconomic environment of ASEAN and South Asian countries. The better understanding of macroeconomic factors will help policymakers to make wise R&D investment decisions in presence of limited financial resources. This way, the proper allocation of financial resources will help to invest in R&D along with looking the alternative ways to enhance R&D expenditures. This way, it helps in setting a new theoretical and empirical direction for better policy suggestion among the countries under study.

2.3 Conclusion

The thoughtful review of the existing literature highlights the emergent need for investigation of R&D and macroeconomic factors for increased GDP growth rate. To meet this endeavour and find the generalizable answers to the

research questions, a rigorous series of methods is needed considering R&D and the macroeconomic indicators following economic growth models. Thus, for this impartiality, the study intends to use the panel data model and VECM model on time series data to examine the long-run and short-run effects of these factors on the GDP growth rate. In addition, ex-post forecasting is also needed backed by accurate models resulting from these methods. The details of suggested methods along with their appropriateness with this study have been described in the coming chapter 3 of this study.

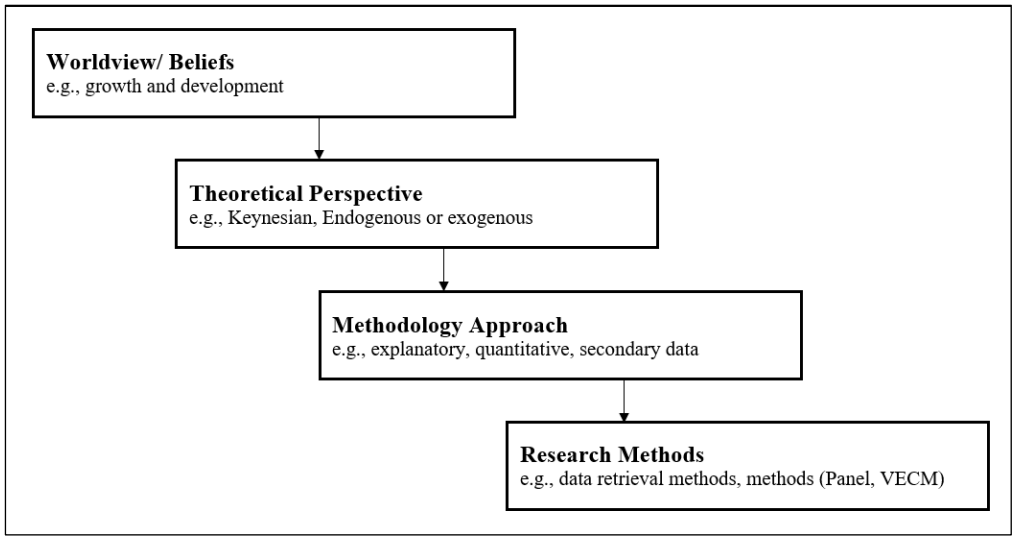
CHAPTER 3: RESEARCH METHODOLOGY

3.0 Introduction

The review of existing literature done in the previous chapter highlighted the need for a study examining R&D expenditures' impact on GDP growth rate considering the current uncertain economic situation of developing countries. For this purpose, this study concluded to account for FDI, NX, EXR, EMR and INF with R&D expenditures as exogenous variables so that a comparative study for sustainable economic growth can be produced. Now, the need is to adopt an appropriate method which can provide rigorous and generalizable results. Accordingly, this chapter explains the research methodology including the research framework, models' specification, analysis procedure, and analytical approach to meet the objectives and to test the research hypotheses. Specifically, at first, this chapter illustrates the conceptual framework of the study followed by the model specification and hypotheses development. To test these hypotheses, the data collection and screening process followed by the description of the data, correlation analysis, and parameters for proposed analysis methods have been discussed. After that, the suitability of panel data and VECM have been discussed. In later stages, model evaluation and accuracy of the results approaches have been given for policy recommendations to boost economic growth at the regional as well as at country level separately for panel and the VECM methods.

3.1 Research Design

A research design is an approach to get answers to research questions or to achieve a research objective (Johnstone, 2014; Sekaran & Bougie, 2016). It begins with the topic and paradigm of the study and leads to setting a research objective(s), defining the population and data sources, then collecting data and finally selecting appropriate analysis methods hence, this study adopted the research design depicted in Figure 3.1.



Source: Adapted from (Creswell, 2011; Hedlund-de Witt; 2012; Johnstone, 2014)

Figure 3.1: Four Levels of Research Design

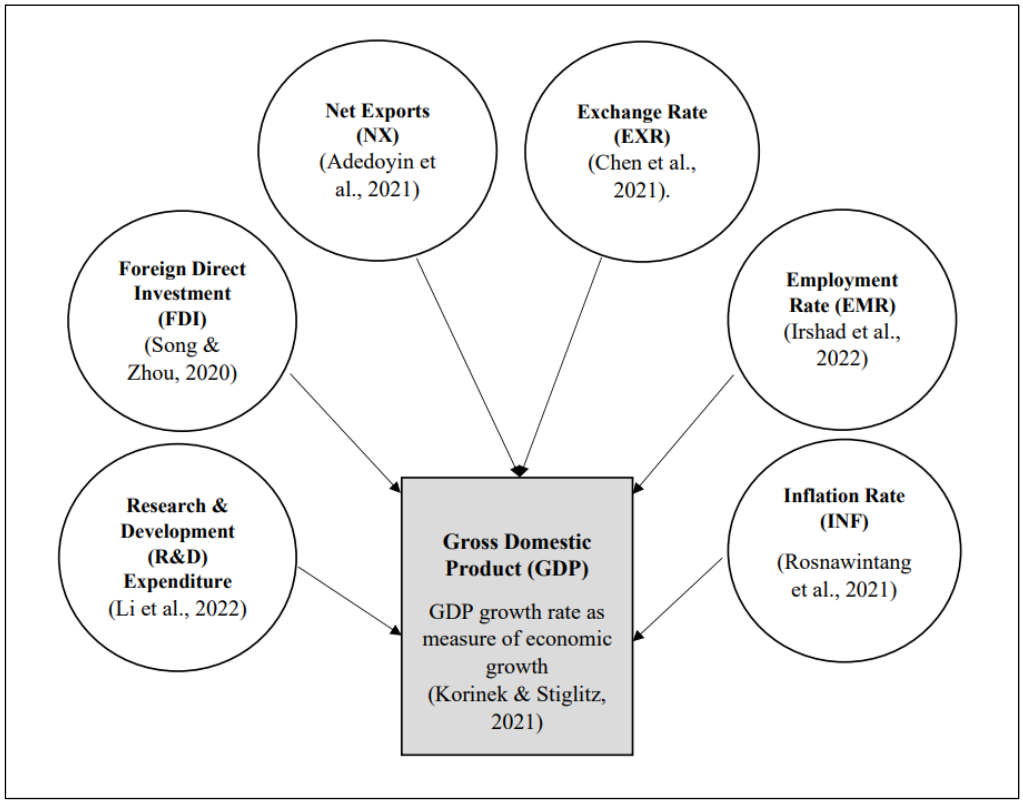
The methodological approach introduced by Hedlund-de Witt (2012) advocates for the integration of quantitative data studies with a worldview perspective, especially concerning sustainable development extending the mixed method approach of Creswell, 2011. Hedlund-de Witt's methodology highlights the importance of using secondary data and aligning research designs with specific worldviews. In this methodological framework, the study adapts the research topology to accommodate quantitative methods, drawing from the

methodological worldview proposed by Hedlund-de Witt and Creswell. In later years, Johnstone (2014) modified the approach truly from a macroeconomic perspective. This adaptation involved a deliberate alignment of research design elements with the chosen worldview, influencing decisions regarding data collection, analysis, and interpretation from macro-perspectives. Hence, the research methodology for this study has been based on its placement with the underlying theoretical perspective, which guides the selection of appropriate procedures for gathering, analyzing, and interpreting data for testing the different theories at the same time. The methodology serves as a systematic guide, ensuring that the research process is coherent and robust to assess the application of R&D-based endogenous and exogenous viewpoints. Detailed attention is given to the research framework, with a focus on delineating specific components such as data collection techniques, analytical methods, and interpretation strategies. This methodological approach emphasizes the integration of quantitative methods with theoretical frameworks, aiming to achieve research goals effectively within the context of sustainable development goals emphasizing the economic growth objective.

3.2 Conceptual Framework of the Study

The research framework of this study has been presented below through Figure 3.2. Accordingly, the figure depicts the relationship of R&D expenditures, macroeconomic variables and GDP growth rate for running the models for panel data analysis and VECM analysis methods. Specifically, this study intends to examine the combined effect of R&D expenditure, FDI, NX,

EXR, EMR and INF on GDP growth rate using panel data model using data of ASEAN-5, South Asia-3 and ASEAN-5*SA-3 while VECM analysis using the time series data of each country, Indonesia, Malaysia, the Philippines, Singapore, Thailand, India, Bangladesh, and Pakistan. It is important to mention that data on the GDP growth rate has been used as a measure of economic growth.



Source: Author's own development

Figure 3.2: Conceptual Framework of the Study

3.2.1 Research Approach and Methods

When the same cross-section unit has been observed at multiple times, it described as panel data. As objective of this study is to conduct group-wise analysis at each region and combined, panel data can provide robust and reliable

results because it has economic patterns and relationships (Awan et al., 2020; Coondoo & Dinda, 2002). Further, according to Hsiao (2007) and, Gujarati and Porter (2015) panel data are appropriate in the following ways.

- If there are numerous factors affecting an indicator, panel data model helps to control the effect of omitted variables?
- Panel data model is appropriate to uncover the dynamic impact in case of macroeconomic factors and,
- It also helps in pooling the data to provide forecasts for outcomes rather than using the data for the specific entity to produce predictions rather than individual outcomes.

Panel data model have been used in existing studies due to its wide applicability in empirical studies. For example, Redmond and Nasir (2020) applied this model to examine the impact of international trade and trade openness on economic growth for 30 chosen economies around the world. They concluded that international commerce had a favourable impact on economic growth applying FMOLS and DOLS estimators on panel data. Ribeiro et al. (2020) considered 54 developing countries' panel data from 1990 through 2010 and employed a generalized method of moments (GMM) approach. By observing two different types of impacts on emerging nations, they discovered the dynamic relationships between exchange rate and economic growth: Initially, changes in the production structure were linked to an undervaluation of the currency rate. Second, undervaluation contributed to income disparity, which had a detrimental weight on economic growth.

For time series data, a co-integrated vector autoregressive (VAR) model or the Vector Error Correction Model (VECM) of the order (p -1) can provide better understanding in single country setting. It can be estimated in presence of co-integration among study's variables as it allows to estimate short-run as well as long-run coefficients (Gujarati & Potere, 2015). Using these estimations, it helps to analyse long-run equilibrium and short-run deviation which further help in forecasting (Kuo, 2016; Zhu et al., 2022).

Table 3.1: Existing Research Methods

Title/ Context	Author(s)	Methods
Climate change triggered by energy consumption and economic growth of Turkey through ARDL method	Acaroğlu & Güllü, 2022	Time series ARDL
Examination of spillover effect of economic growth and energy consumption through health and R&D expenditure of ASEAN countries	Haseeb et al., 2019	ARDL
Assessment of public expenditure and economic development of BRICS-SAARC-ASEAN region	Ansari et al., 2021	Fully modified OLS estimator
Investigation of the linkages between macroeconomic indicators and economic growth in Pakistan through wavelet analysis approach	Hayat et al., 2021	ARDL, Granger's Causality test
Correlation between energy consumption, tourism, and economic growth in India	Jayasinghe et al., 2021	ARDL and VECM
Observe the impact of exchange rate on economic growth in Bangladesh	Khan et al., 2021	ADF, Phillips-Peron Unit Root Test, and OLS
Women employment and sustainability for Malaysian economic development	Khin et al., 2021	VECM model
The assessment of environmental sustainability through research and development among ASEAN countries	Mehmood et al., 2021	Dynamic Ordinary Least Squares (DOLS), Modified Ordinary Least Squares (FMOLS)
Examination of the impact of green finance, capital formation, and educational expenditure on growth of ASEAN economies	Ngo et al., 2022	Fixed Effects model (FEM) and generalized method of movements (GMM)
Effects of oil prices volatility and inflation on economic growth among ASEAN-5 countries	Rosnawintang et al., 2021	ARDL, wavelet test
Technological innovation and economic growth in Southern Africa and Asia	Anakpo and Oyenubi, 2022	Dynamic Ordinary Least Squares (DOLS),

Source: Author's own development

As this study intends to conduct growth forecasting with the expected long-term relationship between variables of each country adjustments for GDP growth rate in the short-run, VECM is thought to be the best method for this study setting. To identify the detailed trends considering recent macroeconomics, the researcher went through a profound literature, which has been provided in Table 3.1, for the perusal of appropriate analysis methods to make a decisive conclusion. The table represents the methods used during the last three years to evaluate economic growth and development among the regions under study. To overcome stationarity issues, researchers used the ADF unit root test and then several analyses like ARDL, VCM, VECM, ARIMA and NARDL to observe the relationship among variables, are used by the researchers. Acaroğlu and Güllü (2022), Haseeb et al. (2019) and Khan et al. (2021) applied the ARDL method to the times series data of economic growth. When we relate this study setting with the analysis methods, it reveals that stationarity among macroeconomic variables commonly exists so, the ADF unit root test will be applied to overcome this issue. It is worth mentioning that researchers like Ngiik et al. (2021), Rosnwintang et al. (2021) and Jayasinghe (2021) highlighted that VECM provides a clear long-run and short-run picture of available data which needs to be tested among ASEAN and South Asian countries. Keeping in view the current study setting, suggestions from previous studies, and the need for a comparative study, this research intends to use the Panel Data Model to see the dynamics relationships of macroeconomic indicators with respect to GDP growth rate and Vector Error Correction Model for long-run/short-run co-integration relationship of entities to estimates the coefficients efficiently.

3.2.2 Empirical Model Specification

The model specification is a set of procedures to be followed in order to get study's overall objectives. This section portrays a series of procedures, function, tests, and methods in order to fulfill the general objective of the study. GDP and all six macroeconomic variables involvement in the model has been shown in the following material. This study basically constructs the following function of the EG and other independent variables for ASEAN-5 and South Asian-3 countries:

$$GDP = f(R\&D, FDI, NX, EXR, EMR, INF) \quad \text{(Eq. 3.1)}$$

Where;

GDP = GDP growth rate (Real, in %age)

R&D = Research and development expenditures (%age of GDP in US$)

NX = Net exports (exports – imports in US$)

EMR = Employment rate (% to total labour force)

EXR = Exchange rate (to US$)

FDI = Foreign direct investment (in US$)

INF = Inflation rate (% increase in consumer price)

Natures of all the variables, their meaning and data sources has been discussed in Table3.2 in the coming pages.

3.2.2.1 Panel Model Specification

The panel model for the study has been built as growth equation corresponding to production function considering R&D expenditures and other macroeconomic variables in the following manners.

Panel Model of R&D Expenditures and Economic Growth of ASEAN-5

$$\Delta GDPA_{it} = \beta_0 + \beta_1 \Delta R\&D_{it-1} + \beta_2 \Delta FDI_{it-1} + \beta_3 \Delta NX_{it-1} + \beta_4 \Delta EXR_{it-1} + \beta_5 \Delta EMR_{it-1} + \beta_6 \Delta INF_{it-1} + \varepsilon_1 \quad \text{(Eq. 3.2)}$$

Panel Models for R&D Expenditures and Economic Growth of South Asia-3

$$\Delta GDPS_{it} = \beta_7 + \beta_8 \Delta R\&D_{it-1} + \beta_9 \Delta FDI_{it-1} + \beta_{10} \Delta NX_{it-1} + \beta_{11} \Delta EXR_{it-1} + \beta_{12} \Delta EMR_{it-1} + \beta_{13} \Delta INF_{it-1} + \varepsilon_2 \quad \text{(Eq. 3.3)}$$

Panel Models for R&D Expenditures and Economic Growth of ASEAN-5*SA-3 (Combined Data Model)

$$\Delta GDPAS_{it} = \beta_{14} + \beta_{15} \Delta R\&D_{it-1} + \beta_{16} \Delta FDI_{it-1} + \beta_{17} \Delta NX_{it-1} + \beta_{18} \Delta EXR_{it-1} + \beta_{19} \Delta EMR_{it-1} + \beta_{20} \Delta INF_{it-1} + \varepsilon_3 \quad \text{(Eq. 3.4)}$$

In the above equations (3.2), (3.3) and (3.4); GDPA shows the GDP growth rate of ASEAN-5, GDPS means GDP growth rate of South Asia-3 and GDPAS denotes to GDP growth rate of ASEAN-5*SA-3 respectively. The subscripts '*i*' mean the region and 't' means time in years, β_0 = intercept, and β_1 to β_{20} = the coefficients of the independent variables whereas, Δ represents the first difference data. The 'ε_1' ε_2, and ε_3 represent error term assumed to be homoscedastic and with no serial correlation among the residuals.

3.2.2.2 VECM Model Specification

The macroeconomic variables are non-stationary in nature due to trend and seasonality (Pal & Mittal, 2011; Galadima & Aminu, 2019) which leads this study for multivariate analysis. When such variables have long-run dynamics, VECM depicts most appropriate relationship results and trustworthy results. This model helps in steady adjustment of each variable from long-run to short-run (Ampofo et al., 2021). In order to overcome spurious correlation among variables, this framework created by Johansen co-integration permits the incorporation of a variety of steps in both short-term relationships co-integrating and the long-run adjustments. Depending on the data, different trends and coefficients are specified. The accurate trend specifications must be determined after some preliminary analyses.

VECM Models for R&D Expenditures and Economic Growth of ASEAN-5 Countries

The following VECM model has been specified for each country from ASEAN region i.e., Indonesia, Malaysia, the Philippines, Singapore, and Thailand and has been run separately for each country.

$$\Delta GDPA_t = \beta_{21} + \beta_{22}\Delta R\&D_{t-1} + \beta_{23}\Delta FDI_{t-1} + \beta_{24}\Delta NX_{t-1} + \beta_{25}\Delta EXR_{t-1} + \beta_{26}\Delta EMR_{t-1} + \beta_{27}\Delta INF_{t-1} + \varepsilon_{4t} \quad \text{(Eq. 3.5)}$$

In the given above model, equations (3.5), GDPA means the GDP growth rate of for five countries from ASEAN. The equation shows the general model by using which a separate econometric model has been specified for each

country of ASEAN-5 i.e., Indonesia, Malaysia, Philippines, Singapore, and Thailand. The model shows $\Delta = 1^{st}$ different level of stationary with time-series data and the 'ε_{4t}' represents error terms for VECM models.

VECM Models for R & D Expenditures and Economic Growth of South Asian-3 Countries

$$\Delta GDPSA_t = \beta_{28} + \beta_{29}\Delta R\&D_{t-1} + \beta_{30}\Delta FDI_{t-1} + \beta_{31}\Delta NX_{t-1} + \beta_{32}\Delta EXR_{t-1} + \beta_{33}\Delta EMR_{t-1} + \beta_{34}\Delta INF_{t-1} + \varepsilon_{5t} \quad \text{(Eq. 3.6)}$$

In the same way as it was specified for five (5) countries from the ASEAN region, this model (equation 3.6) shows the VECM models' specification for each country from the South Asian region i.e., Bangladesh, India, and Pakistan. Further, $\Delta = 1^{st}$ different level of stationary with time-series data and the 'ε_5' represents error term for VECM models of each country.

3.2.3 Research Hypotheses

3.2.3.1 Panel Model Hypotheses

Hypotheses Development of R&D Expenditures and Economic Growth for ASEAN-5

H_{01}: There is no significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of ASEAN-5 Countries.

H_{A1}: There is a significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of ASEAN-5 Countries.

Hypotheses Development of R&D Expenditures and Economic Growth for SA-3

H_{02}: There is no significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment rate (EMR) and inflation rate (INF) on economic growth (EG) of South Asia-3 Countries.

H_{A2}: There is a significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of South Asia-3 Countries.

Hypotheses Development of R&D Expenditures and Economic Growth for ASEAN-5*SA-3 (Combined Data)

H_{03}: There is no significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) for ASEAN-5 x SA-3.

H_{A3}: There is a significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) for ASEAN-5 x SA-3.

3.2.3.2 VECM Method Hypotheses for Each Country

Alongside the panel data model hypotheses at the regional level, this study developed the following hypotheses for the VECM method at the country level. It is important to mention that the impact and relationship for VECM are the same, but it has been run using country-level data, hence, hypotheses have been developed for each country in the following manners.

Indonesia

H_{04}: There is no significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Indonesia.

H_{A4}: There is a significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Indonesia.

Malaysia

H_{05}: There is no significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Malaysia.

H_{A5}: There is a significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment

rate (EMR), and inflation rate (INF) on economic growth (EG) of Malaysia.

Philippines

H_{06}: There is no significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Philippines.

H_{A6}: There is a significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Philippines.

Singapore

H_{07}: There is no significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Singapore.

H_{A7}: There is a significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Singapore.

Thailand

H_{08}: There is no significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Thailand.

H_{A8}: There is a significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Thailand.

Bangladesh

H_{09}: There is no significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Bangladesh.

H_{A9}: There is a significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Bangladesh.

India

H_{010}: There is no significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of India.

H_{A10}: There is a significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of India.

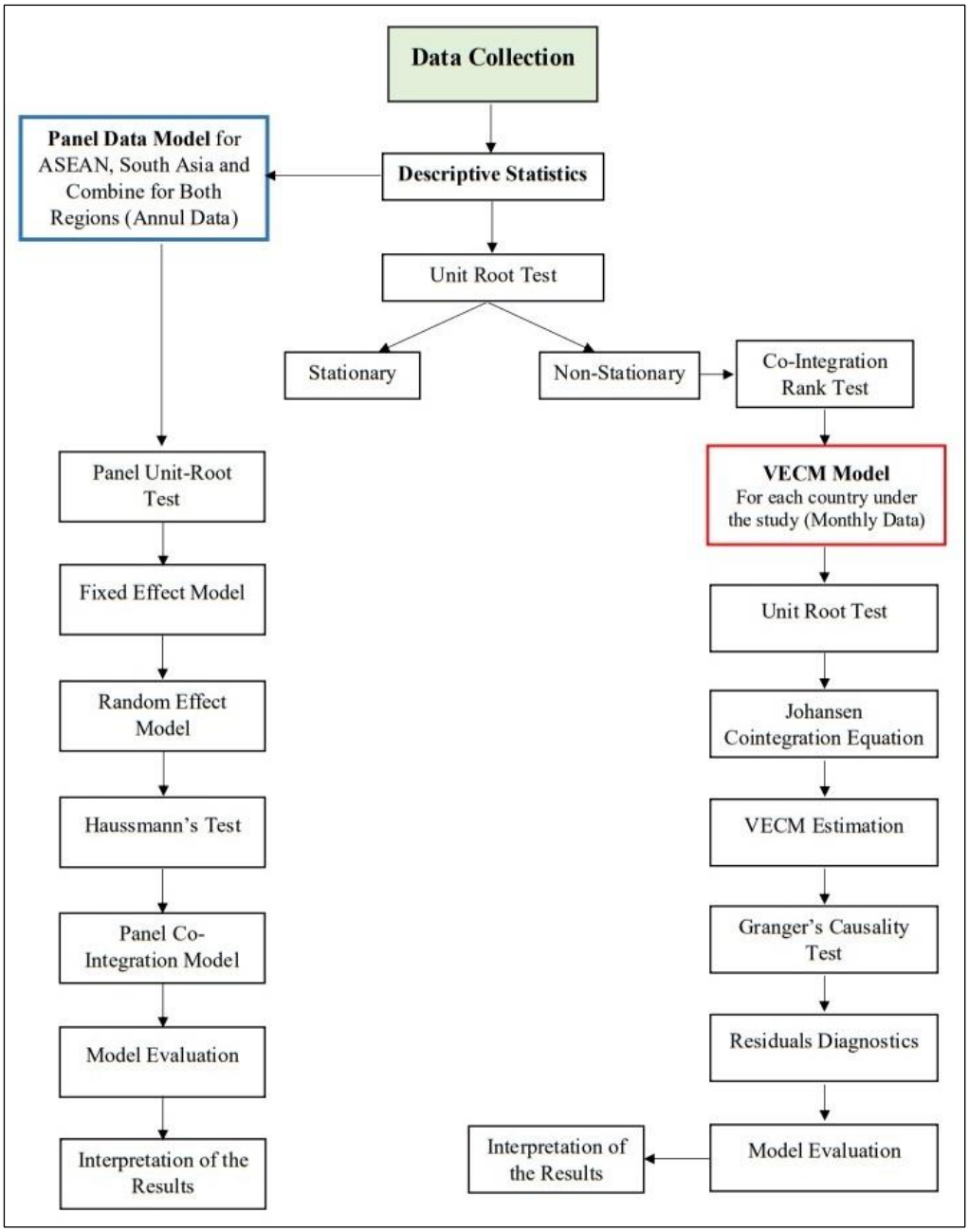
Pakistan

H_{011}: There is no significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Pakistan.

H_{A11}: There is a significant impact of R&D expenditures (R&D), net exports (NX), foreign direct investment (FDI), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Pakistan.

3.3 Analysis Procedure

The research procedure entails a number of organized steps that a researcher must take in order to provide knowledge that will be valued by the project and concentrate on the pertinent topic (Johnston, 2014; Mishra& Alok, 2022). After data collection, this study conducted exploratory analysis of the variables through descriptive statistics which provides understanding of the data. After that panel data analysis procedure was applied as described on the left-hand side of Figure 3.3. At first, the study had to select between the appropriateness of the model from Pooled OLS, Fixed-Effect Model (FEM), or the Random-Effect Model (REM) on the basis of Breusch-Pagan test using Lagrange multiplier and Hausman test results. After analyzing the data using appropriate method, model evaluation and interpretation of the results for panel data analysis has been provided.



Source: Author's own development

Figure 3.3: Analysis Procedure of the Study

Figure 3.3, from right-side is showing that first this study assesses the stationarity of the variables through unit-root tests. Later, it run Johansen's co-integration tests to confirming the existence of long-run co-integration. After confirming the existence of co-integration, the selection between vector autoregressive (VAR) and error correction model (ECM) has been made. In

presence of long-term co-integration, vector error correction model (VECM) has been found best to explain the short-run dynamics among the variables. Granger's Causality test to see the causality between GDP, RD& and macroeconomic variables has been assessed. At later stages, model simulation and prediction has been run using the VECM model results before residual diagnostics. Residual diagnostic tests for heteroscedasticity, multi-collinearity and autocorrelation are important assumptions for a time series model. Hence, these have been checked and verified for the model.

3.3.1 Population of the Study

Population of this study has been described in two categories: regional, and individual country level. Regional data has been analysed using panel data which includes the ASEAN-5, composed of five (5) countries namely Indonesia, Malaysia, the Philippines, Singapore, and Thailand while for South Asian-3 region, Bangladesh, India and Pakistan have been selected to represent their region based on regional representation, GDP volume, investment in R&D and availability of the data (Lakitan, 2019; Ravi & Janodia, 2023). Combined data for these two regions (ASEAN-5*SA-3) also examined using panel data method. For VECM method, this study used monthly data of all eight (8) countries developing a separate hypothesis for each country clearly for testing purpose.

3.3.2 Data and Description of Variables

This study run panel data analysis using regional data while VECM analysis using country-level data. For regional, ASEAN-5, South Asia-3 and ASEAN-5*SA-5, annual panel data ranging from 1990 to 2019 has been used. For VECM analysis, monthly data from 1990 to 2019 of all eight (8) countries has been used in this study. The intension behind skipping the latest years' data (i.e., 2020-2023) was to eliminate the uneven effects of COVID-19 for better policy suggestions using forecasting through multivariate time series data analysis (Ioannidis et al., 2022). It is pertinent to mention that forecasting has been done through exponential smoothing to evaluate long-run followed by short-run estimation amid the variables (Chen et al., 2021a; Keilbar & Zhang, 2021).

Using data of WDI from World Bank data portal has ease of access with reliability for policy suggestion with a wider coverage (Jolliffe et al., 2021) hence, current study retrieved most of the data from World Bank's data portal. A reliable and specialized data source for exports has been suggested (Yang et al., 2023) hence, this study used data of trading economics for trade balance while for employment rate, United Nation has authorized International Labour Organization to maintain data with consultation of countries' data portal (Standing, 2008). Hence, the data used for analysis procedures is reliable, credible and dependable with a view of comparative accuracy and actionable policy suggestions.

Table 3.2: Description of Dependent and Independent Variables

Variable	Meaning	Measurement	Theoretical Justification	Possible impact	Data Source
GDP	Gross domestic product	GDP growth rate (real, in %age)	Classical "economic theory of growth" states that increase in GDP means that economy is doing well	+	World Bank (WDI) IMF
R&D	Research and development expenditures	Expenditures made on R&D as aggregate % of GDP	Investment in R&D seek positive effects on innovation and modernization which further results in economic growth (endogenous growth theory)	+	World Bank (WDI), Statista, UNESCO Institute of Statistics
NX	Exports minus imports (trade balance)	At current USD (converted to %age)	Favourable exports flows funds to the economy which increase the growth level (Keynesian multiplier)	+	World Bank (WDI), Trading economics
EMR	Employment rate	Percentage of labour force	Increased employment rate enhances economic growth as a factor of production (Keynesian multiplier)	+	World Bank (WDI), and ILO
EXR	Exchange rate	Local currency to US$ (at current)	According to the balance of payment concept, it is a resource-seeking indicator which summarizes the transaction through trade and is associated with GPD.	-	WDI- World Bank IMF
FDI	Foreign direct investment	Net inflow, (%age of GDP)	Inflow adding to economic growth (monetarist view of economic growth)	+	World Bank (WDI), and IMF
INF	Inflation rate	Consumer price index (CPI)	Changes in aggregate demand results in inflation which effects growth (Keynesian economics, Philips curve)	-	World Bank (WDI), Trading economics

Source: Author's own development

At first, the data were downloaded from the data portal of the World Bank, IMF, ILO, Statista and Trading Economics as presented in Table 3.2. The table represents the details of variables, their measurement, possible theoretical justification, and the data sources from which the data was obtained for this study. In the first two columns of the table, variables and their meaning have been provided while their measurement and possible economic impact have been given in subsequent columns. It is important to note that the data were downloaded from the source yearly for the panel data model while monthly based on the availability of the given data sources. The author found it difficult to download monthly data, especially for Bangladesh and Pakistan so to solve this issue, this study used the match-sum data technique in EViews-13 to convert yearly and quarterly data into monthly data where appropriate (Godil et al., 2021; Sharif et al., 2019; Suki et al., 2020). This study used data from diverse-natured countries having vast variations (e.g., in exchange rate, growth rate etc.) which needed screening and normalization of the data. Other, GDP per capita growth rates were supposed to be present in percentage (%) whereas other data like EXR and NX were not available in percentage. Hence, in order to avoid any kind of misrepresentation, the author used MS Excel to normalize the data and make all the observations in the same pattern. After that, a number of tests using EViews-13, from different perspectives, were applied to the data for robust results related to the study's goal. For analysis purposes, the author used EViews-13 software as numerous existing studies strongly suggest using this software for panel (Agung, 2013) and time series analysis when the forecasting is the objective of a study (Aljandali et al., 2018).

3.3.3 Descriptive Analysis

Descriptive analysis is a statistical technique which shows the characteristics of the variables included in a study. Normally, it shows the mean, median, maximum/ minimum values and standard deviation of the dataset. The goal of a descriptive analysis is to summarize a sample rather than use the data to infer information about the sample of data which is different and provides the foundation for inferential statistics (Fisher & Marshall, 2009). Hence, to understand the behaviour of the data, a detailed description of the data has been provided before correlation and running the final analyses.

3.3.4 Correlation Analysis

Correlation analysis is a statistical technique that is used to determine whether or not there is a relationship between two variables or a dataset and to determine the intensity of the relationship between the variables or dataset (Gujarati & Porter, 2009; Studentmund, 2014). This means that, in terms of market research, correlation analysis is used to examine quantitative data collected from various research techniques like surveys, polls, and data sources in order to determine whether there are any notable relationships, patterns, or trends between the variables. As this study uses R&D along with five macroeconomic variables i.e., FDI, EXR, NX, EMR, and INF as exogenous variables to predict economic growth though GDP growth rate as the endogenous variable. The nature and intensity of the relationship among the study's variables will be analysed through correlation analysis.

3.4 Panel Data Analysis

Panel data offer multiple observations on individual entities (e.g., countries in this case) at distinct historical occurrences. The persistent use of these methods in scholarly work during the last four decades can predominantly be attributed to two principal factors; 1) panel data offers the capacity to mitigate the influence of specific unobserved heterogeneities and endogeneity issues arising from omitted variables and measurement inaccuracies and, 2) it facilitates the estimation of dynamic relationships from high volume data, avoiding aggregation bias, collinearity among variables, more degrees of freedom and efficiency in presence of large amount of data (Chamberlain, 1984; Baltagi et al., 2013; Gujarati & Porter, 2015). This method was first developed by Holtez-Eakin in 1988 and later got vide fame due to its multi-functionality, especially in the case of a larger set of data on macroeconomics. It is appropriate for examining not only the link between complex variables but also to evaluate the impact of one variable on another (Shen, 2020).

Panel data is a combination of both cross-sectional and time-series data and is denoted by subscript ‘it’ as ‘i’ belongs to cross-sectional data and ‘t’ belongs to time-series data (Sarafidis & Wansbeek, 2021). The panel data model has unique attributes to provide insightful answers to the research questions related to two regions separately and as a whole as well because of analytical type questions on large data. In this study, FEM has been tested for efficiency and variability of the data to control the missing effect by introducing dummies in the data (Hsiao, 2007). Due to this time trend and endogeneity, this study

applied a panel data model benefitting from the long panel data sets (Sarafidis & Wansbeek, 2021). As this study uses a long panel with diverse natures of time series, the panel data analysis necessitates a comprehensive consideration of both spatial and temporal dimensions inherent within the data.

Among available studies, a chronological review of the panel data analysis method for the last three years depicts the use of a panel data model to see the relationship of variables using large-scale of large-scale datasets. Panel vector autoregressive (PVAR) was used on macroeconomic data of 105 countries to find a relationship among the variables and suggest a suitable policy measure (Hao, 2022) because the panel data model is an important tool to observe fixed and random effects among the large-scale data for authentic and reliable outcomes (Batrancea et al., 2022; Khan et al., 2021). Some researchers used a panel data model for the long-term effects of COVID-19 on e-commerce. The results of the study highlight the generalizability of the panel model in every field of life. This is the case of a developed economy but when we want to know about this model functionality among developing countries, it reveals gender equality (one factor) has a significant relationship with economic development (another variable) exists among developing nations of sub-Saharan countries (Altuzarra et al., 2021; Kawasaki et al., 2022). In the case of South Asian and ASEAN countries, the panel model is equally important to evaluate the connection on fixed effect and random effect basis, the relationship between endogenous and exogenous variables is bidirectional and significant (Bibi, 2020; Ho et al., 2022). In a study on BRICS and ASEAN countries, Rahman (2021), successfully applied a variety of panel model tools like the

panel quantile regression method, panel co-integration test, and heterogeneous panel causality test and impulse response function. The author found a long-run association among macroeconomic variables of economic development and suggested a suitable functionality of the model.

Given these studies' outcomes, it is evident that the panel data model has been described as the best model when we talk about the macroeconomic factors at a larger scale of the economy. Hence, considering exogenous factors for GDP growth rate for this study, the panel data model can meet the objective of the study for examining the combined effect of long panel data.

3.4.1 Panel Unit-root Test

Examination of the trends in data is the initial and most fundamental parameter to conduct a panel data analysis especially when a regression has been applied to panel data (Kwiatkowski et al., 1992). Usually, macroeconomic time series data is non-stationary with uneven mean, and variance which makes data handling difficult and non-reliable regression results (Pesaran, 2012; Sukmawati & Haryono, 2021). Econometricians have proposed various tests for assessing stationarity, such as those introduced by Dicky and Fuller (1979), Levin-Lin-Chu (2002), and Im, Pesaran, and Shin (2003). Subsequently, Maddala and Wu (1999) suggested the Augmented Dicky and Fuller (ADF) (1981) test, which accounts for variations in slope and intercept in cross-country panel data. These tests have since been refined and are now considered second-

generation tests, offering more robust results than standard time-series unit root tests (Narayan & Liu, 2015).

The data of this study has greater fluctuations in macroeconomics (i.e., macroeconomic variables like exchange rate), and convergence of macroeconomics towards GDP growth rate. Hence, the study intends to apply stationarity tests on the data using Levin-Lin Chu and Im-Pesaran & Shin for panel data. The test parameters suggest that if the result of unit root tests indicates p> 0.05, then the null hypothesis will be rejected. These tests have been conducted to check the stationarity of the data to run the panel data analysis in subsequent among Pooled OLS, FEM and REM to know the relationship and effects among panel data variables.

3.4.2 Panel Co-integration Test

A panel co-integration test needs to be conducted to examine the existence of co-integration among a study's variables. As discussed earlier, this study uses macroeconomic variables which are expected to be stationary at the first difference *I*(1) which leads to testing the panel co-integration. If the data is found stationary at level *I*(0), the Angle Granger test is suggested and where the data is stationary at the first difference *I*(1), the Johansen Co-integration test is recommended. This study uses panel data analysis on the regional level, so it intends to evaluate long-run and short-run relationships among the variables through panel co-integration which is suggested by many previous researchers (Jin & Kim, 2018). Kao (1999) tests assuming that all of the co-integrated

vectors in each cross-section data are identical by combining all of the residuals from all of the cross-sections in the panel. For this purpose, the following equation has been formed.

$$Y_{it} = a_i + X_{it}\beta + \mu_{it} \quad \text{(Eq. 3.7)}$$

After that, to treat heterogeneity, tests suggested by Pedroni (2004) have been applied to examine the null hypothesis (H_0) that there is no co-integration in nonstationary panels. A set of seven test statistics allow for both short-run dynamics and long-run slope and intercept coefficient variability in the panel. For this test, Pedroni proposed following equation model.

$$Y_{it} = a_i + \delta_t \sum_{m=1}^{M} \beta_{mi} X_{mi,t} + \mu_{it} \quad \text{(Eq. 3.8)}$$

Where;

Y= dependent variable, 'δt' shows time effect, X are supposed to be combined of order one 1(1) while μ shows error term.

3.4.3 Panel Model Selection

After unit-root and panel co-integration tests, this study aims to select the appropriate model for panel data of ASEAN-5, South Asia-3 and combined data model. For this purpose, a rigorous process including Pooled OLS, Breusch-Pagan test (Breusch & Pagan, 1979) and Hausman's test has been performed to select appropriate model to run as discussed below. These steps and procedures to be followed in the following manners separately for each dataset.

1. Pooled OLS

   H0: Pooled OLS is appropriate. (P> 0.05)

   H1: Either REM or FEM is appropriate. (p< 0.05)

   Apply ***Breusch-Pagan*** Test for POLS appropriateness, if p< 0.05, reject null hypotheses and go for REM or FEM.

2. Run REM

   H0: REM is preferred. (p> 0.05)

   H1: FEM is appropriate. (p< 0.05)

   Apply ***Hausman Test*** for REM appropriateness, if p>0.05, accept null hypotheses which means REM is appropriate. Otherwise, go for FEM.

3. At later stage, run the appropriate model based on the results of Hausman test results.

3.4.3.1 Fixed Effect Model

A statistical model called fixed effect model (FEM) uses fixed (non-random) values as its parameters. It is typically used to examine the relationship between predicting and outcome factors within an entity and to examine the impact of variables that change over time (country, company, person, etc.). In an FEM, it is acceptable for the unobserved variables to have any kind of relationship and correlation with the observed variables. It can partially or fully eliminate the impact of time-specific factors with respect to time and entity (Verbeek, 2008; Wooldridge, 2010). The following equation represents the model to test the subsequent hypothesis developed for this method:

$$Y_{it} = \beta_1 X_{it} + \alpha_i + \mu_{it} \qquad \text{(Eq. 3.9)}$$

Where;

Y_{it} is the dependent variables, X_{it} = independent variables, α_i = intercept and μ_{it} = error term for the model.

H_0: POLS is preferred.

H_A: FEM is preferred.

The acceptance or rejection of the hypothesis has to be done on the basis of level of significance obtained through Breusch-Pagan test. If $p \geq 0.05$ then pooled OLS is appropriate and if $p \leq 0.05$ at significance level, then we reject the null hypothesis (H_0) and accept the alternate hypothesis (H_1) for FEM appropriateness.

3.4.3.2 Random Effect Model

Also known as the variance component model (VCM), the random effect model (REM) allows when the parameters are uncorrelated and not fixed, and randomness in the sample exists. It is opposite to FEM as each entity in this model has a different intercept due to differences in factors and independence of the error term for any observation. Following is the mathematical equation of REM followed by a hypothesis to test through this equation.

$$Y_{it} = \beta_1 X_{it} + \alpha_i + \mu_{it} + \varepsilon_{it} \quad \text{(Eq. 3.10)}$$

Where, Y_{it} is the dependent variables, X_{it} = independent variables, α_i = intercept and μ_{it} = error term between the entities (non-random part δ) and ε_{it} is the error term of the entity.

H_0: POLS is preferred.

H_A: REM is preferred.

The acceptance or rejection of the hypothesis has to be done on the basis of level of significance i.e., P's value. If *Ps'* value less than α 0.05 at significance level, then the null hypothesis will be rejected otherwise it leads that REM is appropriate and preferred.

3.4.3.3 Hausman Test

When fixed effect and random effect models have been run, the researcher is allowed to select among FEM and REM through the results of Hausman test (1978), sometimes called test for model misspecification. For this test, following hypothesis has been developed to test through Hausman test for model selection.

H_0: REM is preferred.

H_A: FEM is preferred.

The acceptance or rejection of the hypothesis has to be done on the basis of the level of significance i.e., p's value. If the 'p' value is less than α 0.05 at the significance level, then the null hypothesis will be rejected otherwise, FEM is preferred.

3.5 Vector Error Correction Model Analysis Method

The Vector Error Correction Model (VECM) stands as a basis in econometric analysis, particularly when exploring short-term dynamics among variables within a system. Its integration of key concepts and dynamic adjustments renders it indispensable for empirical investigations, especially in contexts where non-stationarity exists (Lütkepohl, 2013). Unlike its counterpart, the Vector Autoregressive (VAR) model, which assumes stationarity in the time series, VECM offers a robust framework capable of handling non-stationary data while preserving the information rooted in the co-integrating relationships (Gujarati & Porter, 2015; Maitra, 2019). The core principle of VECM lies in its ability to capture both short-term dynamics and long-term equilibrium relationships among variables. This model extends the VAR framework by incorporating the error correction mechanism, enabling it to adjust towards equilibrium in the presence of co-integrating relationships. Thus, it not only provides insights into short-term dynamics but also offers a mechanism to correct any deviations from long-term equilibrium. In a macroeconomic context, where datasets often exhibit non-stationarity, VECM emerges as a reliable tool for analyzing complex interdependencies among variables. Moreover, VECM is particularly advantageous when dealing with large macroeconomic datasets, where traditional models may fall short in capturing the complex dynamics of the underlying econometric system. By incorporating error correction terms, VECM accounts for deviations from equilibrium, thereby offering more accurate and reliable estimates (Khin et al., 2017; Ragmoun, 2023). As this study focuses on ASEAN and South Asian eight

(8) countries, it leverages the power of VECM to explore the short-term relationships among macroeconomic indicators. Specifically, we analyze monthly data encompassing GDP growth rate, R&D expenditure, FDI, EXR, NX, EMP, and INF. Notably, the usage of monthly data represents a novel approach in this context, allowing for a more robust examination of the dynamics within and across these countries (Shahbaz et al., 2021).

3.5.1 Unit-root Test

For data stationarity, this study uses ADF and Phillips-Peron (PP) unit root tests to proceed further for VECM analysis. Due to generic non-stationarity in macroeconomics variables (Elfaki & Ahmed, 2024; Hill, 2010), these tests have been suggested by many of the previous researchers in econometric modeling and data analysis (Andrei & Anderi, 2015; Studenmund, 2014).

3.5.2 Johansen's Co-integration Test

The purpose of a co-integration test is to check the existence of long-term co-integration relationship among the variables. The two most widely used co-integration tests are the Trace test and the Maximum Eigenvalue test. The alternative hypothesis (H_A) in form of r+1 co-integrated vectors is contrasted with the null hypothesis that there are 'r' co-integrating vectors using maximum eigenvalue statistics. Contrarily, Trace statistics compare hypotheses with at least one null hypotheses of non-cointegrated vectors as suggested by Pindyck and Rubinfeld (1998) and Studenmund (2014).

The Trace test and the Maximal Eigen-value test are the two Johansen co-integrating tests (Johansen, 2009) used in the VECM context. These tests are predicated on the idea that, in the VECM, the rank of the long-run impact matrix establishes the co-integration status of the VAR (p) variables. If the test identifies a long-run relationship, it means that variables are co-integrated, and the path is bounded. Johansen and Juselius's (1990) technique tackled the majority of the Engle and Granger (1987) approach's issues, including (i) The order of integration is important in the EG approach because there may be more than one co-integrating relationship when there are more than two variables, and (ii) it uses a two-step methodology. Maximum Eigenvalue and Trace Value test statistics are provided by the Johansen and Juselius method, which was based on maximum likelihood estimates and was used to identify the number of co-integration vectors using the co-integration equation.

$$x_t = A_0 + \sum_{j=1}^{k} A_j x_{t-1} + \varepsilon_t \qquad \text{(Eq. 3.11)}$$

Where;

Ao is an (n x l) vector of constants, Xt is an (n x l) vector of non-stationary variables, k is the number of lags, while Aj is a matrix (n x n) of coefficients and εt is an error term assumed an n x 1 vector of Gaussian error criteria. The above vector autoregressive (VAR) model was reformulated which turned into VECM to apply following test.

$$\Delta x_t = A_0 + \sum_{j=1}^{k-1} (\Delta x_{t-1} + \pi x_{t-k} + \varepsilon_{t-k}) \qquad \text{(Eq. 3.12)}$$

As discussed above, t is an identity matrix, and A is the difference operator. The Trace and the Maximum Eigen Value tests lag numbers that were insignificantly different from the unity. If long-run co-integration exists and Trace tests prevails, VECM considered a good model to combine the levels and differences for estimation process (Mahadevan & Asafu-Adjaye, 2007) which have been applied in this study for each country under study.

3.5.3 VECM Equation for Relationships among Variables

The general equation for VECM model has been formulated as under.

$$\Delta Y_t = a\beta' Y_{t-1} + \sum_{l=1}^{p-1} \pi_l \Delta Y_{t-1} + U_t \qquad \text{(Eq. 3.13)}$$

Where;

Y_t is an *n* dimensional vector, α and β are $n \times h$ dimensional matrices with rank *h*. $\beta' Yt{-}1 = 0$ represents *h* equilibrium relations. Δ is the 1st different level of stationary of unit root test[5].

This test is used for assessing the existence of co-integrated and long-run association among the variables. Nobel laureates Robert Engle and Clive Engle first introduced this concept in 1987. The said that if the result of this test show a stable long-run relationship between the variables, it is said that the time-series is co-integrated even the variables are non-stationary independently, provided that regression of one variable on other is not spurious (Gujarati, 2021).

[5]The VECM model's equations for this study has been described under heading 3.2.2.

3.5.4 Granger's Causality Test

There are three types of causal relationships between variables which are bi-directional causality, unidirectional causality, and no causal relationship (Awe, 2012; Ahmed & Elfaki, 2023). To check the causality between variables, the Granger causality test has been considered the best statistical test in case of time-series for prediction (Granger, 1969; Siggiridou et al., 2019). The Granger causality test will be conducted to examine the dynamic relationship among the variables as R&D, FDI, NX, EXR, EMR, and INF. The test suggests that if the probability value of cause and relation among the variables if less than the suggested value, the null hypothesis will be rejected and vice versa. A profound study of EG and related macroeconomic variables, the Granger's causality test seems feasible testing the hypotheses of current study. The Granger causality approach to be used to study the causal link between the variables. A statistical hypothesis will be tested for detecting if one-time series is helpful for forecasting another is the Granger causality test. The hypothesis would be rejected at if the probability value fell below that threshold.

One of the prevalent issues in the majority of statistical analyses is causality. Researchers would anticipate that when two variables are co-integrated, at least one causal relationship, if not more, should exist between the variables, at least in one direction. The Granger Causality Test, which Granger (1969) proposed, will be used to study the causal linkages between variables in order to identify causative relationships (Gujarati & Porter, 2015; Studenmund,

2014). For causality, following hypotheses has to be tested through causality test.

H_0: 'X' does not Granger Causes Y

H_A: 'X' Granger Causes Y

In F-test, if the *p* value is less than α 0.05 then the null hypothesis (H_0) will be rejected and accept the H_A which mean two variables are stationary and linear combination between the variables and vice versa.

3.5.5 Residual Diagnostics

The residuals are the difference between observations and corresponding fitted values (y & −^y) of a time series data (Alexander et al., 2015). Residuals are helpful for determining whether a model has captured the data's information correctly. According to previous researchers, following parameters should be observed for model simulation and accuracy.

- The residuals should be uncorrelated otherwise; there is some missing information in the forecasts.
- The data should be normally distributed.
- The mean of residuals always be zero. If not, the forecasts are biased ones.

3.5.5.1 Normality Test

The purpose of a normality test is to determine that a data set is normally distributed or not. There are a number of criterion (e.g., Probability Plot, Skewness and Kurtosis, Jarque-Bera test) are available. For data normality, following hypotheses have to be tested through residuals normality test.

H_0: Residuals do not normally distributed.

H_A: Residuals normally distributed.

In the context of a Probability Plot (P-Plot) analysis, when the bulk of the data falls within the bell-shaped curve, we tend to accept the null hypothesis (H_0). Ideally, skewness and kurtosis values should fall within the range of ±3 and ±10, respectively. However, in macroeconomic time series analysis, the assessment of normality via the Jarque-Bera test may be less crucial if strong correlation exists and the data distribution approximates a bell-shaped curve (Mikayilov et al., 2018). In addition, the unit root and co-integration tests lessen the importance of other normality tests for macroeconomic time series data.

3.5.5.2 Heteroscedasticity Test

Because regressions use ordinary least squares (OLS) which presume that the residuals have constant mean and variance. The results of the study may be invalid if there is an unequal dispersion of residuals because this indicates that the population utilized in the regression has an unequal variance. To know that results are valid, it is important to first conduct a regression and examine

the residuals in order to look for heteroscedasticity (Engle, 1982). The heteroscedasticity can be pure and impure which means that:

- When the right number of independent variables are utilized (referred to as a model specification), but the residual plots show unequal variance, this is referred to as pure heteroscedasticity.
- Instances of improper utilization of the proper number of independent variables are referred to be pure heteroscedasticity (known as model misspecification). This regression may have either too few (underspecified) or too many variables (over specified). In any case, it leads to an unbalanced variance model.

For heteroscedasticity, following hypotheses need to be tested.

H_0: There is no heteroscedasticity.

H_A: There is heteroscedasticity.

The heteroscedasticity can be measured through white test and if in F-test, the value of α should be greater than 0.05 which means that there is no heteroscedasticity and accept H_A otherwise reject the null hypothesis (H_0).

3.5.5.3 Multicollinearity Test

Multicollinearity is the situation when two or more predictor variables highly correlated to each other. As the correlation among variables near to ±1, the multicollinearity is high which can be exact ±1 mean perfectly collinear variables. Multicollinearity identified means less reliability of the data (Dormann et al., 2013). According to the authors, there are three methods that

help in identifying and treating the multicollinearity which include dropping highly correlated variables, Variance inflation factor (VIF) and High Tolerance Value (TOL). Value of TOL < 0.19 and VIF value > 10 show a high multicollinearity so, this study intends to test the following hypotheses for multicollinearity.

H_0: There is no heteroscedasticity in case of VIF <10.

H_A: There is heteroscedasticity in case of VIF ≥10.

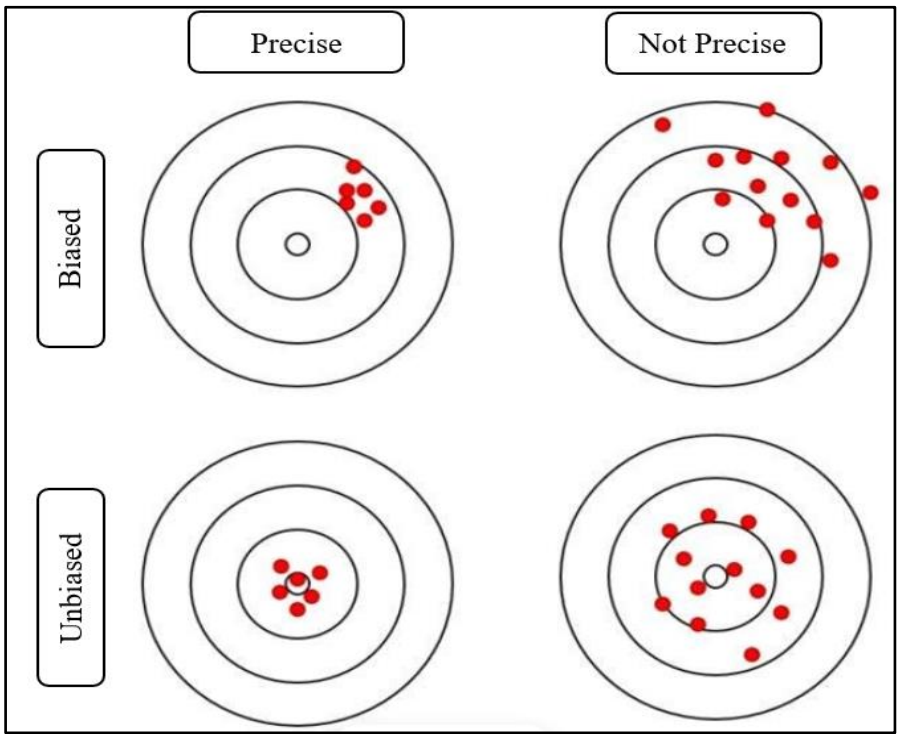
3.6 Ex-post Forecasts

The model simulated forward in time beyond the estimation period is called as ex-post forecast (Nieto, 1998). According to the specific objective of this study, it run the ex-post forecasts for each country under study. In an ex-post forecast, observations on both endogenous variables and the exogenous explanatory variables have already known with certainty during the forecast period which was predicted from July 2019 to December 2019 based on from January 1990 to December 2019 actual data.

3.7 Model Accuracy, Evaluation and Simulation

Model evaluation is the course of applying a number of calculation procedures to know the performance of estimation model along with its strengths and weaknesses. For this study, a range of tests like RMSE, MAE, MAPE and U-Theil have been tested to conclude that panel data models; for ASEAN-5, South Asia-3 and ASEAN-5 xSA-3, and VECM for all the eight

countries, are having a satisfactory and valid forecasting ability. The model accuracy should be precised and unbiased for wider generalizability as shows by Figure 3.4. According to Vandeput (2019), the values of MAPE, MAE, Theil's inequality should be bias free.



Source: Vandeput, 2019

Figure 3.4: Model Precision and Biasness[6] Matric

3.7.1 Root Mean Square Error

The root mean square error (RMSE) is an estimator of a population parameter (MSE). The expected square of the difference between the estimator and the parameter is used to define the mean square error. The RMSE use the same unit of measurement as the parameter of interest, in contrast to the MSE. Variance is frequently equated with an estimator's precision, whereas bias is

[6]*Biasness defined as average error in precision as $e_t = f_t - d_t$

equated with an estimator's accuracy. Following is the statistical formula of RMSE which will be run by using EView-13 software.

$$RMSE = \sqrt{\frac{1}{n}} \sum e^2 t \qquad \text{(Eq. 3.14)}$$

Where $\sum e^2_t$ is sum of the square of error terms.

An estimator's variance, or "random error," pertains to the usage of a sample, whereas the bias is the discrepancy between the true value of the population and the estimator's anticipated value.

3.7.2 Mean Absolute Error

This test is a tool to measure the forecast accuracy which will be determined through VECM model evaluation for prediction of EG among the countries under study. Its formula is as below.

$$MAE = \frac{1}{n} \sum |et| \qquad \text{(Eq. 3.15)}$$

Mean of absolute difference between model prediction and the target value. The upper limit of MAE is 80% or 0.80 crossing which means that the metric is weakening (Armanuos et al., 2020).

3.7.3 Mean Absolute Percentage Error

Mean Absolute Percentage Error (MAPE) is also an important key performance indicator (KPI) for model evaluation and used to measure the

accuracy of forecasting model. It is a relative error measure that uses absolute values to keep the positive and negative errors from cancelling on another and uses error for comparing forecasting accuracy between the time series (Hyndman, 2006; Koyuncu & Tavacioğlu, 2021). The formula of MAPE is as under.

$$M = 1/n \sum_{t=1}^{n} [(A_t - F_t) / A_t] \quad \text{(Eq. 3.16)}$$

M = mean absolute percentage error

n = number of times the summation iteration happens

At = actual value

Ft = forecast value

3.7.4 Theil's Inequality Coefficient

In last, the model accuracy will be examined though Theil's inequality of coefficient test. The value of 'U' (coefficients) always between 0-1 and as this value near to one, as the model accuracy is satisfactory (Pindyck & Rubinfeld, 1998; Taylor & Theil, 1988). Following equation for U-Theil's inequality has been tested.

$$\text{U-Theil Inequality} = \frac{\sqrt{\Sigma(Pt-A)^2}}{\frac{\sqrt{\Sigma(Pt)^2}}{T}+\frac{\sqrt{\Sigma(A)^2}}{T}} \quad \text{(Eq. 3.17)}$$

Further, there is no defined measuring criteria for this coefficient rather it has been observed on the basis of ideal situation among population under study (Song et al., 2020).

3.7.5 Impulse Response Function

Due to the complex set of variables with intention to examine the dynamics, this study run impulse response function (IRF) which is a fundamental concept in time series analysis (Hamilton, 2020; Jordà, 2005). It represents the dynamic response of a variable in a system to a one-time shock or impulse in another variable. In economics and finance, IRFs are commonly used in the context of VAR and associated models to analyze how an exogenous shock to one variable affects the behavior of other variables in the system over time. It provides valuable insights into the dynamics and interrelationships among variables in a complex system. At later stages of the analysis, this study conducted the impulse response analysis for R&D and GDP growth rate using Cholesky One S.D. (d.f. adjusted) Innovation methods at ±2 analytic asymptomatic effects. This way, it has become easy to see the variations in the model for better understanding of the system.

3.8 Conclusion

Chapter-3 of this study presented an extended overview of research methods and procedures to be followed. It entails understanding about the study variables, data collection, and research hypotheses of the study. Further it entails the suitability of analysis methods which was performed and presented in the Chapter 4 of this study.

CHAPTER 4: RESULTS AND DISCUSSION

4.0 Introduction

To analyze the impact of R&D expenditures on the GDP per capita growth rate in the ASEAN-5, South Asia-3 and combined panel data for ASEAN and South Asia regions (ASEAN-5 x SA-3), this study provides the results of panel data analysis and VECM. Following this, section 4.1 presented in this chapter offers exploratory data description and correlation of the variables. After this, panel model selection through a demanding technique Pooled OLS, Random Effects Model (REM), and Fixed Effects Model (FEM) have been done under the sub-section of section 4.2 followed by panel co-integration test for panel data. At later stages in this section, panel regression results have also been provided for testing the hypotheses developed for ASEAN-5, South Asia-3 and ASEAN-5 x SA-3. In Section 4.3, results of the VECM using data for each country (i.e., Indonesia, Malaysia, Philippines, Singapore, Thailand, Bangladesh, India and Pakistan) under study have been presented. Section 4.3 of the chapter focuses on model evaluation and ex-post forecasts, a crucial step in understanding the growth patterns among the countries. These evaluations are essential for making informed policy decisions based on the underlying data behaviours. Moreover, both the panel data model and the error correction model undergo a comprehensive evaluation. Various metrics, including RMSE, MAE, MAPE, and Theil's inequality coefficient tests, were employed to assess the accuracy and validity of the models for policy

suggestions. The detailed impact of R&D on the GDP growth rate has been examined through the Impulse Response Function (IRF) in the subsequent section. Finally, section 4.4 offers a summary of synthesized findings and hypotheses decisions for panel data analysis and the VECM method.

4.1 Exploratory Data Analysis

In this study, data from eight (8) countries; five from the ASEAN region, and three from the South Asian region have been used to examine the impact of exogenous variables on GDP growth rate. In order to avoid COVID-19 effects on economies, the data set ranges from 1990 to 2019 which made 240 (150 of ASEAN-5, and 90 of South Asia-3) total observations as depicted in Table 1 (below). Before the panel data model estimation, exploratory analyses including descriptive statistics, correlation analysis and panel unit-root test to check data stationarity were conducted to understand the relationship and nature of the data.

4.1.1 Descriptive Statistics

For the description of data, the upper part of Table 4.1 presents a comprehensive description of the study's variables for ASEAN-5. The GDP growth rate demonstrates the data ranges between -13.100 and 14.500 with a mean value of 5.1620. The mean values of R&D, FDI, NX, EXR, EMR and INF are 0.6300, 5.3208, 7.1622, 1693.2002, 63.5297, and 4.4935 respectively. The table shows the standard deviation value of the GDP growth rate of ASEAN-5

with a 3.5317 dispersion from its mean. The standard deviation for R&D is 0.717 having 2.596 maximum while 0.015 minimum values. FDI, NX, EXR, EMR and INF have maximum values of 29.760, 31.270, 14481.000, 74.129, and 58.451 respectively with standard deviations of 6.745, 10.649, 3815.103, 7.134, and 5.702 from their mean values. The table displays the highest inflation value among the countries under consideration, which is 58.451, and the lowest inflation number is -0.900. Taking a further look, it becomes clear from the table that the highest value of inflation was reported for Indonesia in 1998 during the exchange rate-led recession in the ASEAN region.

Table 4.1: Descriptive Statistics

ASEAN-5							
	GDP	**R&D**	**FDI**	**NX**	**EXR**	**EMR**	**INF**
Mean	5.162	0.630	5.321	7.162	1693.200	63.530	4.494
Median	5.350	0.245	2.719	4.602	30.153	62.587	3.393
Maximum	14.500	2.597	29.761	31.270	14481.000	74.129	58.451
Minimum	-13.100	0.015	-2.757	-12.076	1.250	57.600	-0.900
Std. Dev.	3.532	0.718	6.745	10.650	3815.104	4.728	5.702
						Observations	**150**
SA-3							
	GDP	**R&D**	**FDI**	**NX**	**EXR**	**EMR**	**INF**
Mean	5.499	0.336	0.973	-4.331	59.250	51.694	7.323
Median	5.200	0.228	0.769	-4.661	57.108	50.419	6.716
Maximum	10.300	0.859	3.668	0.940	154.866	57.030	20.286
Minimum	1.100	0.012	0.005	-10.830	18.070	43.922	2.007
Std. Dev.	1.915	0.294	0.784	2.667	24.881	3.271	3.421
						Observations	**90**

Note(s): GDP= gross domestic product growth rate, R&D= R&D expenditures, FDI= foreign direct investment, NX= net exports, EXR= exchange rate, EMR= employment rate, and INF= inflation rate. Std. Dev= standard deviation

The lower part of Table 4.1 provides descriptive statistics pertaining to variables within the South Asian-3 region dataset. Specifically, it presents details regarding GDP growth rate, R&D expenditure, FDI, NX, EXR, EMR, and INF. The GDP growth rate exhibits a range spanning from 1.100 to 10.300,

with a mean value of 5.498. R&D, FDI, NX, EXR, EMR, and INF possess mean values of 0.336, 0.972, -4.330, 59.249, 51.694, and 7.323 respectively. Standard deviation values provide insights into the dispersion of data from the mean. For the GDP growth rate, the standard deviation is 1.915, indicating a dispersion of 1.915 units from the mean. R&D exhibits a standard deviation of 0.294, with maximum and minimum values of 0.858 and 0.012 respectively. FDI, NX, EXR, EMR, and INF showcase maximum values of 3.668, 0.939, 154.865, 57.030, and 20.286 correspondingly. Their respective standard deviations are 0.784, 2.666, 24.881, 3.271, and 3.421, indicating the spread of data from their respective means. Among the South Asian countries considered, the highest inflation value is recorded at 20.286, while the lowest stands at 2.007.It is important to mention that the Jerque-Bera values were calculated from these results but they are irrelevant in presence of other tests while conducting panel data analysis like unit root test (Baltagi, 2001).Further, the results of results of Johansen co-integration results provided in the table 4.21 (later parts of this chapter) provides robust results related to non-normality of error term hence, this problem does not affect the results and goodness of model for long panel time series data (Gonzalo, 1994; Gregoriou & Kontonikas, 2010).

4.1.2 Correlation Analysis

Table 4.2 describes the correlation of the study's variables among each other for data of ASEAN-5. GDP growth rate has significant relationship with R&D at t-statistics value 1.6566 while its relationship with FDI, NX, and EX is also significant with values of t-statistics 3.9894, -4.3485, and -2.4210. It is

important to mention that relationship of GDP growth rate with NX and EMR, in case of ASEAN-5, is negative. The correlation between GDP growth rate and INF is also negative with value of Pearson correlation -0.4487 at -5.0410 value of t-statistics.

Table 4.2: Correlation Analysis (ASEAN-5)

		GDP	R&D	FDI	NX	EXR	EMR	INF
GDP	Pearson Correlation	1						
	Sig. (2-tailed)							
R&D	Pearson Correlation	0.137	1					
	Sig. (2-tailed)	1.656*						
FDI	Pearson Correlation	0.316	0.092	1				
	Sig. (2-tailed)	3.989**	1.105					
NX	Pearson Correlation	-0.341	-0.038	0.098	1			
	Sig. (2-tailed)	-4.348**	-0.464	1.678*				
EXR	Pearson Correlation	-0.198	-0.010	-0.035	0.088	1		
	Sig. (2-tailed)	-2.421**	-0.120	-0.421	1.060			
EMR	Pearson Correlation	0.017	-0.010	0.038	0.229	0.014	1	
	Sig. (2-tailed)	0.216	-0.127	0.465	2.819**	0.167		
INF	Pearson Correlation	-0.448	0.009	-0.003	0.139	0.407	-0.011	1
	Sig. (2-tailed)	-5.041***	-4.827**	-3.750**	-3.116**	4.0389**	-1.317	

Note(s): GDP= gross domestic product growth rate, R&D= R&D expenditures, FDI= foreign direct investment, NX= net exports, EXR= exchange rate, EMR= employment rate, and INF= inflation rate.
*p < 0.10, **p < 0.05, and *** p < 0.01 level of significance.

It has been observed that most of the correlation between exogenous variables like R&D, FDI, NX, EXR, EMR and INF is insignificant with each which confirms that there is no issue of multicollinearity when we observe correlation among exogenous variables. The correlation of GDP growth rate is significant with R&D and other variables showing that the model best describes the economic growth relationship of exogenous variables with endogenous variables i.e., GDP growth rate. Further correlation analysis for examination of the relationship between the GDP growth rate of South Asia with R&D, FDI, NX, EXR, EMR and INF has been presented in Table 4.3 (below).

Table 4.3: Correlation Analysis (South Asian-3)

		GDP	R&D	FDI	NX	EXR	EMR	INF
GDP	Pearson Correlation	1						
	Sig. (2-tailed)							
R&D	Pearson Correlation	0.325	1					
	Sig. (2-tailed)	3.232**						
FDI	Pearson Correlation	0.257	0.371	1				
	Sig. (2-tailed)	2.499**	3.748**					
NX	Pearson Correlation	0.127	0.421	-0.199	1			
	Sig. (2-tailed)	1.701*	4.356**	-1.911*				
EXR	Pearson Correlation	-0.126	-0.260	0.1327	-0.610	1		
	Sig. (2-tailed)	-1.200	-2.529**	1.256	-7.233***			
EMR	Pearson Correlation	-0.042	-0.604	-0.437	-0.252	-0.054	1	
	Sig. (2-tailed)	-0.401	-7.109***	-4.553**	-2.439*	-0.508		
INF	Pearson Correlation	-0.115	0.116	0.219	-0.162	-0.115	-0.197	1
	Sig. (2-tailed)	-1.874*	1.094	2.114*	-1.539	-1.089	-1.890*	

Note(s): GDP= gross domestic product growth rate, R&D= R&D expenditures, FDI= foreign direct investment, NX= net exports, EXR= exchange rate, EMR= employment rate, and INF= inflation rate.
*p < 0.10, **p < 0.05, and *** p < 0.01 level of significance.

The table shows that the GDP growth rate has a positive correlation with R&D with the value of t-statistics 3.2328 while its correlation with FDI is also positive and significant with a value of 0.2575 with t-statistics 2.4994. Among other macroeconomic variables, INF has a negative correlation with a -0.1152 value of Pearson correlation, t-statistics -1.8746 at p <0.05 level of significance. Examination of values of Pearson correlation among exogenous variables states that the majority of the variables have insignificant correlation with each other stating the minimum chances of multicollinearity issue. Hence, the correlation of GDP growth rate with exogenous variables is significant, especially for R&D and GDP growth rate among South Asian-3 countries.

In summary, the correlation analysis indicates that relationship of the study's variables. Values of t-statistics show the alpha (α) value for significance which shows that R&D is significant but, in case of South Asian-3, it has strong

correlation with GDP growth rate at $\alpha < 0.01$ showing strong relationship of macroeconomic factors with GDP growth rate. These results provide insights that how these variables have relationship with each other but do not explain the underlying mechanisms driving these relationships which needs to be examined through adopted methods of analysis.

4.2 Panel Model Results

In this section, at first the results of panel model for ASEAN-5 have been presented followed by panel model analysis of South Asia-3. This process includes panel unit root tests, panel co-integration test results and panel model selection results have been presented. Later, this study checked model accuracy using the data of appropriate model suggested by panel model selection process.

4.2.1 Panel Model Results for ASEAN-5

This study also tested data stationarity through graphical and correlation methods, but they have been considered as non-formal tests (Tien, 2021). Therefore, it follows the formal analysis procedure of data stationarity for panel unit root test as suggested by Morina et al. (2020) and Olaoye et al. (2021). This way, Livin-Lin-Chu, and Im, Pesaran & Shintests have been applied to test the hypotheses established for panel data in Chapter 3 regarding the stationarity of yearly panel data.

4.2.1.1 Panel Unit Root Test

Table 4.5 presents the results of panel unit root tests conducted on GDP growth rate, R&D expenditure, FDI, NX, EXR, EMR, and INF for ASEAN-5 countries. For the panel data model, the results of Levin-Lin-Chu and Im, Pesaran & Shin have been considered adequate as described in section 3.4.1. Henceforth, the results of these tests have been presented below which indicate that the majority of the variables are non-stationary at level I(0). However, they have been found stationary at the first difference I(1), and these changes are statistically significant at a significance level of $\alpha < 0.01$ (see table 4.3). From the table, it is observed that the p-values of all test statistics at the level of data are greater than 0.05, with the exception of GDP at $\alpha < 0.01$ level under the Im, Pesaran & Shin test. However, for inflation (INF), the p-values are less than 0.05 under both tests. This indicates that all variables are stationary at the first difference I(1) under both tests i.e., LLC and Im, Pesaran & Shin at $\alpha < 0.01$ level. Consequently, the null hypothesis (H0) for the presence of a unit root in the series has been rejected for stationarity of the variables.

Table 4.4: Panel Unit Root Test Results (ASEAN-5)

Variable	Levin-Lin Chu		Im, Pesaran & Shin	
	Level	1st Diff.	Level	1st Diff.
GDP	-3.285***	-14.211***	26.134***	164.745***
R&D	2.265	15.554***	1.809	306.614***
FDI	2.177**	12.549***	14.426	146.395***
NX	-0.781	-11.456***	11.844	119.455***
EXR	-0.39	-10.389***	3.277	112.039***
EMR	0.718	8.745***	5.663	91.877***
INF	-5.187***	-15.055***	41.129***	174.778***

Note(s): GDP= gross domestic product growth rate, R&D= R&D expenditures, FDI= foreign direct investment, NX= net exports, EXR= exchange rate, EMR= employment rate, and INF= inflation rate. *p <0.10, **p <0.05, and ***p <0.01 level of significance

4.2.1.2. Panel Co-integration Test

While using stationary macroeconomic data, it is advised to check the co-integration between the variables prior to final analysis (Pegkas et al., 2019). In this regard, Pedroni (1999, 2004) recommended applying a dynamic panel data model on the data having variations.

Table 4.5: Panel Co-integration Test (ASEAN-5)

Pedroni Test		**Kao Test**	
Criteria	**Statistics**	**Criteria**	**Statistics**
Panel v-Statistic	-0.184	ADF	-6.079***
Panel rho-Statistic	-0.784		
Panel PP-Statistic	-4.914***		
Panel ADF-Statistic	-4.331***		
Group rho-Statistic	-0.036		
Group PP-Statistic	-6.319***		
Group ADF-Statistic	-4.936***		

Source: EViews output
Note: *p <0.10, **p <0.05, and ***p <0.01 level of significance

Further, Kao test (1999) employs the same basic methodology as the Pedroni test, with the exception that it calls for a regression with individual intercepts, with no deterministic trend, and homogenous regression coefficients. Considering this suggestion, this study run Pedroni and Kao tests for co-integration evaluation. Table 4.4 displays the results of the panel co-integration analysis among the variables using the Pedroni and Kao statistics. The table displays that, the α less than 0.10 level of significance, four out of the seven Pedroni tests reject the null hypothesis that there is no co-integration using both the panel and group version tests. Moreover, the Kao test fully rejects the null hypothesis (H_0) that there is no co-integration at the 5% significance ($\alpha < 0.05$) level in the data. Hence, this study proceeds to go for panel data model selection process.

4.2.1.3. Panel Model Selection and Results

Table 4.5 provides the detail of all the process in model selection for ASEAN-5 countries. Although, in presence of data stationarity, Pooled OLS is not recommended but it has been assessed for rigorousness of the results.

Table 4.6: Model Selection (ASEAN-5)

Test	Hypotheses	Results	Conclusion
Redundant Fixed Effects Tests	If p >0.05, H_0 = POLS is preferred. If p <0.05, H_1 = REM is preferred.	χ^2=131.196, p <0.05	Reject H_0.
Breusch-Pagan Test	If p >0.05, H_0 = POLS is preferred. If p <0.05, H_1 = REM is preferred.	χ^2=65.354, p <0.05	Reject H_0.
Hausman Test	If p >0.05, H0 = REM is preferred. If p <0.05, H_A = FEM is preferred.	χ^2 =41.366, p <0.05	**Reject H_0, FEM is preferred.**

Source: EViews output

From the table, it is evident that the value of $p < 0.05$ showing inappropriateness of Pooled OLS model for ASEAN-5 panel data. Further, chi-square (χ^2) 65.35 and $p < 0.05$ through Breusch-Pagan (BP) test confirmed that this REM or FEM can provide robust results for this study. Hence, this study conducted Hausman test to select between REM and FEM which showed that cross-section FEM is appropriate model to run the analysis with values of chi-square (χ^2) 41.36 and $p < 0.05$. On the basis of this model selection procedures, this study run panel model estimation using GDP growth rate as endogenous variables for ASEAN-5that has been presented in Table 4.7.

After confirming the data stationarity, panel model analysis using first difference panel data, as highlighted by Δ in the table, has been run. According to the model's results, 72.77% (value of R squared) of the variation in the GDP growth rate among the ASEAN-5 countries could be explained by the

explanatory factors. Compared to the macroeconomic variables, R&D expenditures have a smaller beta value (0.0962, t-stat. 2.70 and p<0.10). R&D expenditures increase of one unit resulted in a 0.096 (at $\alpha < 10\%$) rise in GDP growth rate. When it comes to macroeconomic factors, FDI significantly impact GDP growth rate of the region with 0.255 change cause by one (1) unit change in FDI at p <0.01. Net exports have positive significant impact on GDP growth rate (β= 0.254 and p <0.01), the exchange rate nominal negative impact with alpha <0.01, employment rate (β= 0.334 and p <0.05) and inflation have a significant negative impact on the GDP growth rate (β= -0.294 and p<0.01).

Table 4.7: Panel Model Estimation (ASEAN-5)

Dependent Variable: GDP growth rate				
Variables	**Coeff.**	**S.E.**	**t-Stat.**	**Prob.**
C	29.566	8.482	3.486	0.001***
ΔR&D	0.096	0.811	2.700	0.091*
ΔFDI	0.255	0.075	3.418	0.001***
ΔNX	0.254	0.039	6.501	0.000***
ΔEXR	0.000	0.000	-2.630	0.010**
ΔEMR	0.334	0.136	2.452	0.015**
ΔINF	-0.294	0.045	-6.482	0.000***
R-squared		**0.728**		
Adjusted R-squared		**0.644**		

Source: EViews output
Note: Δ denotes the 1st difference data

Decision: Hypotheses H_{A1}regarding relationships between R&D expenditures, net exports, exchange rate, foreign direct investment, employment rate, and inflation rate have been proved true and H_{01} has been rejected as overall impact of the exogenous factors is significant with p <0.05 while the impact of R&D is at $\alpha < 0.10$ level of significance. Specifically, R&D is significant at p <0.10 while macroeconomic indicators are significant at p <0.05 which shows that these countries need to make efforts to favour the macroeconomic which in turn can boost GDP growth rate. Considering the results, H_{01} for R&D and

macroeconomic indicators' impact on the GDP growth rate of ASEAN-5 has been rejected.

4.2.1.4. Model Accuracy

The model evaluation presented in the following figures (Figure 4.1 and 4.2) confirms that the aim of this study, to find the effect of R&D and macroeconomic variables, proved true. The period-fixed model comparison with random effects shows that Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), and Theil's inequality (1.67, 1.26, 54.35 and 0.136) stating higher accuracy of fixed-effect model as shown in Figure 4.1.

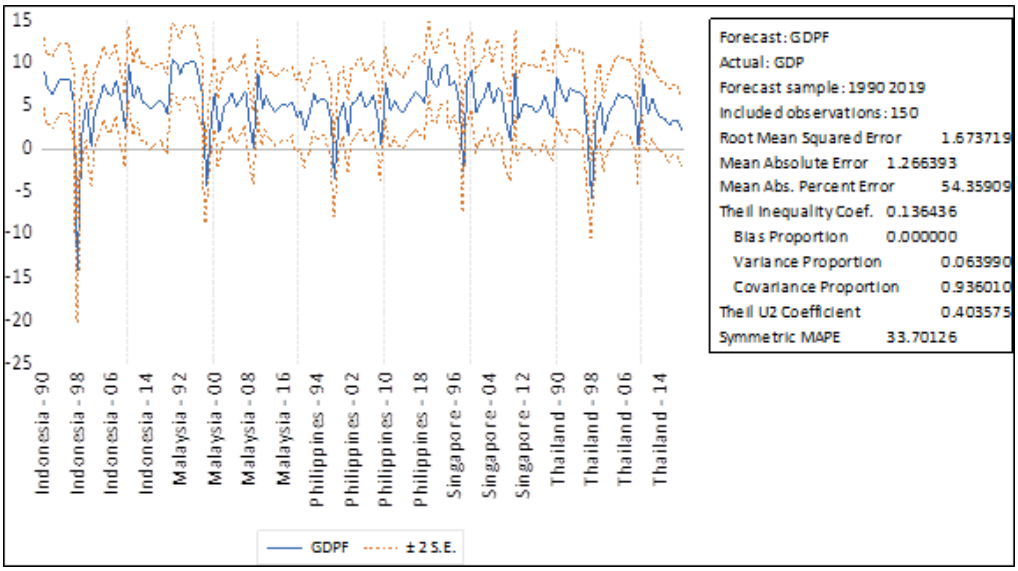


Figure 4.1: Fixed Effect Model

The values of RMSE, MAE, MAP and Theil's inequality coefficient given in the figure 4.2 are 2.0154, 1.2663, 54.3591 and 0.1686 respectively.

Hence, the figure clearly states that results of period-fixed model for ASEAN-5 countries are reliable and good.

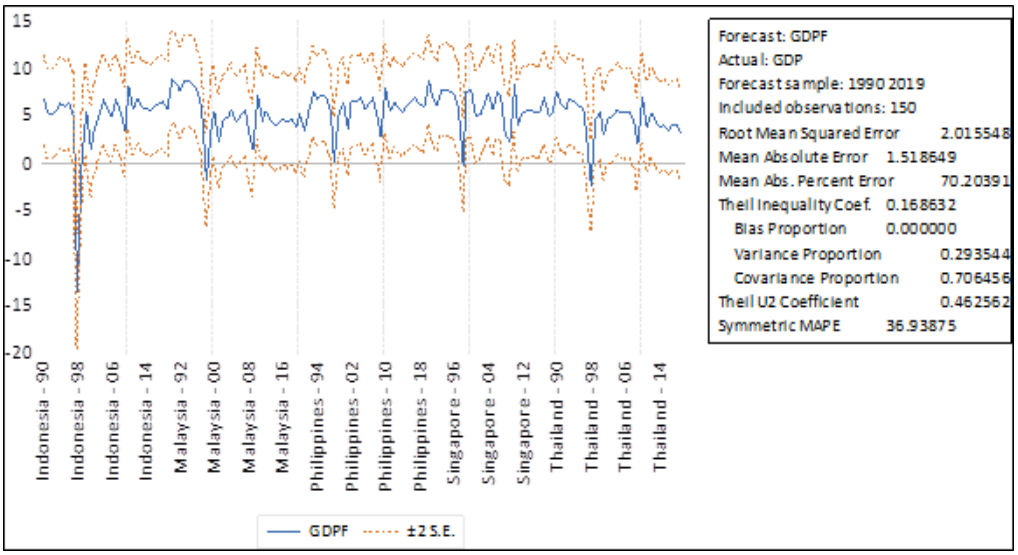


Figure 4.2:Random-Effect Model

4.2.2 Panel Model Results for South Asia-3

4.2.2.1. Panel Unit Root Test

Table 4.7 presents results of panel unit root tests for South Asia-3 which indicates that all variables are non-stationary at the level of data except GDP under Im, Pesaran & Shin except GDP. Under Levin-Lin Chu (LLC), FDI and INF are stationary at significance level $p<0.01$ and $p<0.05$ respectively but all other variables were found non-stationary which need to run the analysis at first difference as well. From the table it is clear that all the variables became stationary at first difference I(1) at $\alpha < 0.01$ stating 99% significance level under both the panel unit root tests. Consequently, the null hypothesis (H_0) for the presence of a unit root in the series has been rejected, affirming the stationarity

of the variables at first difference. Hence, this study used first difference data (Δ) to run the panel model estimation.

Table 4.8: Panel Unit Root Test Results (South Asia-3)

Variable	Levin-Lin Chu		Im, Pesaran & Shin	
	Level	1st Diff.	Level	1st Diff.
GDP	0.554	-11.536***	4.094***	102.714***
R&D	-0.081	-16.494***	7.677	320.036***
FDI	-1.674*	-8.621***	7.965	72.993***
NX	-1.253	-9.704***	5.714	85.517***
EXR	5.260	-5.053***	0.017	33.318***
EMR	-0.084	-6.633***	2.731	49.438***
INF	-2.201**	-11.094***	10.372	101.384***

Note(s): GDP= gross domestic product growth rate, R&D= R&D expenditures, FDI= foreign direct investment, NX= net exports, EXR= exchange rate, EMR= employment rate, and INF= inflation rate. Std. Dev= standard deviation.
*p <0.10, **p <0.05, and ***p <0.01 level of significance

4.2.2.2. Panel Co-integration Test

As all the variables are stationary at first difference, hence, this study used Dicky and Fuller test for panel co-integration model.

Table 4.9: Panel Co-integration Test (South Asia-3)

Pedroni Test		Kao Test	
Criteria	**Statistics**	**Criteria**	**Statistics**
Panel v-Statistic	-0.691	ADF	-5.468***
Panel rho-Statistic	-1.256		
Panel PP-Statistic	-5.524***		
Panel ADF-Statistic	-5.507***		
Group rho-Statistic	-0.395		
Group PP-Statistic	-6.178***		
Group ADF-Statistic	-6.002***		

Source: EViews output
Note: *p <0.10, **p <0.05, and ***p <0.01 level of significance

Table 4.9 displays the results of the panel co-integration analysis among the variables using the Pedroni and Kao statistics. Out of seven (7) tests of Pedroni criteria, four (4) criteria tests are significant at p<0.01 with statistics values -5.52, -5.51, -6.18, and -6.00 respectively which shows that there is non-existence of co-integration among the residuals which can disturb the results of

the panel data analysis of South Asia-3 data (see the table). Especially, the results of panel ADF-statistics for Pedroni and Kao testsis significantly good with a value of -5.5238 and -5.4679 at α <0.01. Hence, the results states that there is long term co-integration using both the panel and group version tests and reject the null hypothesis (H_0) that there is no co-integration at the 1% significance level between the variables under study.

4.2.2.3. Panel Model Selection and Results

The process for panel model selection for South Asia-3 was also run to determine the appropriate model for panel data. During the test, the value of P for Pooled OLS was found < 0.05 for the period and cross-section applying fixed and random terms which shows that REM cannot be run so by testing, FEM directly. It also showed the overall F-statistics are significant at 3.587 and p <0.05. The R-square value was found 0.218 whereas, R&D was significantly associated with GDP.

Table 4.10: Model Selection (South Asia-3)

Test	Hypotheses	Results	Conclusion
Redundant Fixed Effects Tests	If p >0.05, H0 = POLS is preferred. If p <0.05, H1 = FEM is preferred.	X^2=58.089, p <0.01	Reject H_0, FEM is preferred.
Hausman Test	If p >0.05, H0 = POLS is preferred. If p <0.05, H1 = REM is preferred.	X^2 =20.867, p <0.01	**Reject H_0, FEM is preferred.**

Source: EViews output

The results of Pooled OLS were found that p <0.05 for the Pooled OLS model for SA-3 panel data. The value of p for the Breusch Pagan Test using Lagrange Multiplier was >0.05 showing the suitability of cross-section and period effects for final selection. This way, the study checked the

appropriateness of FEM or REM for which Hausman Test was run. The chi-square value was found 20.867 with p <0.01 showing that overall model fitness was good, so the study proceeds with the FEM appropriateness (see Table 4.10). The results suggested cross-section and period fixed model as appropriate model to test the regression analysis. On the basis of model selection results, results of fixed-effect model for cross-section FEM have been displayed in the following Table 4.11.

Table 4.11: Panel Model Estimation (South Asia-3)

Dependent Variable: GDP growth rate				
Variables	**Coeff.**	**S.E.**	**t-Stat.**	**Prob.**
C	3.977	4.756	0.836	0.006***
ΔR&D	2.491	0.902	2.761	0.007***
ΔFDI	0.721	0.298	2.416	0.018**
ΔNX	0.035	0.113	0.309	0.758
ΔEXR	-0.003	0.011	-0.284	0.777
ΔEMR	0.173	0.083	2.085	0.040**
ΔINF	-0.091	0.061	-1.490	0.140
R-squared		**0.639**		
Adjusted R-squared		**0.605**		

Source: EViews output
Δ denotes the 1st difference data.

According to the model's results, one (1) unit change in R&D expenditures results in a 2.49-unit change in GDP growth rate which states the importance of R&D expenditures for the region. Associated with the macroeconomic variables, GDP growth rate has a positive significant impact on FDI and EMR with 0.721 and 0.173 values of change in GDP growth rate. The t-statistics values for these variables were found 2.416 and 2.085 with $\alpha < 0.05$ showing the significance of FDI and EMR for GDP growth rate by comparing their means. Table 4.10 further shows that the effect of NX on GDP growth is positive (0.035) but insignificant with values of t-statistics 0.30 and $\alpha > 0.05$ while, EXR and INF have an insignificant negative impact on GDP growth rate

(-0.003 and -0.091 respectively) among these countries of this region with α >0.05 which shows the negative but manageable impact of these variables.

Decision: Hypothesis H_{A2} regarding relationships between R&D expenditures, net exports, exchange rate, foreign direct investment, employment rate, and inflation rate has been proved true. The impact of R&D on the economic growth of South Asia was also found significant with α <0.05 with coefficient value 2.491 which means a single unit increase in R&D bring a 2.49 unit increase in economic growth through GDP. The overall impact of exogenous variables is significant when α < 0.05. Hence, R&D expenditures are significantly important for the South Asian region's economic growth, and, on the basis of the results, this study rejects H_{02}.

4.2.2.4. Model Accuracy

The comparison between the models for South Asia-3 has been depicted by the figures below. Figure 4.3 confirms that the accuracy of the selected model (i.e., Cross-section and Period fixed effect). The values of RMSE=1.1378, MAE=0.9009, MAPE=22.0917, and Theil inequality coefficient is 0.0987under FEM for South Asia-3.

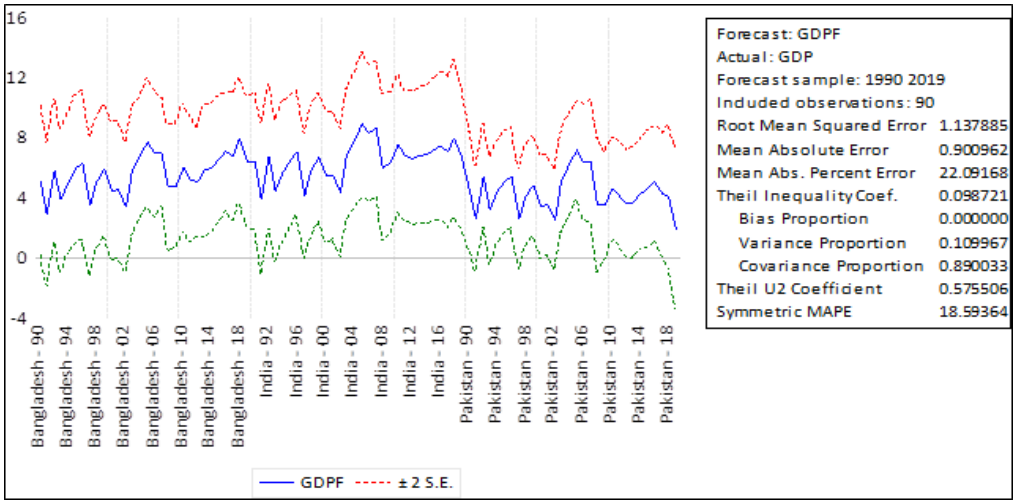


Figure 4.3: Fixed-Effect Model

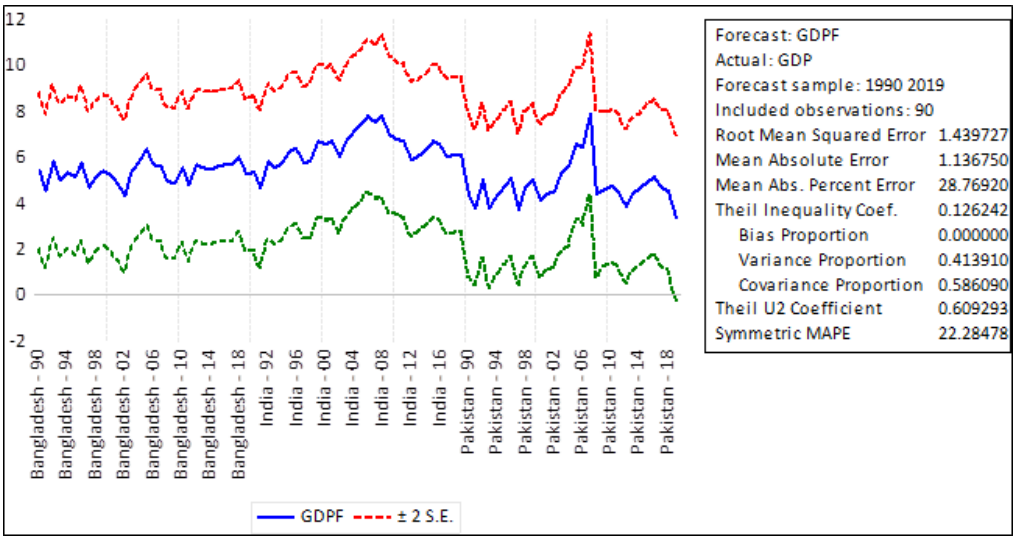


Figure 4.4: Random Effect Model

Figure 4.4 shows the values of RMSE=1.4397, MAE=1.1367, MAPE=28.7692, and Theil inequality coefficient is 0.1262 for REM model for South Asia-3 region. The comparative statistics for model accuracy are relative measures and there is no such hard and fast rule to decide which model is accurate but previous researchers set some rules that show that proximity of RMSE and Theil inequality coefficient values to one (1) shows that the model is accurate and can produce the good predictions than another model (Khin et

al., 2017; Li & Yang, 2008; Palmer et al., 2006). For the model of South Asia-3, as the results show above, FEM for South Asia-3 represent the accurate and practical forecasts.

4.2.3 Panel Model Results for Combined Data

4.2.3.1 Panel Unit Root Test

Table 4.12 presents results of panel unit root tests for combined data for both the regions (i.e., ASEAN-5 and South Asia-3) which indicates that all variables are non-stationary at level data except GDP under Im, Pesaran & Shin with 0.01 level of significance while all other variables are stationary at level.

Table 4.12: Panel Unit Root Test (Combined Data)

	Levin-Lin Chu		Im, Pesaran & Shin	
Variable	**Level**	**1st Diff.**	**Level**	**1st Diff.**
GDP	-0.796	-17.923***	-6.836***	-16.106***
R&D	0.820	-22.754***	0.577	20.35***
FDI	-2.725	-14.705***	-3.638***	-13.474***
NX	-1.390*	-14.974***	-1.761**	-11.281***
EXR	3.878	-11.276***	1.587	-8.046***
EMR	0.549	-10.934***	-0.059	-6.137***
INF	-4.984***	-18.483***	-6.518***	-16.610***

Note(s): GDP= gross domestic product growth rate, R&D= R&D expenditures, FDI= foreign direct investment, NX= net exports, EXR= exchange rate, EMR= employment rate, and INF= inflation rate. Std. Dev= standard deviation.
Note: *p <0.10, **p <0.05, and ***p <0.01 level of significance

However, all the variables become stationary at the first difference, and these changes are statistically significant at a significance level of $p<0.01$. This indicates that all variables eventually become stationary at the first difference level I(1) under both panel unit root tests. Consequently, the null hypothesis (H_0) for the presence of a unit root in the series has been rejected, affirming the stationarity of the variables at first difference.

4.2.3.2. Panel Co-integration Test

For the purpose of co-integration among for combined panel data, table 4.13 displays the results of the panel co-integration results among the variables using the Pedroni and Kao statistics. The table presents those values for Panel PP-Statistic, Panel ADF-Statistics, Group PP-Statistics and Group ADF-Statistics are -8.9761, -6.9138, -10.6607 and -6.3252 with $p< 0.01$ which shows that out of seven (7) tests of Pedroni criteria, four (4) criteria tests are significant along with panel ADF which is crucial in this case.

Table 4.13: Panel Co-integration Test (Combined Data)

Pedroni Test		**Kao Test**	
Criteria	**Statistics**	**Criteria**	**Statistics**
Panel v-Statistic	-1.055	ADF	-6.594***
Panel rho-Statistic	0.102		
Panel PP-Statistic	-8.976***		
Panel ADF-Statistic	-6.914***		
Group rho-Statistic	1.159		
Group PP-Statistic	-10.661***		
Group ADF-Statistic	-6.325***		

Source: EViews output
Note: *p <0.10, **p <0.05, and ***p <0.01 level of significance

The criteria for Kao test also significantly well with a value of -6.5938 whereas, value of $\alpha<0.01$. Hence, the results states that there is no co-integration using both the panel and group version tests and reject the null hypothesis (H_0) for co-integration at the 5% significance level. Hence, the study proceeds to go for panel model selection for the sake of robust results.

4.2.3.3. Panel Model Selection and Results

For combined data model, this study also run the model selectin process in the same manner as it did with previous models to know appropriate model for panel data which is depicted by Table 4.14.

Table 4.14: Panel Model Selection (Combined Data)

Test	Hypotheses	Results	Conclusion
Redundant Fixed Effects Tests	If p >0.05, H_0 = POLS is preferred. If p <0.05, H_1 = FEM is preferred.	X^2=61.183, p <0.01	Reject H_0, FEM is preferred.
Breusch-Pagan Test	If p >0.05, H_0 = POLS is preferred. If p <0.05, H_1 = REM is preferred.	X^2=79.467, p <0.01	Reject H_0, REM is preferred.
Hausman Test	If p >0.05, H0 = REM is preferred. If p <0.05, H_A = FEM is preferred.	X^2 =22.206, p <0.01	**Reject H_0, FEM is preferred.**

Source: EViews output

The table shows that value of α is greater than 0.05 for Pooled OLS which leads to accept alternate hypotheses (H_A) for panel data model of combined data. From the table, it is evident that the value of Chi-square ($\chi^{2)}$ using Lagrange Multiplier for Breusch-Pagan test is 79.467 with p <0.01 which showed the inappropriateness of REM for the model. Proceeding further, values of χ^2 =22.206 with p<0.01 show that REM is not appropriate and rejects the null hypotheses (H_0) for REM. Here, the study found that FEM is appropriate model for combined panel data. Hence, the study rejects null hypothesis accepting the alternate hypothesis to use FEM with cross-section fixed effect as shown in the Table 4.15. According to the table, 63.01% (R-square) proportion of variance in GDP growth rate has been occurred due the independent variables. Extending this fitness of the mode, the value of adjust R-square is = 0.5512 (55.12%) which means that the model provides robust and reliable results.

Table 4.15: Panel Model Estimation (Combined Data)

Dependent Variable: GDP growth rate				
Variables	**Coeff.**	**S.E.**	**t-Stat.**	**Prob.**
C	9.706	1.694	5.731	0.000***
ΔR&D	0.381	0.502	0.759	0.448
ΔFDI	0.158	0.048	3.311	0.001***
ΔNX	-0.129	0.028	-4.537	0.000***
ΔEXR	0.000	0.000	2.315	0.021**
ΔEMR	-0.062	0.027	-2.300	0.022**
ΔINF	-0.237	0.036	-6.520	0.000***
R-squared		**0.630**		
Adjusted R-squared		**0.551**		

Source: EViews output
Note: *p <0.10, **p <0.05, and ***p <0.01 level of significance
Δ denotes the 1st difference data

The value of intercept for this model is 9.71 which is quite good with a value of t-statistics greater than 5.0 and $p < 0.01$. R&D brings a 0.3805 change in the GDP growth rate if one (1) unit of R&D has been spent among the regions which significantly brings the change, but the value of p states the relative insignificance at $\alpha < 0.10$ of R&D compared to macroeconomic variables. Collectively for both of the regions, FDI and EXR have a positive impact on the GDP growth rate at $\alpha < 0.05$ respectively (see Table 4.15). Further, the table shows the negative impact of NX, EMR and INF on the GDP growth of the regions with values of coefficients -0.1285, 0.0618 and -0.2369 at $\alpha < 0.05$. The results showed the true shared economic situation of both regions as it has been observed practically that NX, EMR and INF are major issues in the way of growth of the Asian developing economies.

Decision: For combined model (ASEAN-5 x SA-3), this study rejects the null hypothesis (H_{03}) regarding the significant impact of R&D expenditures, net exports, exchange rate, foreign direct investment, employment rate, inflation rate on GDP growth rate. We can observe in the table that model's overall beta

value is 9.821 with p <0.001. In conclusion, Asian developing regions including ASEAN and SAARC need to pay attention on macroeconomic indicators. Specifically, trade balance, inflation and employment rates are crucial for South Asian regions where prices are going high with limited employment opportunities. In case of ASEAN, exchange rate of Indonesia and Malaysia is having adverse impact on GDP growth rate. This way, the results of combined model present true depiction of the situation. Hence, due to results of overall impact, this study rejects the null hypotheses (H_{03}) for combined panel model.

4.2.3.4 Model Accuracy

At this level, the author also checked the model accuracy of the selected model for combined panel data which has been depicted by the figures below.

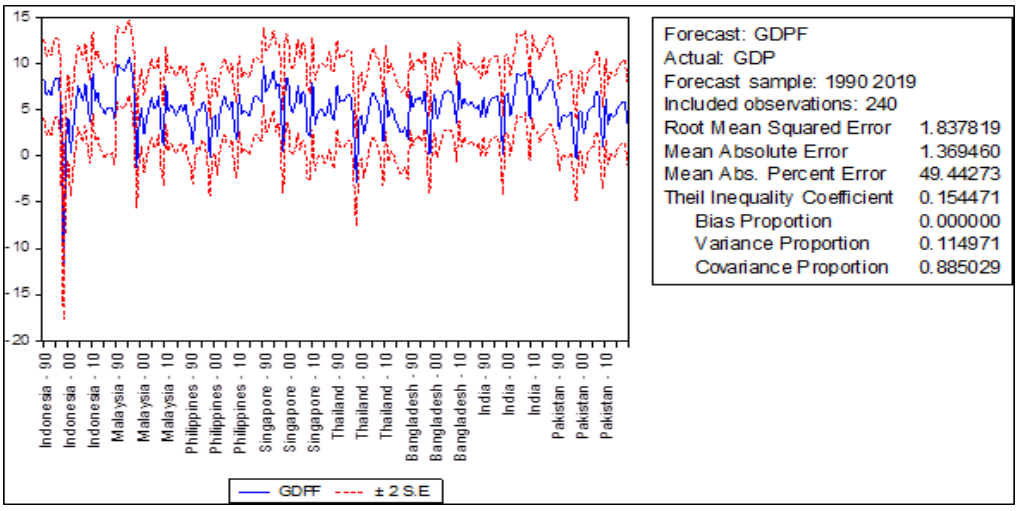


Figure 4.5: Fixed-Effect Model Accuracy

Figure 4.5 shows the values of RMSE=1.8378, MAE=1.3694, MAPE=49.4427, and Theil's inequality coefficient = 0.1544 for FEM of combined data. Figure 4.6 shows the values of RMSE=2.1725, MAE=1.6968,

MAPE=67.2743, and Theil's inequality coefficient is 0.1861 for FEM panel data model. The comparison for both the models shows that the results of FEM for cross-section and period are more appropriate depicting the high accuracy of FEM for combined data model.

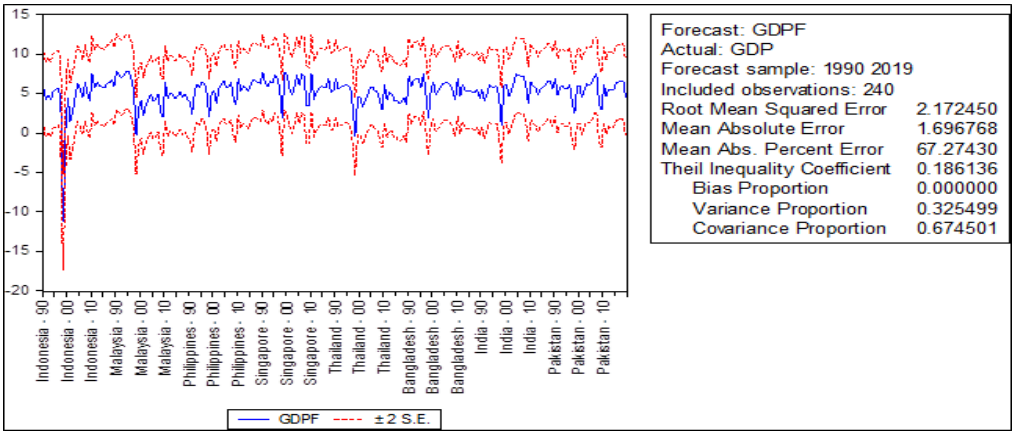


Figure 4.6: Random-Effect Model Accuracy

4.3 Vector Error Correction Model (VECM) Results

As the behaviour of macroeconomic country-level data is non-stationary at level, VECM analysis can provide robust and reliable results. After the VECM results, Johansen co-integration test has been run to check the suitability of the model to see the dynamics between GDP growth rate and exogenous variable over the long run (Studenmund, 2014). Hence, first this study checked the stationarity of the variables to pursue the VECM analysis.

4.3.1 Unit Root Test Results

To check the stationarity of the data, Table 4.16 presents the results of ADF and Philip-Parron test only for time-series data.

Table 4.16: Unit Root Test Results

	Indonesia				Malaysia			
	ADF		Phillips-Perron Test		ADF		Phillips-Perron Test	
	Level	1st Diff	Level	1st Diff	Level	1st Diff	Level	1st Diff
GDP	-2.747**	-4.227***	-1.921*	-4.681***	-2.684**	-4.672***	-1.774*	-5.184***
R&D	-0.156	-4.581***	1.050	-5.071***	0.571	4.31***	1.501	-4.717***
FDI	-2.172	-3.931***	-1.328	-4.277***	-1.874*	-4.684***	-1.373	-5.167***
NX	-2.004**	-4.243***	-1.287	-4.657***	-1.343	-4.094***	-0.855	-4.425***
EXR	0.635	-3.773***	1.614	-4.094***	0.523	-3.61***	1.066	-3.894***
EMR	-0.292	-3.278***	0.346	-3.488***	0.998	-2.971***	1.485	-3.155***
INF	-3.334***	-4.618***	-2.105**	-5.098***	-2.014**	-4.927***	-1.247	-5.454***

	Philippines				Singapore			
	ADF		Phillips-Perron Test		ADF		Phillips-Perron Test	
	Level	1st Diff	Level	1st Diff	Level	1st Diff	Level	1st Diff
GDP	-1.744*	-2.360**	-1.188	-2.777**	-2.576**	-4.546***	-1.874*	-5.029***
R&D	-1.808*	-5.515***	-0.897	-5.933***	-0.654	-5.055***	-0.188	-5.601***
FDI	-1.394	-4.415***	-0.895	-4.835***	-1.127	-4.795***	-0.395	-5.335***
NX	-1.924*	-2.856***	-1.513	-2.174**	-1.380	-1.913**	-0.715	-2.213**
EXR	0.168	-3.933***	0.723	-4.285***	-0.791	-2.922***	-1.474	-3.035***
EMR	-1.045	-1.870**	-1.372	-2.193**	0.913	-3.544***	1.979	-3.835***
INF	-2.970***	-4.444***	-2.952***	-4.897***	-2.898***	-4.534***	-1.920*	-5.014***

	Thailand				Bangladesh			
	ADF		Phillips-Perron Test		ADF		Phillips-Perron Test	
	Level	1st Diff	Level	1st Diff	Level	1st Diff	Level	1st Diff
GDP	-2.682**	-4.085***	-2.196**	-4.526***	-0.988	-3.117***	-0.798	-3.499***
R&D	-0.015	-3.313***	2.311	-3.547***	-3.181***	-4.823***	-2.027**	-5.355***
FDI	-1.824*	-4.473***	-1.312	-4.956***	-1.263	-4.285***	-0.737	-4.715***
NX	-2.716**	-3.372***	-1.69*	-3.694***	-1.273	-2.916***	-1.246	-3.275***
EXR	-0.353	-4.531***	-0.110	-5.017***	1.725	-3.297***	3.836	-3.487***
EMR	-0.955	-3.620***	-1.493	-3.878***	-0.744	-3.548***	-0.824	-3.890***
INF	-2.366**	-4.790***	-1.740*	-5.339***	-1.425	-4.479***	-0.896	-4.933***

	India				Pakistan			
	ADF		Phillips-Perron Test		ADF		Phillips-Perron Test	
	Level	1st Diff	Level	1st Diff	Level	1st Diff	Level	1st Diff
GDP	-1.293	-3.380***	-1.020	-3.781***	-1.871*	-3.911***	-1.274	-4.340***
R&D	0.444	-2.691**	0.793	-2.964***	-1.477	-5.651***	-0.91	-6.072***
FDI	-0.545	-4.073***	0.044	-4.472***	-1.854*	-3.124***	-1.034	-3.290***
NX	-1.536	-3.454***	-0.976	-3.783***	-2.026**	-2.853***	-1.325	-3.210***
EXR	1.633	-4.113***	3.195	-4.374***	1.954	-2.675**	5.283	-2.763***
EMR	-1.334	-2.988***	-1.924*	-3.391***	-0.786	-4.035***	0.257	-4.122***
INF	-1.560	-4.398***	-1.415	-4.850***	-1.377	-4.376***	-0.790	-4.808***

Source: EViews output

Note: *p <0.10, **p <0.05, and ***p <0.01 level of significance

The table shows that most of the variables for each country under study were non-stationary at level I(0) and later, they become stationary at first difference I(1) at α <0.05. Specifically, GDP, NX and INF were stationary for Indonesia at α <0.05 while all other variables were found non-stationary at level. For Malaysia, GDP and INF were found stationary at level I(1) while for the Philippines, only INF was stationary at level. For Singapore and Thailand, GDP and INF were found stationary at α <0.05. When we talk about South Asian countries, it reveals that R&D was stationary at level while only INF was stationary at α <0.05. All the variables for each country under study became stationary at first difference I(1) resulting in the rejection of null hypotheses (H_0) for data stationary for GDP, R&D and macroeconomic variables at $\alpha < 0.05$ using ADF and Phillip-Parron tests (see Table 4.16).

4.3.2 Co-integration Equation Results

Following table 4.17 presents the co-integration equations for each country. Results of Indonesia equation state that R&D, NX, EXR, EMR and INF have long-term co-integration with GDP growth rate. Specifically, results are based on co-integration at 1stdifference for Indonesia, Malaysia, and India whereas, at level data for the Philippines, Singapore, Thailand, Bangladesh and Pakistan. The asymptotic impact of co-integration in time series assumes that the sum of mean in a co-integration equation should be equal to or less than zero (Kremers et al., 1992) which has been presented in the give table. From the Table 4.17, results show that R&D expenditures have long-term co-integration with GDP growth rate for Philippines, Bangladesh and Pakistan at 99% level of

significance (at $\alpha < 0.01$), 95% level of significance (at $\alpha < 0.05$) for Indonesia, Thailand and India while 90% level of significance (at $\alpha < 0.10$) with GDP growth rate of Malaysia and Singapore. FDI has long-term co-integration at $\alpha < 0.01$ with GDP growth rate of Thailand while at $\alpha < 0.05$ in the case of Indonesia, Bangladesh, India and Pakistan. Net exports (NX) have integration at $\alpha < 0.01$ for Pakistan only while its co-integration for long-run Indonesia, Philippines, Singapore and Thailand it at $\alpha < 0.05$ while for Malaysia, it is significant at $\alpha < 0.01$. Exchange rate has long-term co-integration with GDP at $\alpha < 0.05$ for all the countries under study. It is important to mention that GDP growth rate of Thailand has long-term co-integration relationships with EMR at 99% ($\alpha < 0.01$) while the co-integration of inflation rate it significant with GDP of all the countries at $\alpha < 0.05$ except Singapore with $\alpha > 0.10$, and Indonesia with $\alpha < 0.01$ levels of significance. As the major estimator of GDP growth rate for this study is R&D expenditures, hence, this study proceeds to examine the VECM equation to test the hypotheses from H_{04} to H_{011} developed for each country.

Table 4.17: Co-integration Equations for Indonesia, Malaysia, Philippines, Singapore, Thailand, Bangladesh, India and Pakistan

	D(GDP)	D(R&D)	D(FDI)	D(NX)	D(EXR)	D(EMR)	D(INF)	
Indonesia								
CointEq1	0.027**	-0.001**	-0.003**	-0.009**	-5.417**	-0.000	-0.099***	= 0
t-stat	[4.899]	[-2.326]	[-2.259]	[-0.328]	[-4.157]	[0.576]	[-6.252]	
Malaysia								
CointEq1	-0.063**	-0.000*	-0.0112*	0.022*	0.0013*	0.000	0.0197**	= 0
t-stat	[-3.696]	[-1.6545]	[-1.983]	[1.529]	[1.7743]	[0.284]	[3.244]	
Philippines								
CointEq1	-0.0063**	-0.001***	-0.0002	-0.005**	0.015**	-0.000	0.014**	= 0
t-stat	[-1.969]	[-5.610]	[-0.271]	[-2.354]	[3.911]	[-0.491]	[4.598]	
Singapore								
CointEq1	-0.030***	-0.001*	-0.0295**	0.015**	0.000	0.001	0.002	= 0
t-stat	[-6.210]	[-1.772]	[-3.794]	[3.042]	[1.075]	[1.455]	[1.131]	
Thailand								
CointEq1	-0.003*	-0.000**	-0.0045***	-0.005**	0.009**	0.002***	-0.003**	= 0
t-stat	[-1.8177]	[-4.683]	[-5.893]	[-2.739]	[3.918]	[6.262]	[-2.437]	
Bangladesh								
CointEq1	-0.529**	-0.001***	-0.0016**	0.002	0.002	-0.001	-0.012**	= 0
t-stat	[-3.181]	[-7.014]	[-4.274]	[1.127]	[0.797]	[-1.225]	[-3.417]	
India								
CointEq1	0.028*	-0.001**	-0.0052**	0.001	-0.057**	0.011**	-0.044**	= 0
t-stat	[1.956]	[-2.887]	[-2.030]	[0.137]	[-3.183]	[3.036]	[-3.133]	
Pakistan								
CointEq1	0.000*	-0.001***	0.001**	-0.001***	0.001**	0.000	-0.001***	= 0
t-stat	[1.635]	[-7.478]	[3.399]	[-4.979]	[2.299]	[0.204]	[-6.467]	

Source: EViews output

Note: *p <0.10, **p <0.05, and ***p <0.01 level of significance

4.3.3 VECM Equation Estimates

Table 4.18 shows the results of VECM equations' estimations for each country under the study. From the table, it has been evident that R&D, FDI and NX are important 23.588, 1.213 and 0.771 at 95% significance level (α <0.05). Inflation rate has beta value 0.504 at 99% level of significance (α <0.01) while EMR has insignificant beta value of 0.244. For Malaysia, R&D has 0.179 value of slope with t-statistics value at 90% level of significance (α <0.10). With macroeconomic indicators FDI and NX have 0.049 and 0.016 slope value at 95% level of significance (α <0.05) while other variables have insignificant slope when GDP growth rate is endogenous variables. For Philippines, R&D expenditures have not significant relationship with GDP growth rate with 0.2805 value of beta while it only has 0.1423 relationship with FDI at 90% level of significance. GDP growth rate of Singapore has significant relationships with R&D, EXR and EMR (-0.073, -4.451 and 0.454 with p< 0.05). This way, this study rejects the null hypothesis of R&D expenditures and macroeconomic indicators significant relationship with economic growth. For Thailand economic growth, this study rejects the null hypothesis (H_{08}) as it has positive relationship with R&D expenditures, EXR and INF (2.247, -0.032 and 0.002) considering R&D as major estimator for economic growth.

Table 4.18: Result of VECM Equations for Indonesia, Malaysia, Philippines, Singapore, Thailand, Bangladesh, India and Pakistan

	Indonesia	Malaysia	Philippines	Singapore	Thailand	Bangladesh	India	Pakistan
	ΔGDP	**ΔGDP**	**ΔGDP**	**ΔGDP**	**ΔGDP**	**ΔGDP**	**ΔGDP**	**ΔGDP**
D(GDP(-1))	1.123	1.213**	0.939***	0.894***	0.916***	0.932	0.963***	0.899***
t-stat	[15.699***]	[2.734]	[30.229]	[31.598]	[29.238]	[30.086***]	[27.918]	[37.577]
D(R_D(-1))	23.588	0.179	0.281	-0.073**	2.247	-0.752	1.144	-0.254
t-stat	[3.5703**]	[1.809*]	[0.311]	[-2.293]	[1.855*]	[-4.550**]	[0.596]	[-0.643]
D(FDI(-1))	1.213	0.049	0.142	-0.013	-0.022	-0.094	0.015	-0.122
t-stat	[2.734**]	[2.047**]	[1.581*]	[-0.673]	[-0.255]	[-0.788]	[0.089]	[-1.101]
D(NX(-1))	0.771	0.016	-0.006	0.033	0.029	-0.038	-0.065	0.002
t-stat	[3.472**]	[2.995**]	[-0.161]	[1.638*]	[1.067]	[-1.503*]	[-1.895*]	[0.104]
D(EXR(-1))	0.000	0.007	0.010	-4.452	-0.032	-0.004	0.041*	-0.012
t-stat	[1.500**]	[0.085]	[0.447]	[-2.1569**]	[-1.649*]	[-0.239]	[1.7788]	[-1.611*]
D(EMR(-1))	0.244	-0.015	0.0706	0.455**	0.022	0.0267	-0.035	0.015
t-stat	[0.859]	[-0.496]	[0.578]	[2.089]	[0.151]	[0.507]	[-0.388]	[0.174]
D(INF(-1))	0.504	0.017	0.005	-0.033	0.002	0.008	0.018	-0.006
t-stat	[14.006***]	[0.628]	[0.194]	[-0.407]	[0.029]	[0.464]	[0.740]	[-0.336]
C	-3.928	-0.001	-0.004	-0.019	-0.011	-0.001	-0.009	0.002
t-stat	[-2.261**]	[-0.069]	[-0.627]	[-1.644*]	[-1.788*]	[-0.045]	[-1.554*]	[2.348**]
R-squared	0.809	0.795	0.861	0.814	0.817	0.852	0.842	0.825
Adj. R-squared	0.805	0.791	0.858	0.809	0.813	0.849	0.839	0.821

Source: EViews output
Note: *p <0.10, **p <0.05, and ***p <0.01 level of significance

In case of Bangladesh, R&D expenditures are significant at $p<0.05$ (α <0.05) with value 0.7518-unit change. This way, null hypothesis (H_{09}) for Bangladesh has also been rejected for this study. Among macroeconomic indicators, only NX has significant relationship with GDP growth rate. For India and Pakistan, R&D has not significant relationship with GDP growth rate while NX and EXR have significant relationship with economic growth of India with values -0.0655 and 0.0411 respectively. Lastly, in case of Pakistan, same indicators i.e., NX and EXR have significant relationship with GDP growth rate (-0.0021 and -0.0118 respectively). This way, this study accepts the null hypotheses H_{010} and H_{011} developed for these economies of South Asia.

When we further see the Table 4.18, values of R-Square ranges from 0.7915 to 0.8524 for all the countries showing the effectiveness of the models. The lowest value of adjusted R-squared (0.7955) for Malaysia and highest values of adjusted R-squared (0.8590) for the Bangladesh show that VECM methods significantly present the model in good manners showing reliable and valid results for each country under study.

4.3.4 Johansen Co-integration Rank Tests

Since all the variables for this study have been found stationary at level *I*(1) which meet the assumption to run co-integration rank test for VECM. Following the Schwarz Criteria for Johansen co-integration tests, following tables show the results of Rank test and Eigen value tests for confirming the VECM methods.

Table 4.19: Co-integration Rank Test (Indonesia)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.148	137.774	111.781	0.000
At most 1 *	0.137	97.690	83.937	0.004
At most 2 *	0.093	60.775	60.061	0.044
At most 3	0.086	36.164	40.175	0.120
At most 4	0.028	13.575	24.276	0.573
At most 5	0.024	6.373	12.321	0.392
At most 6	0.001	0.272	4.130	0.663

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.148	40.084	42.772	0.096
At most 1 *	0.137	36.916	36.630	0.046
At most 2	0.093	24.610	30.440	0.224
At most 3	0.086	22.589	24.159	0.080
At most 4	0.028	7.203	17.797	0.791
At most 5	0.024	6.101	11.225	0.338
At most 6	0.001	0.272	4.130	0.663

Notes: Trace test indicates 3 cointegrating eqn (s) at the 0.05 level
* Denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 4.19 shows different result for Trace statistics and Eigen Value statistics for Indonesia. Trace statistics values is significant for three criteria with 137.7740, 97.6903 and 60.7747 at 5% significance ($\alpha < 0.05$) while for Eigen Value statistics, two criteria were found significant with $\alpha < 0.05$ with 40.08367 and 36.91559 which shows the prevalence of Trace statistics. Hence, this study rejects the null hypothesis (H_0) considering Trace good for co-integration for Indonesia.

Table 4.20(below) shows different results at most 1, 2, 3 and 4, Trace statistics values are significant at 95% ($\alpha < 0.05$) compared to not a single Eigen Value statistics significance for Malaysia. Hence, reject the null hypothesis (H_0) considering Trace statistics confirming VECM for analysis.

Table 4.20: Co-integration Rank Test (Malaysia)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.152	130.601	111.781	0.002
At most 1 *	0.129	93.373	83.937	0.009
At most 2 *	0.099	62.063	60.061	0.034
At most 3	0.087	38.619	40.175	0.071
At most 4	0.056	18.173	24.276	0.242
At most 5	0.012	5.127	12.321	0.550
At most 6	0.010	2.326	4.130	0.150

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.1519	37.2276	42.7722	0.1798
At most 1 *	0.1294	31.3099	36.6302	0.1833
At most 2	0.0985	23.4441	30.4396	0.2876
At most 3	0.0865	20.4466	24.1592	0.1472
At most 4	0.0561	13.0451	17.7973	0.2249
At most 5	0.0123	2.8016	11.2248	0.8178
At most 6	0.0102	2.3258	4.1299	0.1502

Notes: Trace test indicates 3 cointegrating eqn (s) at the 0.05 level
* Denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 4.21: Co-integration Rank Test (Philippines)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.205	152.856	111.781	0.000
At most 1 *	0.133	95.203	83.937	0.006
At most 2 *	0.107	59.498	60.061	0.056
At most 3	0.060	31.177	40.175	0.296
At most 4	0.036	15.776	24.276	0.396
At most 5	0.026	6.653	12.321	0.361
At most 6	0.000	0.066	4.130	0.833

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.205	57.653	42.772	0.001
At most 1 *	0.133	35.705	36.630	0.064
At most 2	0.107	28.321	30.440	0.090
At most 3	0.060	15.401	24.159	0.473
At most 4	0.036	9.122	17.797	0.581
At most 5	0.026	6.587	11.225	0.288
At most 6	0.000	0.066	4.130	0.833

Notes: Trace test indicates 3 cointegrating eqn (s) at the 0.05 level
* Denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

For the Philippines, Table 4.21 shows that Trace statistics is significant at 95% (α <0.05) for three criteria with 152.8561, 95.2030, and 59.4978 while for Eigen Values, it is also significant at 95% (α <0.05) for three criteria with 57.6532, 35.7052 and 28.3213. Based on similar results, it is suggested to reject the null hypothesis (H_0) also considering Trace statistics good for co-integration (Lüutkepohl et al., 2001).

Table 4.22:Co-integration Rank Test (Singapore)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.158	131.514	111.781	0.002
At most 1 *	0.132	88.420	83.937	0.023
At most 2 *	0.081	52.886	60.061	0.174
At most 3	0.061	31.648	40.175	0.274
At most 4	0.039	15.988	24.276	0.380
At most 5	0.024	6.018	12.321	0.434
At most 6	0.000	0.026	4.130	0.895

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.158	43.094	42.772	0.046
At most 1 *	0.132	35.535	36.630	0.067
At most 2	0.081	21.238	30.440	0.439
At most 3	0.061	15.660	24.159	0.451
At most 4	0.039	9.971	17.797	0.488
At most 5	0.024	5.991	11.225	0.351
At most 6	0.000	0.026	4.130	0.895

Notes: Trace test indicates 3 cointegrating eqn (s) at the 0.05 level
* Denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

For Singapore, Table 4.22 show the significance of two criterion for both Trace and Eigen Value statistics as presented by the table so, according to Lüutkepohl et al. (2001) this study rejects the null hypothesis (H_0) for Singapore also considering the prevalence of Trace good for co-integration. Table 4.23 confirms the prevalence of Trace values with three significant criteria with values 130.9347, 89.7411 and 59.8370 provided that VECM has provided good

results rejecting the null hypothesis (H_0) for co-integration in case of Thailand's model as well.

Table 4.23:Co-integration Rank Test (Thailand)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.151	130.935	111.781	0.002
At most 1 *	0.112	89.741	83.937	0.018
At most 2 *	0.101	59.837	60.061	0.052
At most 3	0.067	33.260	40.175	0.208
At most 4	0.044	15.853	24.276	0.390
At most 5	0.011	4.578	12.321	0.627
At most 6	0.007	1.730	4.130	0.221

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.151	41.194	42.772	0.074
At most 1 *	0.112	29.904	36.630	0.246
At most 2	0.101	26.577	30.440	0.141
At most 3	0.067	17.407	24.159	0.313
At most 4	0.044	11.275	17.797	0.361
At most 5	0.011	2.848	11.225	0.811
At most 6	0.007	1.730	4.130	0.221

Notes: Trace test indicates 3 cointegrating eqn (s) at the 0.05 level
* Denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 4.24: Co-integration Rank Test (Bangladesh)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.200	142.402	111.781	0.000
At most 1 *	0.115	86.271	83.937	0.034
At most 2 *	0.093	55.708	60.061	0.110
At most 3	0.063	31.349	40.175	0.288
At most 4	0.039	15.123	24.276	0.446
At most 5	0.017	5.195	12.321	0.541
At most 6	0.004	0.935	4.130	0.386

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.200	56.130	42.772	0.001
At most 1 *	0.115	30.564	36.630	0.215
At most 2	0.093	24.359	30.440	0.237
At most 3	0.063	16.226	24.159	0.403
At most 4	0.039	9.928	17.797	0.493
At most 5	0.017	4.260	11.225	0.587
At most 6	0.004	0.935	4.130	0.386

Notes: Trace test indicates 3 cointegrating eqn (s) at the 0.05 level
* Denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 4.24 shows the results of Trace and Eigen Value statistics for Bangladesh which leads to reject null hypothesis (H_0) with two criteria' values of 142.4016 and 86.2712 with p<0.05 (α <0.05) compared to single criterion significance under Eigen Value statistics. Tables 4.25 shows the co-integration rank test results for India which depicts the prevalence of Trace for India with 126.1053 and 85.8602 values with p<0.05(α <0.05). For Eigen Value, only single criterion meets the requirement, hence reject the null hypothesis (H_0) for ranking the India's co-integration equation as well.

Table 4.25: Co-integration Rank Test (India)

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.148	126.105	111.781	0.005
At most 1 *	0.110	85.860	83.937	0.036
At most 2 *	0.079	56.691	60.061	0.093
At most 3	0.070	35.944	40.175	0.125
At most 4	0.039	17.668	24.276	0.270
At most 5	0.024	7.806	12.321	0.252
At most 6	0.007	1.698	4.130	0.226

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.148	40.245	42.772	0.092
At most 1 *	0.110	29.169	36.630	0.285
At most 2	0.079	20.747	30.440	0.477
At most 3	0.070	18.276	24.159	0.256
At most 4	0.039	9.862	17.797	0.500
At most 5	0.024	6.108	11.225	0.338
At most 6	0.007	1.698	4.130	0.226

Notes: Trace test indicates 3 cointegrating eqn (s) at the 0.05 level
* Denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Finally, Table 4.26 shows the equal number of criteria at 95% significance level (α <0.05) with 144.1658 and 93.0170 statistics values for Trace while 51.1488 and 40.6415 for Eigen Value statistics. Hence, the study rejects the null hypothesis (H_0) here for Pakistan's co-integration equation also.

Table 4.26: Co-integration Rank Test (Pakistan)

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Trace Statistic**	**0.05 Critical Value**	**Prob.****
None *	0.184	144.166	111.781	0.000
At most 1 *	0.149	93.017	83.937	0.009
At most 2 *	0.069	52.376	60.061	0.188
At most 3	0.059	34.466	40.175	0.166
At most 4	0.049	19.012	24.276	0.199
At most 5	0.022	6.516	12.321	0.375
At most 6	0.003	0.842	4.129	0.414
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Max-Eigen Statistic**	**0.05 Critical Value**	**Prob.****
None	0.184	51.149	42.772	0.005
At most 1 *	0.149	40.642	36.630	0.016
At most 2	0.069	17.909	30.439	0.705
At most 3	0.059	15.454	24.159	0.468
At most 4	0.049	12.496	17.797	0.262
At most 5	0.022	5.674	11.224	0.388
At most 6	0.003	0.842	4.129	0.414

Notes: Trace test indicates 3 cointegrating eqn (s) at the 0.05 level
* Denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Conclusively, the study found the prevalence of Trace Tests among all the countries shows fewer co-integration among the variables under each country data. It is evident that VECM provided the robust and practicable results for all eight (8) countries under study.

4.3.5 Granger's Causality Test

Table 4.27, below, represents the causal relationships between GDP growth rate, R&D expenditures, foreign direct investment, net exports, exchange rates, employment rate, and inflation rate for each country under study. It is important to mention that Granger's causality has been calculated applying Ad-hoc selection methods taking one (1) lag to the data considering the appropriateness to macroeconomic data (Jones, 1989).

Table 4.27: Pairwise Granger's Causality Results

	Indonesia		Malaysia		Philippines		Singapore		Thailand		Bangladesh		India		Pakistan	
Null Hypothesis:	**F-Stat**	**Prob.**	**F-Stat**	**Prob.**	**F-Stat**	**Prob.**	**F-Stat**	**Prob.**	**F-Stat**	**Prob.**	**F-Stat**	**Prob.**	**F-Stat**	**Prob.**	**F-Stat**	**Prob.**
R&D does not Granger Cause GDP	4.354	0.03**	0.214	0.64	29.151	0.00***	0.055	0.82	4.891	0.02**	3.808	0.05**	1.333	0.24	5.316	0.02**
GDP does not Granger Cause R&D	0.398	0.52	25.409	0.00***	1.952	0.16	0.252	0.61	0.736	0.39	1.741	0.18	98.754	0.00***	1.591	0.20
FDI does not Granger Cause GDP	28.602	0.00***	0.719	0.39	5.922	0.02**	2.466	0.11	42.163	0.00***	8.704	0.00***	17.382	0.00***	19.974	0.00***
GDP does not Granger Cause FDI	68.781	0.00***	0.994	0.31	2.420	0.12	0.001	0.97	5.454	0.02**	8.553	0.00***	0.232	0.63	134.622	0.00***
NX does not Granger Cause GDP	37.034	0.00***	21.133	0.00***	23.473	0.00***	0.619	0.43	60.392	0.00***	9.578	0.00***	10.979	0.00***	37.367	0.00***
GDP does not Granger Cause NX	66.850	0.00***	15.642	0.00***	91.387	0.00***	31.552	0.00***	61.333	0.00***	0.995	0.31	86.975	0.00***	225.373	0.00***
EXR does not Granger Cause GDP	0.074	0.78	1.356	0.24	24.248	0.00***	7.144	0.00***	4.367	0.03**	2.293	0.13	20.473	0.00***	14.268	0.00***
GDP does not Granger Cause EXR	8.173	0.00***	21.781	0.00***	11.952	0.00***	86.352	0.00***	0.979	0.32	0.078	0.78	12.931	0.00***	21.268	0.00***
EMR does not Granger Cause GDP	6.144	0.01**	6.921	0.00***	153.202	0.00***	10.344	0.00***	0.399	0.52	0.719	0.39	27.784	0.00***	10.492	0.00**
GDP does not Granger Cause EMR	12.962	0.00***	20.035	0.00***	5.346	0.02**	242.106	0.00***	97.520	0.00***	2.920	0.08*	18.718	0.00***	2.782	0.09*
INF does not Granger Cause GDP	11.174	0.000***	1.512	0.22	11.266	0.00***	30.118	0.00***	8.657	0.00***	5.423	0.02**	14.553	0.00***	16.305	0.00***
GDP does not Granger Cause INF	0.303	0.58	7.567	0.00***	18.181	0.00***	75.792	0.00***	24.906	0.00***	1.905	0.16	10.724	0.00***	30.056	0.00***
														Observations		**359**

Source: EViews output
Note: *p <0.10, **p <0.05, and ***p <0.01 level of significance

For Indonesia, R&D has causal relationship with GDP so reject H_0 for R&D to GDP while accept null hypotheses (H_0) for GDP to R&D. This means the unidirectional causality for R&D to GDP only. GDP has bidirectional causality with FDI NX and EMR leading to reject null hypotheses (H_0) for foreign direction investment, next exports and employment rate. Exchange rate does not Granger causes GDP while GDP Granger causes EXR showing unidirectional causal relationship. GDP of Malaysia Granger causes R&D having unidirectional relationship. Net exports and employment rate have bidirectional Granger causality relationship with GDP leading to reject null hypotheses (H_0) in these cases. GPD has Granger causality with inflation rate while inflation rate does not Granger cause GDP showing unidirectional causal relationship. For Philippines, net exports, exchange rate, employment rate and inflation rate have bidirectional Granger causality with GDP growth rate leading to reject H_0 for Granger causality for NX, EXR, EMR and INF for Philippines. R&D does have Granger causality with GDP while GDP does not Granger causes R&D showing unidirectional causality.

In case of Singapore, exchange rate, employment rate, and inflation rate have bidirectional causality with GDP leading this study to reject null hypotheses (H_0) for Granger causality at lag 1. R&D expenditures and FDI have no causal relationship with GDP, hence, accept null hypotheses (H_0) while net exports have unidirectional Granger causality with GDP. R&D expenditures have unidirectional causality with GDP growth rate of Thailand while FDI, net exports and inflation rate have bidirectional causality with GDP leading to reject null hypotheses (H_0) for these variables' relationship. Exchange rate and

employment rate have unidirectional causality with GDP. In case of Bangladesh, R&D does have unidirectional Granger causality with GDP while, FDI has bidirectional causality with GDP which leads to reject null hypotheses (H_0) for FDI. Net exports and inflation rate have unidirectional granger causality with GDP. R&D expenditures, foreign direct investment have unidirectional Granger causality with GDP while all other variables do have significant causal relationship with GDP of India. Hence, this study rejects the null hypotheses for R&D to GDP, FDI to GDP, NX to GDP, GDP to NX, EXR to GDP, GDP to EXR, EMR to GDP, GDP to EMR, INF to GDP and GDP to INF for India at 5% significance level taking 1 lag for Ad-hoc Granger causality (see Table 4.27). Lastly, R&D of Pakistan does have unidirectional Granger causality with GDP which directs this study to reject null hypotheses (H_0) for R&D to GDP while accepting null hypotheses (H_0) for GDP to R&D. For all other relationships of FDI, net exports, exchange rate, employment rate, and inflation rate with GDP, this study reject null hypotheses (H_0) on the basis of the results of Granger's causality.

Considering the results provided by above Table 4.27, it emphasizes how complicatedly the economic factors interrelate with each other in case of each economy. This crucial relationship is helpful to comprehend the unique dynamics that exist within each nation's economy to properly understand the causal links and implications for economic policy and development initiatives, more research and policy considerations are required.

4.3.6 Residual Diagnostics

The analysis of normal distribution through P-plots (as presented in the annexures) found majority of the data were within the bell-shaped curve which leads to ignore the Jarque-Bera statistics for time series (Laskar & King, 1997). Hence, in further subsections, results of multicollinearity and heteroscedasticity for residual error diagnostics have been presented.

4.3.6.1 Multicollinearity Test

Based on the appropriate data model, Table 4.28 shows the multicollinearity test results through the variance inflation factor (VIF).

Table 4.28: Multicollinearity Test

	Centered VIF							
	Indo	**Mal**	**Phil**	**Sing**	**Thai**	**Ban**	**Ind**	**Pak**
R&D	1.1140	1.2434	1.9712	1.9985	1.1069	1.2374	1.3115	1.9307
FDI	1.9691	1.1945	1.4648	3.1242	1.4530	8.9907	1.3983	1.8362
NX	2.8994	1.8588	1.4582	2.4812	1.4491	1.7099	1.1293	2.8527
EXR	1.3391	1.9768	2.7975	5.2823	1.1712	3.6431	1.3764	2.4648
EMR	1.0590	1.0498	1.4067	7.0249	1.6871	7.4706	1.1655	1.2119
INR	2.1014	1.2715	2.0069	1.7295	1.2020	1.5953	1.0303	1.5376

Source: EViews output
Notes: Indo, Mal, Phil, Sing, Thai, Ban, Ind, and Pak are Indonesia, Malaysia, Philippines, Singapore, Thailand, Bangladesh, India and Pakistan respectively.
Values of VIF subject to <10 (James et al., 2013)

Values of centered VIF for Indonesia, Malaysia, Philippines, Thailand, India and Pakistan lie between 1.0590- 2.8994 which are quite less than 5 showing no multicollinearity while VIF values for EXR and EMR of Singapore a greater than 5 (5.28 and 7.02 respectively) but less than 10. In the case of Bangladesh data, VIF of FDI and EMR (8.99 and 7.47 respectively) were found

greater than 5 but less than 10 meaning under the acceptable range (O'brien, 2007). It is important to note that this study used time series data comprising seven (7) variables. According to James et al. (2013), the VIF values for variables falling between 5 and 10, with value of VIF < 10, are considered satisfactory indicating the absence of multicollinearity issues. Hence, it has been concluded that data of independent variables for all eight (8) countries is not correlated to each other and results from this data present the robustness of the analysis for effective explanation.

4.3.6.2 Heteroscedasticity Test

The following table 4.29 presents the results of heteroscedasticity to evaluate the equal distribution of the residuals which are necessary to examine in regression analysis in time series data.

Table 4.29: Heteroscedasticity Tests

Country	F-stat	Prob	Decision
Indonesia	3.5560	0.1966	Do not reject H_0: The is no heteroscedasticity (at α>0.10)
Malaysia	5.5035	0.1830	Do not reject H_0: The is no heteroscedasticity (at α>0.10)
Philippines	11.5093	0.0550	Do not reject H_0: The is no heteroscedasticity (at α>0.05)
Singapore	7.9555	0.0652	Do not reject H_0: The is no heteroscedasticity (at α>0.05)
Thailand	14.7360	0.0889	Do not reject H_0: The is no heteroscedasticity (at α>0.05)
Bangladesh	52.7301	0.0805	Do not reject H_0: The is no heteroscedasticity (at α>0.05)
India	47.0667	0.1279	Do not reject H_0: The is no heteroscedasticity (at α>0.10)
Pakistan	16.5644	0.0848	Do not reject H_0: The is no heteroscedasticity (at α>0.05)

Source: EViews output

From the table, it is clear that for all the countries under study value of $\alpha < 0.05$ states no issue of heteroscedasticity with the residuals. Specifically, for Indonesia, Malaysia and India α is greater than 0.10 and for Philippines, Singapore, Thailand, Bangladesh and Pakistan value of $\alpha > 0.05$ is still under the acceptable range for social sciences using time series regression (Berger et al., 2017). In addition, it has also been clarified that all the tests were run taking the first (1) log of the data due to non-stationarity at level data. Values of F-statistics also shows a significant ratio of the variances for heteroscedastic test.

From these results, this study does not reject the null (H_0) for each country's time series data describing that there is no heteroscedasticity problem with the data which provides robust and reliable data analysis for R&D expenditures as an estimator of GDP growth rate with macroeconomic variables (Can et al., 2017; Lazarus et al., 2018). This way, the running of VAR regression for VECM for all the models can be described as normally distributed fulfilling the basic assumptions for time series data analysis.

4.3.7 Models' Accuracy and Ex-post Forecasts

4.3.7.1. Models' Accuracy

The VECM model provided a precise yield and implications about the economic phenomena in the given environment. Previous researchers suggested that values of RMSE, MAE, MAPE and Theil inequality coefficient varied across the context (Armstrong & Collopy, 1992).

Table 4.30: Measurement of Model Accuracy

Country	RMSE	MAE	MAPE	Theil Inequality Coef.
Indonesia	1.094	0.748	15.932	0.091
Malaysia	2.103	1.497	36.313	0.169
Philippines	1.338	1.129	36.999	0.137
Singapore	1.973	1.490	43.546	0.154
Thailand	2.268	1.718	51.119	0.217
Bangladesh	0.523	0.399	7.223	0.046
India	1.917	1.611	28.962	0.144
Pakistan	1.367	1.035	26.104	0.154

Note: RMSE= root mean square error, MAE= mean absolute error, and MAPE= mean absolute percentage error.

Values of RMSE given in Table 4.30 ranged from 0.523 and 1.917 which shows that, irrespective of the conditions, the model significantly provided reliable forecasting for the countries under study (Zhang et al., 2018). For values of MAE, it shows the values near to 1 while for MAPE, it also shows accurate and precise results based on the behaviour of data provided by descriptive statistics. The measurement of model accuracy showed the value of Theil inequality coefficient near one (1) ranged from 0.091 to 0.217 which shows that model has precise accuracy comparatively presenting the good model simulation. In this manner, we can say that VECM models run for each country are significantly reliable with minimum chances of error.

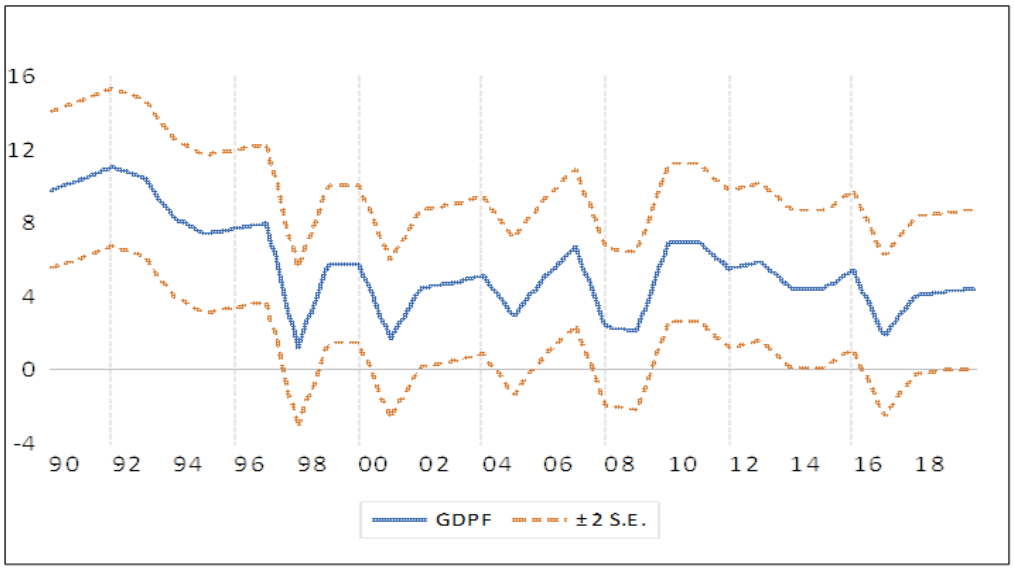
4.3.7.2. Ex-post Forecasting

Figure 4.7 clearly describes R&D implications and assesses its ability to reproduce economic growth over an extended period. The model simulation provided in the given figure has been calculated on the monthly data for five (5) years to make it more precise in a practical way using statistical output. It presents the randomness which is a successful explanation of the model. For

each country, the forecasted impact of the model for R&D expenditure does not involve zero (0) which means predictability and explanation of the model for each country under study (Ouliaris, 2012). Figure 4.7 clearly describes that the VECM model for Indonesia can adjust and reproduce the economic growth of Indonesia.

Source: EViews output

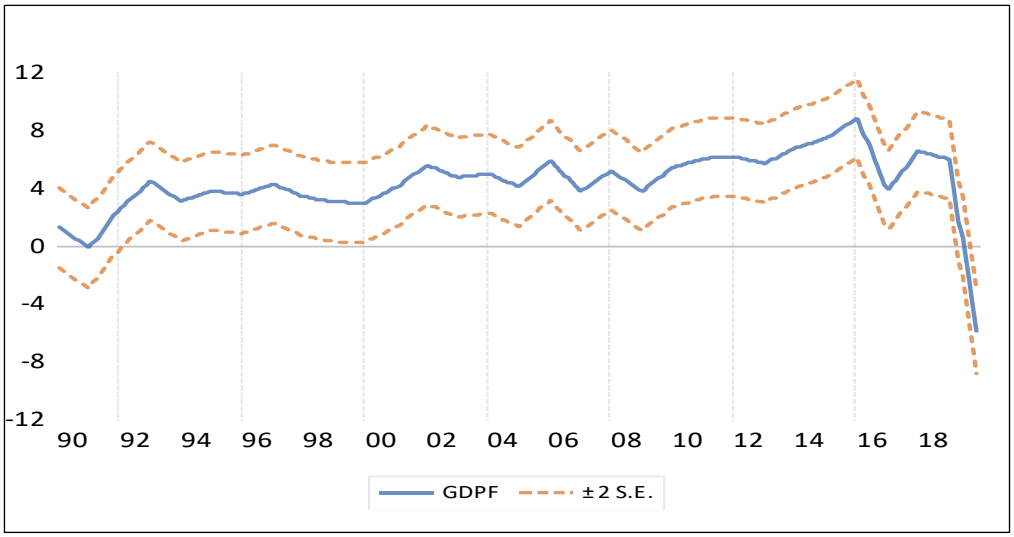
Figure 4.7: Model Forecasts for Indonesia



Source: EViews output

Figure 4.8: Model Forecasts for Malaysia

It presents the randomness which is a successful explanation of the model. It is apparent from Figure 4.8 that the VECM model for Malaysia also stabilizes the adjusted growth pattern for the estimations of GDP growth near to mean as shown in blue curves under the relevant headings. For the Philippines, in Figure 4.9, it has a decreasing trend which needs after period 18 which needs to account for clear policy making. It is important to mention that the same situation was faced by the country after 2019 but, for the sake of model accuracy, it is evident that the model produced accurate results.



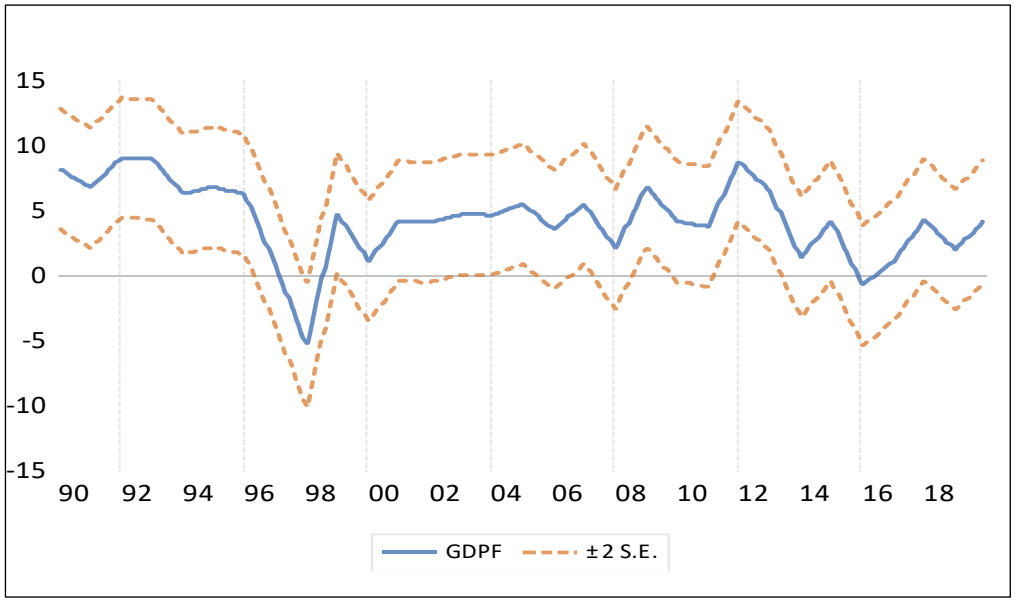
Source: EViews output

Figure 4.9: Model Forecasts for Philippines

Further with Singapore, VECM has significant correcting power for economic growth (see Figure 4.10). For Thailand, the trend is not towards correction which can be seen in Figure 4.11.

Source: EViews output

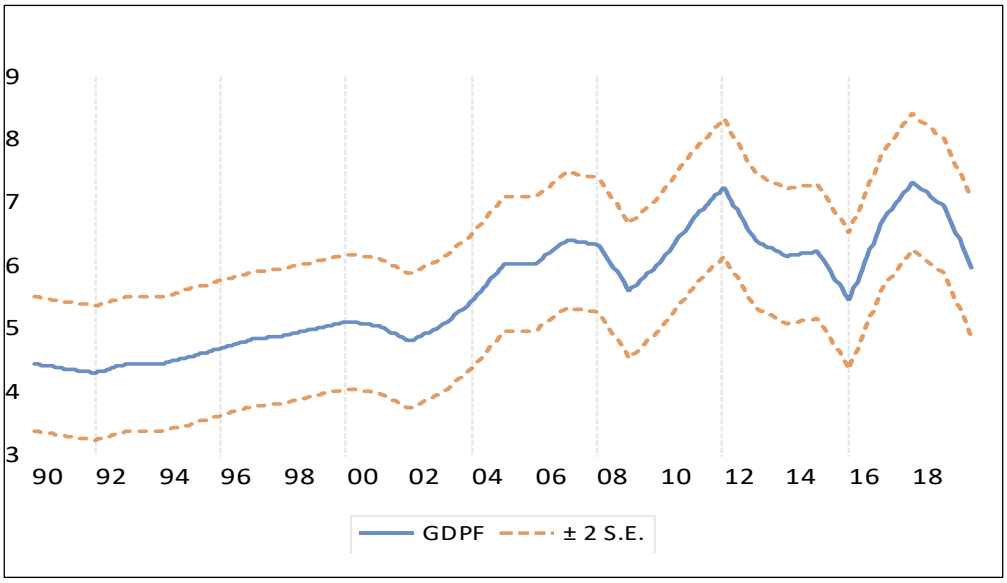
Figure 4.10: Model Forecasts for Singapore



Source: EViews output

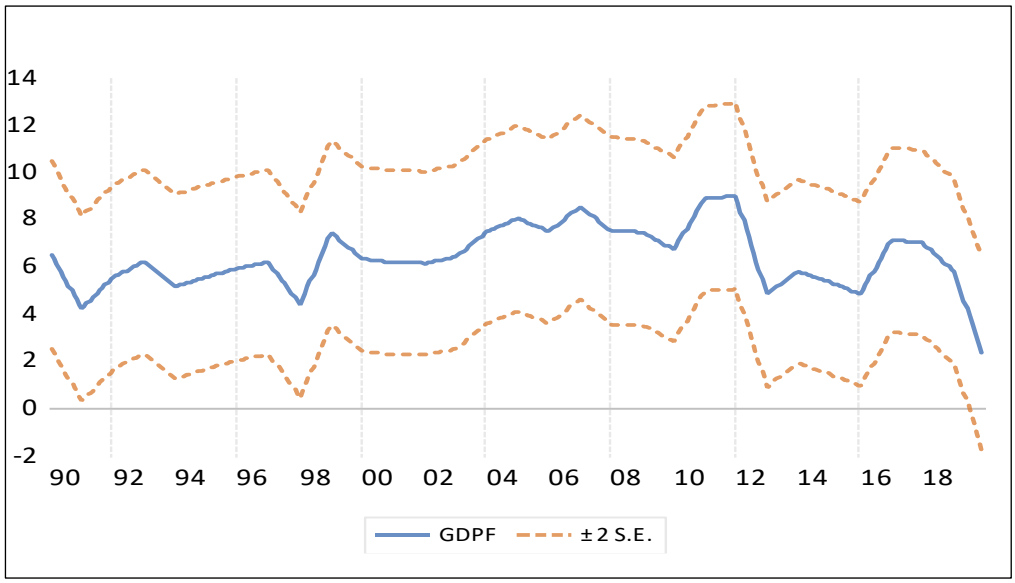
Figure 4.11: Model Forecasts for Thailand

Following Figure 4.12 presents the forecasts for Bangladesh showing the decreasing and adjusting trends. For India, in Figure 4.13, the results of the adjusted VECM model also tend towards adjustment that can be preserved for effective policy making.



Source: EViews output

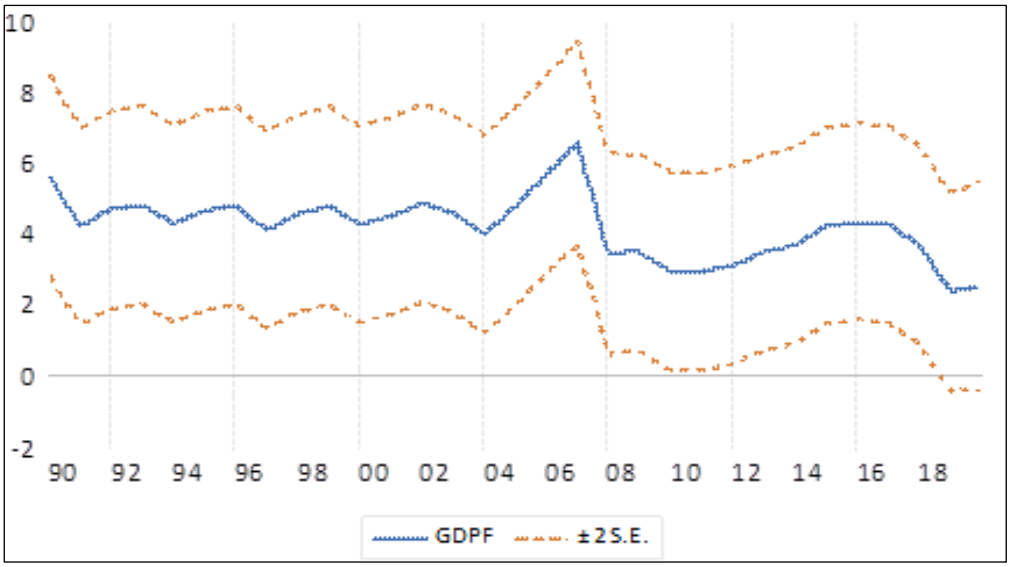
Figure 4.12: Model Forecasts for Bangladesh



Source: EViews output

Figure 4.13: Model Forecasts for India

Lastly, Figure 4.14 presents the forecasts for Pakistan which shows VECM adjusted the trends after period 16 but after period 18, it is stable but not towards correction. This way, we can say that the VECM method has effective correction power by stabilizing the growth trends for Pakistan.



Source: EViews output

Figure 4.14: Model Forecasts for Pakistan

Further, this study analyzed ex-post forecast comparing actual GDP growth data with forecasted data for the last six years i.e., 2014 to 2019 for each country have been presented in Table 4.31 below. The table shows that actual GDP growth rate was declining while the forecasted figures, for the GDP growth rate of Indonesia, first show increasing followed by decreasing trends from 2016 to 5.487 during 2019.For Malaysia, it also shows slight but increasing trends from 4.2888 in 2019M07 to 4.3533 in 2019M12. In the case of the Philippines and Singapore, the trends are decreasing but adjusting from a negative GDP growth rate to lower the negative effects while Thailand, got increasing trends from 3.0299 during 2019M07 to 3.9814 in 2019M12.

Among South Asian countries, Bangladesh's GDP growth rate has decreasing trends in forecasted VECM with 6.4048 and 5.9629 for 2019M07 and 2019M12 respectively. India's GDP growth rate has also been forecasted to decrease by the model with 2.3041 in 2019M12. The forecasts predicted by

VECM have increasing trends for the GDP growth rate of Pakistan, as Table 4.31 shows, 2.4896 for 2019M07 and 2.5457 for 2019M12.

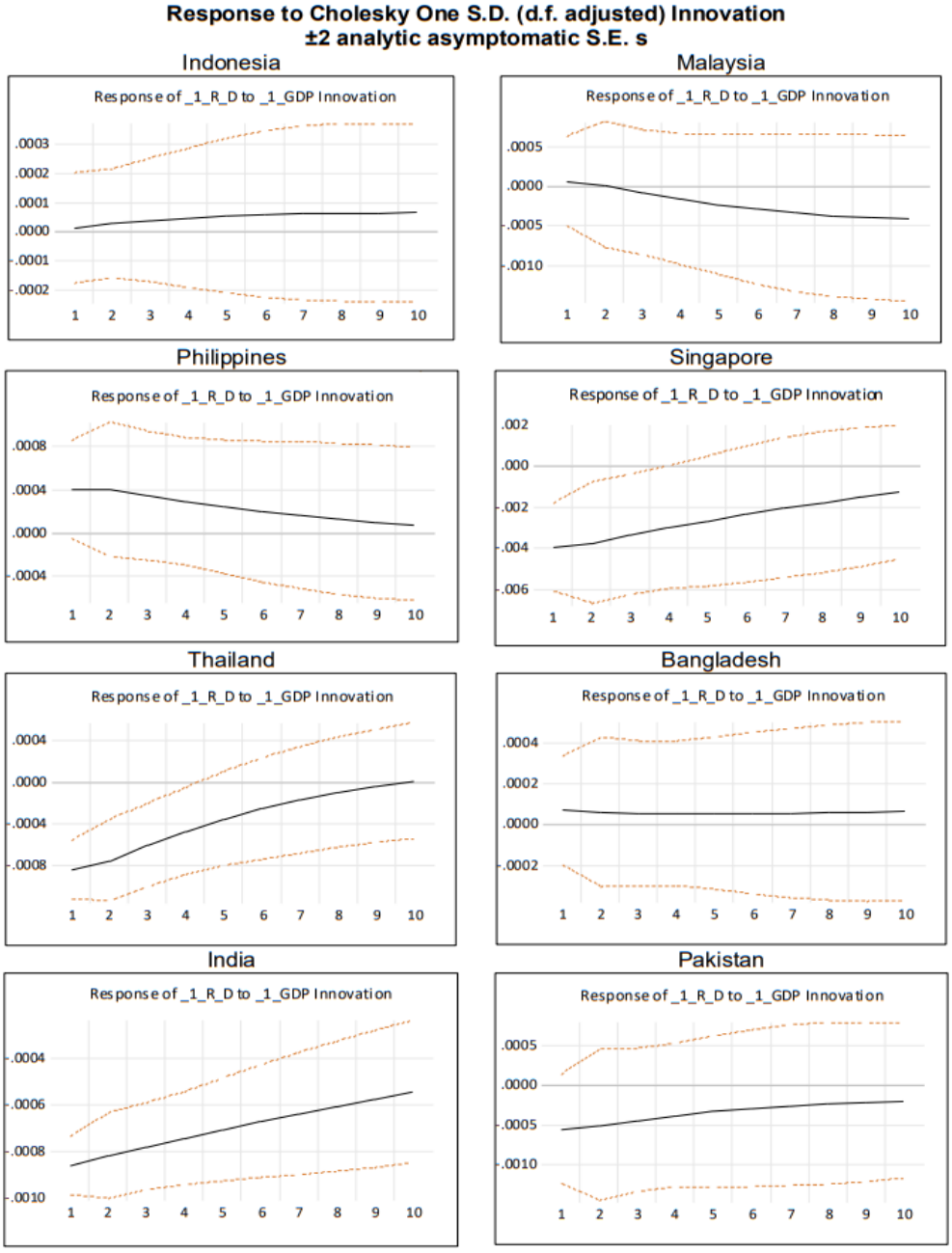
Table 4.31: Ex-post Forecasts for GDP growth

	Actual	Forecasts		Actual	Forecasts
Indonesia			**Malaysia**		
2014	5.000	5.681	2014	6.000	3.942
2015	4.900	5.450	2015	5.000	4.161
2016	5.000	5.929	2016	4.400	4.623
2017	5.100	6.323	2017	5.800	4.182
2018	5.200	6.477	2018	4.800	4.592
2019	5.000	5.487	2019	4.400	3.651
Philippines			**Singapore**		
2014	6.300	5.293	2014	3.900	5.476
2015	6.300	6.007	2015	3.000	5.270
2016	7.100	6.496	2016	3.600	5.241
2017	6.900	6.766	2017	4.500	6.794
2018	6.300	6.129	2018	3.600	4.946
2019	6.100	5.910	2019	1.300	5.043
Thailand			**Bangladesh**		
2014	1.000	3.737	2014	5.492	6.100
2015	3.100	3.924	2015	5.576	6.600
2016	3.400	3.336	2016	5.646	7.100
2017	4.200	3.838	2017	5.651	6.600
2018	4.200	3.973	2018	6.030	7.300
2019	2.100	2.950	2019	5.252	7.900
India			**Pakistan**		
2014	6.309	7.400	2014	4.389	3.900
2015	6.676	8.000	2015	4.633	3.600
2016	6.553	8.300	2016	4.962	3.800
2017	6.036	6.800	2017	5.153	4.100
2018	6.089	6.500	2018	4.649	4.600
2019	6.079	3.900	2019	4.514	6.100

Source: EViews output

4.3.7.3. Impulse Response Function

Figure 4.15 (below) presents the impulse response function between GDP and R&D at the degree of freedom innovation with ±2 analytic standard error.



Source: Author's presentation based on EViews output

Figure 4.15: Impulse Response Functions

For understanding, it may be noted that the blue line in the center of each figure shows the impulse response function for each country while the upper and lower lines show a 95% confidence interval in the impulse response function calculation. The figure shows the increasing trend to one S.D. change in R&D to GDP growth rate for Indonesia which shows the symmetric impact

of R&D on GDP growth rate. For Malaysia and Philippines, the figure shows the asymmetric impact of R&D on GDP as it tends positive to negative after periods 1 and 2 respectively for Malaysia and Philippines. Looking further, it revealed that, in the case of Singapore, the innovative impact of R&D is going stronger after period seven (7) also showing the asymmetric impact.

In the case of Thailand, the asymmetric impulse impact of R&D becomes negative to positive on the GDP growth rate. It shows that this impact has been stronger and positive. When we talk about South Asian countries, it reveals that the impact of R&D on GDP has remained positive with an invisible change-taking impulse response system in view. For India, it is negative but with an increasing trend while in the case of Pakistan, it is also negative and tends to stabilize which shows a strong policy making for recovery.

4.3.8 Summary of Hypotheses Results

For panel data analysis, author developed three null hypotheses H_{01} for ASEAN-5, H_{02} for South Asia-3 and H_{03} for combined (ASEAN-5*SA-3) panel data analysis. For panel data, this study rejects null (H_0) hypotheses for ASEAN-5, South Asia-3 and Combined data of ASEAN-5*SA-3. This way, it suggested that R&D expenditures and macroeconomic indicators are important for regional economic growth. In second stage, this study run VECM on monthly data of each country developing eight (8) hypotheses, one for each country from H_{04} to H_{011}. Decision made on the basis of this study's results, following table 4.31 presents a summary of the decisions for hypotheses of the study.

Table 4.32: Summary of Hypotheses for Panel Models Analyses

	Null Hypotheses (H_0)	Decision
Description		
ASEAN-5 (H_{01})	There is no impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of ASEAN-5 Countries.	Reject H_0 (Combined affect)
South Asia-3 (H_{02})	There is no impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of South Asia-3 Countries.	Reject H_0 (Combined affect)
ASEAN-5 x SA-3 (H_{03})	There is no impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) for ASEAN-5 x SA-3.	Reject H_0 (Combined affect)

Source: Author's own presentation based on EViews results

For VECM analysis, Table 4.33 shows varied results for the countries under study. It has been summarized in the table that null hypotheses (H_0) for Indonesia, Malaysia, Singapore, Thailand and Bangladesh have been rejected for impact of R&D expenditures on GDP growth rate. For the Philippines, India and Pakistan, null hypotheses (H_0) have been accepted showing insignificance of R&D expenditures on GDP growth rate stating that foreign development investment, trade balance, exchange rate and inflation are the important factors than R&D expenditures. From these results we can understand that, for higher growth level, these countries need to work for these macroeconomic indicators first for GDP growth to see commercialization of R&D expenditures in long-run.

Table 4.33: Summary of Hypotheses for VECM Analyses

	Hypotheses	Decision	
Descriptions		**Long-run**	**Short-run**
Indonesia (H_{04})	There is no impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Indonesia.	Reject H_0 ($\alpha < 0.05$)	Reject H_0 ($\alpha < 0.05$)
Malaysia (H_{05})	There is no impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and	Reject H_0 ($\alpha < 0.10$)	Reject H_0 ($\alpha < 0.10$)

	inflation rate (INF) on economic growth (EG) of Malaysia.		
Philippines (H_{06})	There is no impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Philippines.	Reject H_0 (α <0.01)	Do not reject H_0 (α >0.10)
Singapore (H_{07})	There is no impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Singapore.	Reject H_0 (α <0.10)	Reject H_0 (α <0.05)
Thailand (H_{08})	There is no impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Thailand.	Reject H_0 (α < 0.05)	Reject H_0 (α <0.10)
Bangladesh (H_{09})	There is no impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Bangladesh.	Reject H_0 (α <0.01)	Reject H_0 (α <0.05)
India (H_{010})	There is no impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of India.	Reject H_0 (α <0.05)	Do not reject H_0 (α >0.10)
Pakistan (H_{011})	There is no impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Pakistan.	Reject H_0 (α <0.01)	Do not reject H_0 (α >0.10)

Source: Author's own presentation based on EViews results

4.4 Conclusion

This chapter presented the results and details of hypotheses developed on panel data analysis on yearly data of ASEAN-5, South Asia-3 at regional as well as for combined panel data model. Results of VECM models also showed the robustness of the analysis methods along with unbiased model simulation presented in the relevant figure which needs the effective policymaking. For theoretical confirmation and empirical suggestion, coming chapter Discussion and Conclusion provides a qualified approach in light of results of this study.

CHAPTER 5: DISCUSSION AND CONCLUSION

5.0 Introduction

The results presented in the previous chapter depict the output of EViews-13 applying panel data and VECM methods. In the coming lines, Section presents a summary of statistical analyses for better discussing the findings which have been presented in section 5.2 in this chapter. Section 5.3 provides theoretical and practical contributions of this study while section 5.4 discusses the limitations of this study. Recommendations for prospect studies have been provided in section 5.5 before conclusion of the chapter.

5.1 Discussion of Research Findings

The study examined eleven (11) hypotheses: H_{01} for ASEAN-5, H_{02} for South Asia-3, $H_{03}$for combined panel data (ASEAN-3 x SA-3) model, and H_{04} to H_{011} for individual countries: Indonesia, Malaysia, the Philippines, Singapore, Thailand, Bangladesh, India, and Pakistan (Mahadevan & Asafu-Adjaye, 2007; Saluja et al., 2010). It aimed to analyze the impact of R&D expenditures and other macroeconomic indicators on GDP growth rate at regional and country levels. Opening with correlation analysis revealed significant relationships between R&D expenditures, FDI, NX, EXR, EMR, and INF with GDP growth rate. Although relationships between R&D expenditures, FDI, and NX were inverse, overall impact of R&D on GDP was positive in line

with the study of Mahadevan and Asafu-Adjaye (2007). Panel unit-root tests confirmed data stationarity at first difference I (1), meeting a decisive requirement for panel data analysis. Subsequent panel model selection using Bruesch-Pagan and Hausman tests favored Fixed Effect Model (FEM) for ASEAN and South Asia-3, showing significant impacts of R&D expenditures and other macroeconomic indicators on GDP growth rates (Mahadevan & Asafu-Adjaye, 2007; Saluja et al., 2010).

Additionally, ADF and Philop-Parron unit root tests, followed by cointegration rank tests, supported the application of VECM tests on monthly data for each country. Granger's causality tests revealed bidirectional causality between GDP growth rate, R&D expenditures and other macroeconomic indicators indicating the significance of R&D expenditure in economic growth of the counties under study. Regarding ex-post forecast's objective of this study, it met objectives of model accuracy and ex-post forecasts, with low RMSE values ranging from 0.523 to 2.103, MAE from 0.399 to 1.497, and Theil's inequality coefficients near zero, validating the reliability of VECM. Forecasting drifts indicated increasing trends for Indonesia, Malaysia, Thailand, and Pakistan, while decreasing trends for the Philippines, Singapore, Bangladesh, and India (Vandeput, 2019). In summary, the study confirmed significant role of R&D expenditures, FDI, NX, EXR, EMR, INF, on GDP growth rates at regional and country levels, supporting the rejection of null hypotheses as discussed above.

5.1.1 Recapitulation of the Model

As emphasized by the results, this study acknowledged the R&D expenditures' important role in fostering sustainable economic growth, particularly for developing Asian countries. As these nations strive to transition from agrarian to knowledge-based economies, investing in R&D becomes indispensable for driving innovation, enhancing productivity, and bolstering competitiveness on the global stage. Specifically, R&D investments act as catalysts for technological advancements but as discussed earlier, these nations are facing financial difficulty in supporting R&D and the recent investment in R&D also shows this situation. It is well-known that, by allocating resources towards scientific research, these countries can develop new technologies, processes, and products that not only address domestic challenges but also create opportunities for export and foreign investment in the form of FDI.

Moreover, R&D investments contribute to human capital development as highlighted by economic growth theories like Keynesian and exogenous growth models. As governments and businesses allocate funds to research initiatives, they simultaneously invest in education, training, and skill development which results in a more knowledgeable and skilled workforce capable of driving innovation across various sectors of the economy. Consequently, the increased productivity and expertise translate into a rise in employment rate which can higher GDP growth rates over the long term. The Keynesian multiplier concept states that these factors affect economic growth in positive manners which may stimulate demand for intermediate goods and

services, creating a ripple effect throughout the economy. As a result, successful research outcomes will lead to new industries or revitalize existing ones, generating employment opportunities and fostering entrepreneurship towards sustainable economic growth. In the context of the countries under study, where innovation capabilities are developing, R&D expenditures become instrumental in reducing the technology gap among the countries of these two regions. By leveraging indigenous research and innovation, these nations can carve out niche markets, attract foreign direct investment, and enhance their overall economic growth.

5.2 Discussion of the Findings

Linking objective of this study with the research problem and gaps identified after profound literature study, this section discusses a thorough discussion of the findings obtained through the major findings in following way.

5.2.1 Panel Data Models' Results

5.2.1.1. Panel Data Model Findings forASEAN-5

The specific objective for combined effects of R&D expenditures and macroeconomic variables among ASEAN-5, South Asia-3 and ASEAN-5*SA-3 was evaluated through panel data analysis. For this purpose, one (1) hypothesis has been developed for each region and combined data for

both the regions. For ASEAN-5, following null hypothesis was developed and tested through panel data.

> ***H_{A1}:*** There is a significant impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of ASEAN-5 Countries.

The results state that R&D has a positive significant impact on the GDP growth rate which is aligned with the conclusions of Haseeb et al. (2019), Tulchynska and Vovk (2021), and Olaoye et al. (2020) accurately reflecting the economic conditions of the countries under study during a specific timeframe. This may be due to a relatively better level of innovation and use of technology among the countries of this region as noted by Charutawephonnukoon et al. (2021). For technology and its impact on sustainable economic growth among ASEAN nations, the results of this study hold the idea that technology can be improved through continuous investment in R&D in line with the study of Elfaki and Ahmed (2024). However, this study focused on macroeconomic factors which distinguished it from the contribution made by the existing studies. Consistent with Adedoyin et al. (2020) and Li et al. (2020), this study affirms the positive influence of FDI and EMR on the GDP growth rate. Additionally, the analysis supports the notion that increasing FDI positively affects business activities, leading to enhanced job opportunities (Choong et al., 2004).

The relationship of EXR and INF with GDP growth has been found negative and significant. As discussed in the problem statement, mainly GDP of India, Pakistan, Indonesia and Malaysia rely on primary and service industries with notable contribution from service sector. Results revealed the need to pay attention towards inflation rate, trade balance and FDI to compete with advanced countries in the international market. The combined effect of R&D and other macroeconomic environment can produce good outcomes resulting in the innovative products and favourable trade balance for these nations. Currently, it has also been evidenced that the exchange rate has become a big problem for ASEAN nations after the exchange rate led recession during 1997-98 (Klyuev & Dao 2016). In addition, their working population is decreasing which can have an adverse effect on the GDP growth rate so these nations should pay prior attention towards automation for which, increased R&D is needed. Related to the role of exchange rate on regional economic growth, results of this aligned with the study of Iqbal et al. (2022) which they conducted among BRICS economies. This way, the results of this study help ASEAN region's policymakers to formulate and apply strong policymaking towards inflation, exchange rate and trade balance through an increased level of R&D expenditure. Most importantly, the study's objective to assess the impact of R&D expenditures and FDI, NX, EXR, EMR, and INF on economic growth, emphasizing the primary role of R&D expenditures in ASEAN-5 has been met in a comprehensively which can help in sustainable economic growth of this region.

5.2.1.2. Panel Data Findings for South Asia-3

The results showed a significant relationship between R&D and economic growth. The results confirm that investment in R&D expenditures, along with macroeconomic indicators, is important for the GDP growth rate of countries of this region which confirms the results of the study conducted by Ahmad et al. (2022). Among macroeconomic indicators, EXR and INF have insignificant negative impacts in line with the studies of Ali et al. (2021), Carrasco and Gracia (2021), and Rosnawintang et al. (2021) in the case of developing nations. Following hypothesis was developed for this region.

> ***H_{A2}:*** There is a significant impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of South Asia-3 Countries.

The results revealed that the relationship between trade balance (NX) and GDP is positive but insignificant. From the result, we can say that these nations are facing unfavourable trade balance due to which it has an insignificant relationship, but the results show a theoretical relationship which stands true in the case of South Asian countries. For employment rate, Abid et al. (2022) found that it plays an important role considering multiplier effects of human capital while the results of this study confirmed the results but at a broader level as it accounts for the employment rate at the regional level which was missing in the existing literature. This way, results depict the true situation

of these nations especially; negative trade balance, increasing inflation and depreciating exchange rates continuously damaging the economy of these nations which requires corrective measures pursuant to economic growth. Among these nations, Bangladesh's industrial sector performed well during the last three years which is mainly due to outsourcing and offshoring. There has been evidence that industries from neighbouring countries migrated towards Bangladesh (Mohiuddin et al., 2019) due to cost factors which brought a short-term economic boom. For sustainable economic growth, countries of this region need to invest in R&D otherwise, it can continue to lower production levels and unemployment. Hence, countries like Pakistan must realize the significance of R&D for the GDP growth rate which may add to setting a moderate inflation and exchange rate. In India's case, it has been observed that some areas are participating in GDP through the service sector while other areas still lack technological advancements (Kochhar et al., 2006). In this scenario, the country's policymakers should devise policies to equalize the benefits of technical growth throughout the country. Further, inadequate investment caused by insufficient financial resources leads to lower R&D expenditures which worsens the situation by affecting industrial activities in the region leading to limited exports only about primary industry. About the trade balance role in economic growth, the results of this study aligned with the studies of Ahsan et al. (2022) and Aijaz et al. (2022). Concussively, a healthy economic environment led by a favourable trade balance attracts the FDI, and policymakers can readjust investment in R&D in the long run otherwise the situation may worsen in the coming years.

5.2.1.3. Panel Data Findings for ASEAN-5 x SA-3

The outcomes of the combined data model exposed a significant importance of R&D expenditures in ASEAN and South Asian countries with a 95% confidence interval. Mixed type of economic data model, followed by separate models, revealed that R&D is always important for Asian developed, emerging and developing nations like Singapore, Malaysia, India, Bangladesh and Pakistan. Results confirmed the impact of R&D expenditures as an exogenous variable invested from inside the economy as an internal force phenomenon of economic growth because alongside R&D expenditures, the overall impact of all other exogenous variables was also found significant.

> ***H_{A3}:*** There is a significant impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) for ASEAN-5 x SA-3.

The rejection of null hypothesis (H_{03}) for combined data is consistent with the study of Hobbs et al. (2021), and Mehmood et al. (2022), which underscores the standing of R&D while considering FDI as a primary funding source of R&D in developing nations. Results of this study showed that trade balance and inflation are important for the countries under study which is aligned with the findings of Batrancea et al. (2021), portraying the current state of affairs. In the case of Asian developing economies, Zhu et al. (2022) study found that export levels and exchange rates are important factors for higher

levels of economic growth. This way, the results of this study confirm the results of previous studies related to the importance of macroeconomic indicators for sustainable development and growth. Majorly, ASEAN and South Asian countries' exports are among the developing parts of the world (WTO, 2022) which need investment in R&D to produce quality innovative products. The role of employment rate for GDP growth rate was highlighted by Irshad et al. (2022) which suggested to improve employment rate for economic growth through industrial growth. This study confirmed their results, but it accounts for the R&D and macroeconomic indicators at broader spectrum which make it stand alone in presence of numerous studies discussing the spillover effects of R&D and GDP at regional level. In addition, results of the current study help to understand macroeconomic environment prevailing due to COVID-19 cyclic effects which add significantly to the existing understanding of R&D, macroeconomics and sustainable economic growth. The imperative to transition from primary and service industry reliance toward value-added industrial products holds promise for boosting employment rates and stimulating FDI, thereby overcoming heightened economic situations across these nations. The specific objective of this study was to examine the combined effect of R&D, FDI, NX, EXR, EMR, and INF on GDP growth rates of the ASEAN-5, South Asia-3, and the ASEAN-5*SA-3 regions which have been met effectively. Such an analysis has been positioned to address the principal objectives of SDG-8, pertaining to sustained economic growth through enhanced partnership (SDG-17), which underscores the importance of strengthened global partnerships in pursuit of sustainable development objectives.

5.2.2 VECM Findings for Each Country

The research objective of analyzing the long-run and short-run impacts of R&D, FDI, NX, EXR, EMR, and INF on economic growth in countries of ASEAN and South Asia countries was met through the results of VECM applying to each country's data. According to Granger's causality results, R&D expenditures promote productivity, technological improvements, and innovation, all of which support economic growth. In addition, R&D expenditures can also enhance human capital by promoting knowledge and skills, which in turn promotes economic growth through increased productivity and creativity. This way, it will help to maintain a good employment level. Long-term economic growth can be promoted in this way and unidirectional causal relationships can be amplified by policies that stimulate R&D expenditures. The results of causality analysis suggest a self-reinforcing dynamic in which endogenous economic growth theory states that R&D expenditures is complimented to foster innovation, productivity, and employment for rapid GDP growth. Under VECM analysis, below hypothesis was developed for Indonesia.

H_{A4}: There is a significant impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Indonesia.

The results of this study agree in one way with the research of Pamela and Indrawati (2022) who observed a unidirectional correlation between inflation, employment, and exports with economic development. Previous research has found a negative relationship between GDP growth rate and exchange rate, employment, and inflation by applying VECM analysis (Qamaruzzam et al., 2020; Rakhmatillo et al., 2021) in the case of these ASEAN countries. Specifically in relation to Indonesia's economic growth, current study found that FDI, NX and GDP growth are associated with each other which confirm the findings of Sasana (2022). For the relationship of EXR, INF and GDP growth rate, Aprilia et al. (2024) study's results were showing one way causality while this study finds bidirectional causality in the case of INF and GDP growth rate. On the other hand, it confirms their finding for one way causality among EMR and GDP growth rate. This way, it has been concluded that results of current study partially aligned with the existing literature in addition to examining the role of R&D for higher growth rate for Indonesia. Further, following hypothesis (H_{05}) of this study for Malaysia has been rejected.

> ***H_{A5}:*** There is a significant impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Malaysia.

Existing literature with respect to growth of Malaysian economy, results of this study aligned with the study of Sijabat, (2023) who found that FDI has significant role boosting GDP growth rate among ASEAN nations while some

other studies, like study of Baruk (2022) who found that R&D has significant role in determining GDP growth rate. While existing studies used patent application and number of researchers in analysis so we can say that current study significantly abridges the existing gaps in examining the economic impact of R&D pursuant to economic growth of Asian nations. In the recent past, a study conducted by Pascual et al. (2020) and Hasran et al. (2023) found no long-run relationship between GDP and inflation while this study confirms the existence of this relationship while examining the impact of R&D at country level, hence, results partially agree with the literature. In the case of this study, the following hypothesis for the Philippines also proved aligned with the study of the authors.

> ***H_{A6}:*** There is a significant impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of the Philippines.

In relation to GDP growth rate, this study extended the significant relationship between FDI and economic growth with R&D confirming the existence of a long-run relationship among these variables among developing economies (Uddin & Rahman 2023) but, the results of the Granger causality showed the non-existence of R&D and GDP growth rate causal relationship. Results of the study conducted by Defung et al. (2021) confirmed FDI's importance for economic growth at an industry level which is also endorsed at the macro level by the current study. This way, it has been concluded that this

study confirms the insignificance of macroeconomic indicators and also in the case of R&D expenditures. The following null hypothesis for Singapore has also been rejected based on the results.

H_{A7}: There is a significant impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) and economic growth (EG) of Singapore.

In the case of Singapore, all the exogenous variables like R&D expenditures, NX, EXR, EMR and INF have been proven significant except FDI which are according to the results of previous studies. As highlighted in Chapter 2, majority of the existing studies focused on spillover effect of GDP in terms of CO2 emission (Petrović & Lobanov, 2020; Shahbaz et al., 2022), this study deviates from their findings as it focused on R&D's role for economic growth. Hence, in case of Singapore, this study also provides practical results to utilized R&D expenditures purely to stimulate GDP growth rate rather than its consequences. For Thailand, the following hypothesis was developed for this study to test using the VECM analysis method.

H_{A8}: There is a significant impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Thailand.

In the case of Thailand, the above alternative hypothesis has also been accepted rejecting the null hypothesis as R&D expenditures and EXR have a significant relationship with the GDP growth rate of Thailand. The majority of the variables, except NX and INF, have unidirectional causal relationships with GDP growth rate. Hence, this way, H_{08} has been rejected for this study. In absence of adequate literature discussing R&D and macroeconomic indicators with GDP growth rate has provided a novel understanding of the results but overall, the findings of the present study align with the established relationships within the ASEAN region. However, within South Asian countries, VECM results indicate the absence of a relationship between GDP growth rate and employment rate, suggesting underutilization of available labour resources in these nations. Specifically, Wang et al. (2024) study results emphasized technical expertise resulting from R&D investment through several researchers who again deviates from the economic role of R&D for economic growth. The results of this study aligned in terms of positive impact but turned this significance considering the economy's overall R&D expenditures' impact on sustainable economic growth which contradicts the findings of Farajzadeh et al. (2023) in case of developing economies. In case of employment rate, this study endorsed the findings of Islam and Alam (2023) as they found significant relationship between employment and GDP growth rate of Bangladesh. Consequently, following hypothesis for Bangladesh was established which proved true in the case of impact of R&D, macroeconomics and GDP growth rate showing long-run and short-run relationship.

H_{A9}: There is a significant impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Bangladesh.

For H_{09}, it has been rejected with a significant relationship of R&D and NX with GDP growth rate while causal relationship, all the exogenous variables have a unidirectional relationship with the GDP growth rate of Bangladesh except FDI and GDP growth rate. With other countries in South Asia, the following null hypothesis for India was developed.

H_{A10}: There is a significant impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of India.

As shown, this study does not reject the null hypothesis (H_{010}) with evident non-existence of a significant impact of R&D expenditures on GDP growth rate of India as the main focus of this study was on the economic role of public R&D expenditure. The relationship between GDP growth rate and R&D expenditures has a long-run relationship which requires the country policymakers to work on R&D and macroeconomic indicators for sustainable economic growth. This way, this study confirms the results of Godil et al. (2021) study in which they examined the role of R&D expenditures in assessing institutional quality and energy consumption. Pertaining to the relationship

between exports and economic growth, the results of this study are in line with the study of Alsamara et al. (2024) who found a positive relationship between export level and GDP growth rate. Lastly, the following null hypothesis for Pakistan does not been rejected by the results.

> ***H_{A11}:*** There is a significant impact of R&D expenditures (R&D), foreign direct investment (FDI), net exports (NX), exchange rate (EXR), employment rate (EMR), and inflation rate (INF) on economic growth (EG) of Pakistan.

This way, the study guides towards acceptance of alternative hypotheses for panel data models while, for the Philippines, India and Pakistan, alternative hypotheses for VECM have been accepted while other five (5) hypotheses using time series data for VECM have been rejected. The association between R&D expenditure and GDP holds true for Bangladesh but not for India and Pakistan. These observations confirm the findings of Ciobanu (2021) only in the case of R&D, who identified a negative association between institutional R&D investment and GDP growth rate. The difference between the results is that this study discusses the role of R&D expenditures along with macroeconomic indicators while study of Ciobanu (2021) only discusses the institutional role. This way, current study presents a novel comprehension of macroeconomics which can be used to invest R&D rightly where needed. In addition, the results of model simulations in this study meet the requisite criteria for accuracy and model fitness, minimizing potential biases. Consequently, this study effectively

achieves its objectives and contributes novel theoretical and empirical insights to the literature.

5.3 Contribution of the Study

This study uses the historical data at regional as well as at country levels applying the panel data model and VECM model with model simulation for ex-post forecasting. Hence, this study has significant theoretical and practical implications for academicians, economists and policymakers.

5.3.1 Theoretical Contribution

Theoretical discussions related to the role of R&D in economic growth often investigated into two prominent theories: exogenous growth theory and endogenous growth theory. The exogenous growth theory, originating from the Solow-Swan model, emphasizes the paramount importance of technological advancement in boosting economic growth, suggesting it as independent of internal economic dynamics (Barro, 1996; Domer, 1946; Easterly & Levine, 2001). Conversely, the endogenous growth theory suggests that R&D generates continuous returns to the economy through innovation, thereby promoting economic growth (Grossman & Helpman, 1991; Romer, 1994). This perspective broadens the scope beyond technological advancements, incorporating internal forces as significant drivers of growth as suggested by Ulku, (2004).

In this context, the present study applied R&D expenditures as an exogenous variable, affirming its pivotal role in economic dynamics and growth. The findings validate the significance of R&D expenditures, endorsing prior researchers (Parente, 2001; Wang & Zhang, 2021). Notably, the study unveils the multifaceted nature of R&D expenditures, portraying as both internal phenomena necessitating governmental investment and requiring external support, in the form of foreign investment, due to unstable financial conditions of developing parts of the world. This duality invites researchers to prompt into the endogenous and exogenous dimensions of R&D's role for economic growth. By treating R&D expenditures as exogenous variables, while acknowledging the internal requirement of government investment, the study sheds light on the complex interplay between exogenous and endogenous factors. Consequently, it fortifies the validity of the endogenous growth model, enriching our understanding of economic growth mechanisms. Simultaneously, the demonstrated exogenous role of R&D expenditures also strengthens the exogenous theory's applicability within the study's model. This way, a theoretical review considering endogenous and exogenous role of R&D can opens the novel insights purely in economic growth terms.

This study makes substantial contributions to economic growth theories by addressing the interplay between exogenous and endogenous factors, a facet often overlooked in existing literature. Expanding upon this study’s findings, it becomes evident that the study not only reaffirms the significance of R&D expenditures but also underscores the complexities inherent in their role within the broader economic landscape. By acknowledging both the internal necessity

of governmental investment in R&D and the external support required to overcome financial constraints, the study highlights the nuanced nature of R&D's contribution to economic growth. The inclusion of multiple indicators with R&D expenditures among two regions data converted into a complex dynamic which was effectively solved through the dynamic panel data estimation as suggested by existing studies related to BRICS, OECD and European Union (Ahmad et al., 2022 & 2023; Alaimo & Maggino, 2020; Ansari et al., 2021). This novel perspective challenges traditional dichotomies between exogenous and endogenous factors, paving the way for a more integrated understanding of growth dynamics. By advocating for an augmented growth model that encompasses investment considerations, the study sets a new theoretical direction, offering valuable insights for future researchers. This novel approach, also underscored by Shahid et al. (2024), charts a new theoretical path, emphasizing the need for integrating both growth models in analyzing R&D investment dynamics for sustainable economic growth.

Expounding from the results, it has been witnessed that countries under study like Pakistan, Indonesia and Bangladesh are facing adverse financial situation and they are relying on various kinds of debts from IMF which need to pay interest, and aid from ADB which in turn limiting their investment capacity. Prospect studies need to account for these ground realities curtailing to majority of the developing nations at world. This phenomenon invites economists to draw fresh theoretical insights using results of this study as it endorses the exogenous and endogenous role of R&D investment in boosting long-term economic growth. In sum, the study not only contributes to theoretical

debates surrounding economic growth but also offers practical insights for policymakers and practitioners alike. By illuminating the multifaceted role of R&D expenditures and advocating for a more integrated approach to growth modeling, the study lays the groundwork for future research and policymaking endeavors aimed at fostering sustainable economic growth in theoretical terms.

5.3.2 Practical Implications

In a study, Yoruk et al. (2023) highlighted that developing nations have been under the impact of an unstable macroeconomic environment and suggested the need for the assessment of R&D's role considering the current heightened economic situation. This study accounts for R&D expenditures to see their impact on the GDP growth rate with an extended understanding of macroeconomic indicators crucial for developing Asia. The intention behind this dynamic approach was to understand the growth disparities and role of R&D expenditures for innovative products and services so that a better policy suggestion can be made based on the comparative accuracy of the findings. In addition, consideration of macroeconomic indicators can help to understand the relationship of macroeconomics so that policymakers can use these results to make R&D expenditures for sustainable economic growth through diversification and technological upgradations as highlighted by the UN under SDG 8.

The results of panel data analysis highlighted that, for ASEAN-5, macroeconomic indicators are more important than R&D expenditures which

urges a careful intention of policymakers in countries from this region. Practically, as it was evidenced, these nations should focus on innovative exports so that they can attract a higher level of FDI which will help them in favouring the economic situation. This way, the exchange rates will also become manageable for the countries, and they can avoid any further economic recession caused by the exchange rate as it was in 2008. For South Asia-3, the results help policymakers to give priority to R&D expenditures which will further help them in favouring the economic environment. For this purpose, these nations can mark a cut on non-productive expenditures for a shorter time which, resultantly, can enhance the business activities for a higher level of economic growth attracting FDI through innovative exports. For policymakers at the Asian level, like the Asian Development Bank, results of significant relationships of macroeconomic indicators help to make policies in the right direction. The results highlighted that a favourable trade balance, increased level of exports, and lower inflation rate are crucial factors for the economic growth of ASEAN and South Asian countries. This way, the UN and ADB can help these economies in policymaking favouring economic growth culture rather than an increased level of debt. By doing this, outsourcing and offshoring in these manpower-rich countries can be mitigated to meet the growth and development standards.

Related to the results of VECM analysis, results of this study highlighted that R&D expenditures are important for GDP growth at country level. Policymakers form Indonesia, Malaysia, Singapore and Thailand must pay due attention to R&D expenditures while making policies related to economic

growth. This investment will help them to diversify primary focus towards innovation and upgradation which will increase their productivity levels favouring high-tech exports. For Philippines, result showed that R&D expenditures are insignificant but have positive impact on the GDP growth rate which invites policymakers to first pay attention in correcting the macroeconomic environment in the country then look the ways to increase R&D expenditures for technological improvements.

Among South Asia, Bangladesh's GDP growth rate is significantly dependent on R&D, as highlighted by the VECM results, which invites policymakers to increase R&D expenditure to maintain the economic growth. During las five years, numerous manufacturing firms moved to Bangladesh considering lower production costs and, investing in R&D for diversification and innovation will help in sustainable economic growth. Regarding results of this study, it is evident that R&D expenditures are favouring GDP growth rate of India while results of granger causality can help Indian policymakers to understand macroeconomic environment which will help in maintaining long-term relationship between R&D and GDP growth rate. Related to economic growth of Pakistan, results of this study are helpful in correcting their macroeconomic conditions rather than immediately making investments in R&D. It has been observed that Pakistan is rich in human capital and natural resources while, effective policymaking in the form of a macroeconomic environment can bring positive and sustained results for higher levels of economic growth. Results of current study can help policymakers of Pakistan

to understand the macroeconomic environment and then invest in R&D to get their long-term commercialization effects.

Asian economies' policymakers can concentrate on creating an atmosphere that is favourable to R&D expenditure as well as economic growth by putting in place policies to promote entrepreneurship, encourage innovation, and ease the transfer and adoption of technology. The GDP growth rate and R&D expenditures have both unidirectional and bidirectional causal relationships, which highlights how important innovation and technical advancement are for long-term economic growth. Greater levels of partnership across Asian economies can support R&D investment and make it easier to translate these research findings into concrete economic benefits to realize the full potential for higher economic growth through strengthening partnership for sustainable development.

5.4 Limitations of the Study

This study examines the dynamics among R&D expenditures, macroeconomic indicators, and GDP growth rate for economic growth across ASEAN-5, South Asia-3, ASEAN-5*SA-3 at regional using panel and, for each country using time series data. First of all, data sourcing from the World Bank, IMF, ILO, and Statista was the key but it encountered challenging. Notably, while accessing R&D expenditure data for Bangladesh and Pakistan, some early time series were missing which was tackled through resorting to the annual reports and existing studies on Bangladesh. For monthly data, this study used

testified statistical techniques[7] to manage missing monthly data sets for VECM analysis. Provided that these issues have not been considered as limitations because these have been resolved through the existing techniques and parameters (Godil et al., 2021; Sharif et al., 2019). Hence, we can say that the study successfully achieves its objective of conducting a comparative analysis of economic growth to recommend strategic partnerships for achieving SDGs, but it may be pertinent to acknowledge that the exclusion of economically significant countries from Asian subcontinents can constitutes a limitation of this study.

An important challenge this study faced is the inclusion of R&D expenditures along with macroeconomic indicators which showed huge structural variation, like in the exchange rate. This issue raised the question of endogeneity, which was solved by applying the robust techniques suggested by the existing econometricians. Nonetheless, reframing these challenges as a potential area for exploration provided an impactful understanding, thereby transforming it into an opportunity for further research and exploration.

5.5 Recommendations for Prospects Research

Subsequent studies into economic growth are imperious due to the complexity and wide-ranging implications of this phenomenon. Economic growth not only affects individual country but also has global consequences which make it a subject of continuing interest for researchers and policymakers

[7] Refer to the data description section in chapter 3 for further details

in same way. In order to enhance the impact of future research in this field, several avenues warrant investigations.

- Firstly, current study has been conducted beyond the five ASEAN nations studied which is be instrumental in explaining the robustness of the relationship between economic growth, R&D and macroeconomic factors. Although, the current study provides valuable insights into these dynamics within the ASEAN-5 and South Asian-3 nations but, a broader sample encompassing nations across all countries among these regions could offer a more comprehensive understanding of the factors influencing sustainable economic growth. By incorporating diverse economies with varying levels of development, researchers can uncover patterns and trends that excel regional boundaries.
- Moreover, current study used GDP growth rate as measure of economic growth. Future research endeavors could benefit from incorporating alternative metrics of economic growth like GINI index, which measures income inequality, and the human development index (HDI), which gauges overall well-being based on factors like education, health, and income, offer nuanced perspectives on economic progress. But for these measures, the endogenous variables should be applied carefully as behaviour of these variables depends upon the economic environment of the area. By integrating these metrics into analyses of economic growth, researchers can develop a more holistic representation of development results and identify areas for targeted intervention to foster inclusive and sustainable growth.

- Furthermore, by comparing sustainable economic growth patterns, policy frameworks, and socio-economic indicators across diverse regions, future researchers can identify commonalities, disparities, and best practices that can inform policy formulation and international cooperation efforts. For this purpose, other regions like the Eurasian Economic Union (EEU) and the Community of Latin American and Caribbean States (CLACS) holds promise for enriching our understanding of global economic dynamics.
- In addition to broadening the geographical scope, future research could investigate into specific thematic areas to deepen the understanding of the drivers and implications of economic growth. For instance, investigations into the role of R&D in cost reduction and technological innovation in minimizing the environmental degradation in shaping growth trajectories can yield valuable insights for policymakers seeking to foster innovation-driven and inclusive economic development.

Decisively, future research on economic growth holds immense potential for advancing our understanding of this multifaceted phenomenon and informing evidence-based policy interventions at both national and global levels. By expanding the sample size, incorporating alternative metrics, broadening the geographical scope and probing into specific thematic areas, researchers can contribute to a more nuanced understanding of the drivers, dynamics, and implications of economic growth in an increasingly interconnected world.

5.6 Conclusion

This study applied a complex set of exogenous variables for GDP growth rate in addition to adding population from two distinct regions. This effort converted into a heterogeneity concern which was solved through rigorous analysis technique. Resultantly, this drawback came into a strength of this study by discussing the synergy of technology, macroeconomics among distinct natured economies. Considering that most of the countries under examination exhibit healthy GDP statistics largely driven by the primary industry sector, there exists a significant opportunity to enhance economic dynamics by channeling investments into technological innovation. This strategic move has the potential to recalibrate the GDP composition, transitioning it from a primary-reliant sector outputs to a more diversified landscape characterized by innovative products and services. The regional-level results of the panel model state the insignificance importance of R&D expenditures in the presence of favourable macroeconomic situations for ASEAN nations while, for SA-3, R&D expenditures have been proved important for economic growth. The combined results state the importance of R&D expenditures which suggests strong collaboration among these two regions pursuant to SDG-8 through strengthening the partnership (SDG-17). The overall economic conditions of these countries are fluctuating showing the unstable macroeconomic circumstances. This way, the objective of assessing the impact of R&D expenditures with macroeconomic indicators becomes insightful for growth through the GDP growth rate. The results effectively meet the general objective of the study for ASEAN and South Asian nations. When

we talk about the specific objective for R&D expenditures' role in GDP growth rate, it is evidenced as an important factor in view of the dynamic technology advancements. The long-run and short-run relationship of R&D expenditures, FDI, NX, EXR, EMR, and INF showed that, specifically, South Asian nations need to account for the macroeconomic situation to make these factors favourable which may add to the general health of these economies. This favourable macroeconomic environment will increase their capacity to further invest in R&D which will increase the productivity and growth patterns of these economies. When we talk about exports, major exports are with developing countries which shows the need for innovative products and services. In order to make modern offerings, these nations need to invest in R&D which significantly improves productivity and attracts FDI favouring trade balance. The recent heightened economic landscape limits the ability of developing countries to make substantial R&D investments which raises the question of how to manage R&D expenditures increase.

The country-level examination of the R&D and macroeconomic indicators for economic growth also met the specific objectives of the study by effectively portraying a detailed analysis. For countries like the Philippines, India and Pakistan, only R&D does not have importance but favourable macroeconomic conditions like inflation rate and employment rate are also important. For other countries e.g., Indonesia, Malaysia, Singapore, Thailand and Bangladesh, R&D expenditures have much importance, so these nations need to manage R&D investment for sustainable economic growth. Further, the objective of ex-post forecasting was fulfilled by showing a diverse range of

accurate models for each country under study. The policymakers of the respective countries can use the results of this study to make decision-making better than earlier.

In conclusion, this study provides theoretical as well as practical insights for prospect studies and for policymakers in each country and region because applied growth models at country and regional growth involving dynamic nature of R&D and macroeconomic indicators with a broader scope. The synergy between R&D expenditures, macroeconomics and economic growth help this study to provide a comparative understanding following real-world relevance approach. Importantly, this study examines the regional insights using panel data models while VECM examines the long-run impact of R&D through its commercialization considering macroeconomic indicators discussing at each country as a separate case. Results reveal that R&D expenditures and macroeconomic indicators are important for countries as well as for regions to boost the growth rate through cooperation in terms of sustainable economic growth. Through this targeted approach, it helps in promoting economic growth through actionable outcomes through forecasted accuracy. Hence, this study can help in achieving sustainable economic growth among developing parts of the world.

REFERENCES

Abid, A., Mehmood, U., Tariq, S., & Haq, Z. U. (2022). The effect of technological innovation, FDI, and financial development on CO2 emission: evidence from the G8 countries. *Environmental Science and Pollution Research*, 29(8), 11654-11662.

Acaroğlu, H., & Güllü, M. (2022). Climate change caused by renewable and non-renewable energy consumption and economic growth: A time series ARDL analysis for Turkey. *Renewable Energy*, 193, 434-447.

Acemoglu, D., Johnson, S., & Robinson, J. A. (2005). Institutions as a fundamental cause of long-run growth. *Handbook of economic growth*, *1*, 385-472.

Adelowokan, O. A. (2019). Infrastructural development, poverty reduction and economic growth in Nigeria. *Euro Economica*,1(38). http://hdl.handle.net/11159/37112019

Adaramola, A. O., & Dada, O. (2020). Impact of inflation on economic growth: evidence from Nigeria. *Investment Management and Financial Innovations*, 17(2), 1-13.

Adedoyin, F. F., Gumede, M. I., Bekun, F. V., Etokakpan, M. U., & Balsalobre-Lorente, D. (2020). Modelling coal rent, economic growth and CO2 emissions: does regulatory quality matter in BRICS economies?. *Science of the Total Environment*, 710, 136284.

Afolabi, J. O., & Ogunjimi, J. (2020). Industralization: A Roadmap to Inclusive Growth in Nigeria. *NESG Economic and Policy Review (EPR)*, 18(1), 20-28.

Aganbegyan, A. G. (2019). On immediate actions to reinvigorate social and economic growth. *Studies on Russian Economic Development*, 30, 1-9.

Aganbegyan, A. G. (2022). The two main macroeconomic theories of Keynes and Friedman and their use in the economic policy of the world's major countries and Russia. *Studies on Russian Economic Development*, 33(5), 471-479.

Aghion, P., & Howitt, P. (1992). A model of growth through creative destruction. Econometrica, 60(2), 323–351.

Aghion, P., & Jaravel, X. (2015). Knowledge spillovers, innovation and growth. *The Economic Journal*, *125*(583), 533-573.

Agung, I. G. N. (2013). *Panel data analysis using EViews*. John Wiley & Sons.

Ahiadorme, J. W. (2023). Unpleasant surprises? Debt relief and risk of sovereign default. *Journal of Financial Economic Policy*, *15*(1), 47-74.

Ahmad, M., Haq, Z. U., Iqbal, J., & Khan, S. (2022). Dating the Business Cycles: Research and Development (R&D) Expenditures and New Knowledge Creation in OECD Economies over the Business Cycles. *Journal of the Knowledge Economy*, 1-45.

Ahmad, G. N., Kuncoro, H., Tazril, H., & Iranto, D. (2021). Volatility Exchange Rate and Economic Growth: Insight from ASEAN Member Countries. *Scientific Annals of Economics and Business*, 68(4), 495-507.

Ahmad, M., Haq, Z. U., Iqbal, J., & Khan, S. (2023). Dating the business cycles: Research and development (R&D) expenditures and new knowledge creation in OECD economies over the business cycles. *Journal of the Knowledge Economy*, 14(4), 3929-3973.

Ahmed, E. M., & Krishnasamy, G. (2013). Human capital investment to achieve knowledge-based economy in ASEAN5: DEA applications. *Journal of the Knowledge Economy*, 4, 331-342.

Ahmed, E. M., & Kialashaki, R. (2023). FDI inflows spillover effect implications on the Asian-Pacific labour productivity. *International Journal of Finance & Economics*, 28(1), 575-588.

Ahmed, E. M., & Elfaki, K. E. (2023). Green technological progress implications on long-run sustainable economic growth. *Journal of the Knowledge Economy*, 1-18.

Ahmed, G., & Rafiuddin, A. (2018). Cultural Dimensions of Economic Development: A Case of UAE. *Theoretical Economics Letters*, *8*(11), 2479-2496.

Ahmed, M. M., & Shimada, K. (2019). The effect of renewable energy consumption on sustainable economic development: Evidence from emerging and developing economies. *Energies*, 12(15), 29-54.

Ahsan, S., Ahmmed, T., & Alam, F. (2022). The COVID-19, power generation and economy–Case study of a developing country. *The Electricity Journal*, 35(6), 107145.

Aijaz, U., Hassan Daud Butt, D., Bano, S., Hayat, A., Raees, M. B., & Mazhar, M. (2022). Dynamics of SEZs a Comparative Analysis of Incentive Packages for Special Economic Zones of Pakistan, Bangladesh & Vietnam. *Journal of Positive School Psychology*, 6(11), 1247-1269.

Akcigit, U., & Nicholas, T. (2019). History, microdata, and endogenous growth. *Annual Review of Economics*, 11, 615-633.

Alaimo, L.S., Ciacci, A. and Ivaldi, E. (2021), "Measuring sustainable development by non-aggregative approach", *Social Indicators Research*, 157(1), 101-122.

Alaimo, L. S., & Maggino, F. (2020). Sustainable development goals indicators at territorial level: Conceptual and methodological issues—The Italian perspective. *Social Indicators Research*, 147(2), 383-419.

Alaimo, L. S., Ciacci, A., & Ivaldi, E. (2021). Measuring sustainable development by non-aggregative approach. *Social Indicators Research*, 157, 101-122.

Alexander, D. L., Tropsha, A., & Winkler, D. A. (2015). Beware of R 2: simple, unambiguous assessment of the prediction accuracy of QSAR and QSPR models. *Journal of chemical information and modeling*, 55(7), 1316-1322.

Ali, I., Khan, I., Ali, H., Baz, K., Zhang, Q., Khan, A., & Huo, X. (2020). The impact of agriculture trade and exchange rate on economic growth of Pakistan: An NARDL and asymmetric analysis approach. *Ciência Rural*, 50.

Ali, M. U., Gong, Z., Ali, M. U., Wu, X., & Yao, C. (2021). Fossil energy consumption, economic development, inward FDI impact on CO2 emissions in Pakistan: testing EKC hypothesis through ARDL model. *International Journal of Finance & Economics*, 26(3), 3210-3221.

Aljandali, A., Tatahi, M., Aljandali, A., & Tatahi, M. (2018). Economic Forecasting Using Regression. Economic and Financial Modelling with EViews: *A Guide for Students and Professionals*, 89-110.

Almasaied, S. W., Baharumshah, A. Z., & Rashid, S. (2008). The impact of domestic and foreign direct investments on economic growth: Evidence from ASEAN countries. *Pertanika Journal of Social Sciences and Humanities*, 16(2), 239-255.

Altunoz, U. (2019). The relationship between real output (real GDP) and unemployment rate: An analysis of Okun's Law for Eurozone. *Sosyoekonomi*, 27(40), 197–210.

Altuzarra, A., Gálvez-Gálvez, C., & González-Flores, A. (2021). Is gender inequality a barrier to economic growth? A panel data analysis of developing countries. *Sustainability*, 13(1), 367.

Alekhina, V., & Yoshino, N. (2019). Exogeneity of world oil prices to the Russian Federation's economy and monetary policy. *Eurasian Economic Review*, 9(4), 531-555.

Ali, B. J., Hasan, H., & Oudat, M. S. (2021). Relationship among export, import and economic growth: Using co-integration analysis. *Psychology and Education Journal*, 58(1), 5126-5134.

Alsamara, M., Mimouni, K., Barkat, K., & Kayaly, D. (2024). Can exchange rate policies and trade partners' income enhance the trade balance in Algeria? Evidence from the nonlinear ARDL model. *International Journal of Emerging Markets*, 19(5), 1135-1156.

Amar, S., & Pratama, I. (2020). Exploring the link between income inequality, poverty reduction and economic growth: An ASEAN perspective. *International Journal of Innovation, Creativity and Change*, 11(2), 24-41.

Amin, A., Liu, Y., Yu, J., Chandio, A. A., Rasool, S. F., Luo, J., & Zaman, S. (2020). How does energy poverty affect economic development? A panel data analysis of South Asian countries. *Environmental Science and Pollution Research*, 27, 31623-31635.

Amin, N., Shabbir, M. S., Song, H., Farrukh, M. U., Iqbal, S., & Abbass, K. (2023). A step towards environmental mitigation: do green technological innovation and institutional quality make a difference?. *Technological Forecasting and Social Change*, 190, 122413.

Amit, S., & Kafy, A. A. (2024). Addressing the dollar crisis by investigating underlying causes, effects, and strategic solutions in emerging economies. *Research in Globalization*, 8, 100187.

Ampofo, G. M. K., Laari, P. B., Ware, E. O., & Shaw, W. (2023). Further investigation of the total natural resource rents and economic growth nexus in resource-abundant sub-Saharan African countries. *Mineral Economics*, 36(1), 97-121.

An, P. T. H., Binh, N. T., & Cam, H. L. N. (2020). The Impact of Exchange Rate on Economic Growth# x2013; Case Studies of Countries in the ASEAN Region. *Global Journal of Management and Business Research*, 20(B8), 13-20.

Anakpo, G., & Oyenubi, A. (2022). Technological innovation and economic growth in Southern Africa: application of panel dynamic OLS regression. *Development Southern Africa*, 39(4), 543-557.

Antwi, S. K., & Hamza, K. (2015). Qualitative and quantitative research paradigms in business research: A philosophical reflection. *European Journal of Business and Management*, 7(3), 217-225.

Ansari, M. A., Khan, F., & Singh, M. K. (2021). Public expenditure and economic development: New evidence from the BRICS-SAARC-ASEAN region. *Theoretical & Applied Economics*, *28*(2).

Andrei, D. M., & Andrei, L. C. (2015). Vector error correction model in explaining the association of some macroeconomic variables in Romania. *Procedia Economics and Finance*, *22*, 568-576.

Aprilia, E., Hidayat, A., & Asngari, I. (2024). Causality Between Exchange Rates, Economic Growth and Inflation in Indonesia. *Economic Analysis*, 57(1), 36-52.

Armanuos, A. M., Al-Ansari, N., & Yaseen, Z. M. (2020). Cross assessment of twenty-one different methods for missing precipitation data estimation. *Atmosphere*, 11(4), 389.

Armstrong, J. S., & Collopy, F. (1992). Error measures for generalizing about forecasting methods: Empirical comparisons. *International journal of forecasting*, 8(1), 69-80.

Asafo-Agyei, G., & Kodongo, O. (2022). Foreign direct investment and economic growth in Sub-Saharan Africa: A nonlinear analysis. *Economic Systems*, 46(4), 101003.

Asian Development Bank. (2020). *Innovate Indonesia: Unlocking growth through technological transformation*. Asian Development Bank Institute. available at: https://www.adb.org/sites/default/files/publication/575806/innovate-indonesia-unlocking-growth.pdf.

Asian Development Bank (2020). *Innovate Indonesia Unlocking Growth Through Technological Transformation*, available at: https://nif.org.in/initiatives

Asian Development Bank (2023). GDP Growth in Asia and the Pacific, Asian Development Outlook (2023). In: *ADB Data Library*. https://data.adb.org/dataset/gdp-growth-asia-and-pacific-asian-development-outlook

Asiedu, E., & Esfahani, H. S. (2001). Ownership structure in foreign direct investment projects. *Review of Economics and statistics*, 83(4), 647-662.

Awan, A. M., Azam, M., Saeed, I. U., & Bakhtyar, B. (2020). Does globalization and financial sector development affect environmental quality? A panel data investigation for the Middle East and North African countries. *Environmental Science and Pollution Research*, 27, 45405-45418.

Awe, O. O. (2012). On pairwise granger causality modelling and econometric analysis of selected economic indicators. *Interstatt journals*. net/YEAR/2012/articles/1208002. pdf.

Ayob, A. H., Freixanet, J., & Shahiri, H. (2023). Innovation, trade barriers and exports: evidence from manufacturing firms in ASEAN countries. *Journal of Asia Business Studies*, 17(1), 203-223.

Bahrini, R., & Qaffas, A. A. (2019). Impact of information and communication technology on economic growth: Evidence from developing countries. *Economies*, 7(1), 21.

Balsalobre-Lorente, D., Zeraibi, A., Shehzad, K., & Cantos-Cantos, J. M. (2021). Taxes, R&D expenditures, and open innovation: Analyzing OECD countries. *Journal of Open Innovation: Technology, Market, and Complexity*, *7*(1), 36.

Balassa, B. (1978). Exports and economic growth: further evidence, *Journal of Development Economics*, 5, 18 1-9.

Baloch, M. A., Khan, S. U. D., Ulucak, Z. Ş., & Ahmad, A. (2020). Analyzing the relationship between poverty, income inequality, and CO2 emission in Sub-Saharan African countries. *Science of the Total Environment*, 740, 139867.

Baltagi, B. H., Egger, P., & Pfaffermayr, M. (2013). A generalized spatial panel data model with random effects. *Econometric reviews*, 32(5-6), 650-685.

Bampi, R. E., & Colombo, J. A. (2021). Heterogeneous efects of foreign exchange appreciation on industrial output: Evidence from disaggregated manufacturing data. *Quarterly Review of Economics and Finance*, 80, 431–451. https://doi.org/10.1016/j.qref.2021.02.013.

Barguellil, A., Ben-Salha, O., & Zmami, M. (2018). Exchange rate volatility and economic growth. *Journal of Economic Integration*, *33*(2), 1302-1336.

Barro, R. J. (1996). Determinants of economic growth: *A cross-country empirical study*.

Baruk, J. (2022). Research and Development Expenditures in the Sector of Polish Enterprises as an Instrument of Research and Development Policy. *Marketing of Scientific and Research Organizations*, *43*(1), 25-52.

Basantwani, L. V., Sharma, S., Dagar, V., & Kharinta, K. (2021). Impact Of National Income and Public Expenditure on Employment and Its Public-Private Sector Composition in Indian Economy. *International Journal of Agricultural & Statistical Sciences*, 17(1).

Basu, A., Marjit, S., & Veeramani, C. (2024). Growth gains from offshore outsourcing. *Journal of Policy Modeling*, 46(1), 90-112.

Batrancea, L., Rathnaswamy, M. K., & Batrancea, I. (2022). A panel data analysis on determinants of economic growth in seven non-BCBS Countries. *Journal of the Knowledge Economy*, 13(2), 1651-1665.

Berger, A. N., Klapper, L. F., & Turk-Ariss, R. (2017). Bank competition and financial stability. *In Handbook of competition in banking and finance* (pp. 185-204). Edward Elgar Publishing.

Besiroglu, T., Emery-Xu, N., & Thompson, N. (2024). Economic impacts of AI-augmented R&D. *Research Policy*, 53(7), 105037.

Bhuiyan, A. B., Ali, M. J., Zulkifli, N., & Kumarasamy, M. M. (2020). Industry 4.0: challenges, opportunities, and strategic solutions for Bangladesh. *International Journal of Business and Management Future*, 4(2), 41-56.

Bibi, R. (2022). Banking sector development and economic growth in south Asian countries: dynamic panel data analysis. *Journal of Environmental Science and Economics*, 1(1), 52-57.

Bieth, R. C. E. (2021, March). The influence of Gross Domestic Product and human development index on CO2 emissions. *In Journal of Physics: Conference Series* (Vol. 1808, No. 1, p. 012034). IOP Publishing.

Bird, G., & Choi, Y. (2020). The effects of remittances, foreign direct investment, and foreign aid on economic growth: An empirical analysis. *Review of Development Economics*, 24(1), 1-30.

Bishwakarma, J. K., & Hu, Z. (2022). Problems and prospects for the South Asian Association for Regional Cooperation (SAARC). *Politics & Policy*, 50(1), 154-179.

Borowy, I., & Schmelzer, M. (Eds.). (2017). History of the future of economic growth: Historical roots of current debates on sustainable degrowth. *Taylor & Francis*.

Bottini, N., Ernst, C., & Luebker, M. (2007). *Offshoring and the labour market: What are the issues?*. International Labour Office. Available at: http://www.oit.org/wcmsp5/groups/public/---ed_emp/---emp_elm/---analysis/documents/publication/wcms_113922.pdf

Boyer, R. (2004). The future of economic growth: As new becomes old. In The Future of Economic Growth. *Edward Elgar Publishing.*

Bölükbaşi, H., & Civcir, I. (2024). Imported Inputs, Balance of Payments and Economic Growth: a model and a test on the case of Turkey. *Structural Change and Economic Dynamics*, 70, 319-332.

Breusch, T. S., & Pagan, A. R. (1979). A simple test for heteroscedasticity and random coefficient variation. *Econometrica: Journal of the econometric society*, 1287-1294.

Buchholz, K. (2019). Strong U.S. Dollar is Rallying Against Global Currencies available at: https://www.statista.com/chart/19004/us-dollar-exchange-index-rates/.

Caballero-Morales, S. O., Guridi, J. D. J. C., Alvarez-Tamayo, R. I., & Cuautle-Gutiérrez, L. (2020). Education 4.0 to support entrepreneurship, social development and education in emerging economies. *International Journal of Entrepreneurial Knowledge*, 8(2), 89-100.

Caesar, A. E., Chen, H., Udimal, T. B., & Osei-Agyemang, A. (2018). The influence of R&D on economic development in the West African Sub-Region. *Open Journal of Social Sciences*, *6*(03), 215.

Calero, C., & Turner, L. W. (2020). Regional economic development and tourism: A literature review to highlight future directions for regional tourism research. *Tourism Economics*, 26(1), 3-26.

Callen, T. (2022). Gross Domestic Product: An Economy's All. Retrieved from https://www.imf.org/en/Publications/fandd/issues/Series/Back-to-Basics/gross-domestic-product-GDP

Caminati, M., & Sordi, S. (2019). Demand-led growth with endogenous innovation. *Metroeconomica*, 70(3), 405-422.

Can, M., Doğan, B., & Değer, O. (2017). The Relationship between research & development investment expenditure, foreign direct investment and economic growth. *Journal of Applied Economic Sciences*, 12(1), 58-62.

Canuto, O. (2022). Emerging economies, global inflation, and growth deceleration, *Policy Centre for the new south*.

Carranza, G., Garcia, M., & Sanchez, B. (2020). Activating inclusive growth in railway SMEs by workplace innovation. *Transportation Research Interdisciplinary Perspectives*, 7, 100193.

Carrasco, I., Castillo-Valero, J. S., Córcoles, C., & Carchano, M. (2021). Greening Wine Exports? Changes in the Carbon Footprint of Spanish Wine Exports. *International Journal of Environmental Research and Public Health*, 18(17), 9035.

Casella, B. (2019). Looking through conduit FDI in search of ultimate investors–a probabilistic approach. *Transnational Corporations*, *26*(1), 109-146.

Cass, D., 1965. Optimum growth in an aggregative model of capital accumulation. *The Review of Economic Studies*, 32(3): 233-240.Available at: https://doi.org/10.2307/2295827.

Celli, V., Cerqua, A., & Pellegrini, G. (2024). Does R&D expenditure boost economic growth in lagging regions?. *Social Indicators Research*, 173(1), 249-268.

Chamberlain, G. (1984). Panel data. *Handbook of econometrics*, 2, 1247-1318.

Chandio, A. A., Jiang, Y., Amin, A., Ahmad, M., Akram, W., & Ahmad, F. (2023). Climate change and food security of South Asia: fresh evidence from a policy perspective using novel empirical analysis. *Journal of Environmental Planning and Management*, 66(1), 169-190.

Charutawephonnukoon, P., Jermsittiparsert, K., & Chienwattanasook, K. (2021). Impact of high technology exports, patent applications and research and development expenditure on economic growth: evidence from ASEAN countries. *Psychology and Education*, *58*(2), 1956-1972.

Chawla, D. (2020). Economic growth and R&D expenditures in selected OECD countries: Is there any convergence?. *African Journal of Science, Technology, Innovation and Development*, 12(1), 13-25.

Chapcakova, A., Heckova, J., Gira, D., Valentiny, T., & Zbihlejova, L. (2019). Quantification of the selected macroeconomic impacts on the EEA countries competitiveness assessment. *Montenegrin Journal of Economics*, *15*(1), 155-171.

Chen, B. (2021). Public–private partnership infrastructure investment and sustainable economic development: An empirical study based on efficiency evaluation and spatial spillover in China. *Sustainability*, *13*(15), 8146.

Chen, X., Wohlfarth, P., & Smith, R. P. (2021). China's money demand in a cointegrating vector error correction model. *Journal of Asian Economics*, *75*, 101338.

Chen, W., Xu, H., Jia, L., & Gao, Y. (2021). Machine learning model for Bitcoin exchange rate prediction using economic and technology determinants. *International Journal of Forecasting*, *37*(1), 28-43.

Chowdhury, I. H. (2020). Extended Exogenous Growth Model: Application and Investigation the Long-Term Growth Determinants of Bangladesh. *Asian Economic and Financial Review*, *10*(1), 35-53.

Chowdhury, A. H. M. Y., Hamid, M. K., & Akhi, R. A. (2019). Impact of macroeconomic variables on economic growth: Bangladesh perspective. *Information Management and Computer Science*, *2*(2), 19-22.

Chugunov, I., Pasichnyi, M., Koroviy, V., Kaneva, T., & Nikitishin, A. (2021). Fiscal and monetary policy of economic development. *European Journal of Sustainable Development*, 10(1), 42-42.

Chung, P. T., Sun, S., & Vo, D. T. H. (2019). How does financial development interact with economic growth in five ASEAN countries?. *The Singapore Economic Review*, 64(03), 441-460.

Ciobanu, A. M. (2021). The impact of FDI on economic growth in case of Romania. *Int. J. Econ. Financ*, 12, 1-81.

Civcir, I., & Akkoc, U. (2021). Non-linear ARDL approach to the oil-stock nexus: Detailed sectoral analysis of the Turkish stock market. *Resources Policy*, 74, 102424.

Collins, D. W., & Nguyen, N. Q. (2022). Aggregate accounting research and development expenditures and the prediction of real gross domestic product. *Journal of Accounting and Public Policy*, *41*(1), 106901.

Coondoo, D., & Dinda, S. (2002). Causality between income and emission: a country group-specific econometric analysis. *Ecological Economics*, 40(3), 351-367.

Coscieme, L., Mortensen, L. F., Anderson, S., Ward, J., Donohue, I., & Sutton, P. C. (2020). Going beyond Gross Domestic Product as an indicator to bring coherence to the Sustainable Development Goals. *Journal of Cleaner Production*, 248, 119232.

Creswell, J. W. (2011). Controversies in mixed methods research. *The Sage handbook of qualitative research*, 4(1), 269-284.

David, O. O., & Grobler, W. (2020). Information and communication technology penetration level as an impetus for economic growth and development in Africa. *Economic research-Ekonomska istraživanja*, 33(1), 1394-1418.

Defung, F., Purnomo, W. D., & Kusumawardani, A. (2021). Foreign direct investment (FDI) and growth of COMPANY'S export: a case study in ASEAN countries. *Academy of Entrepreneurship Journal*, 27(5), 1-12.

Department of Statistics Malaysia-DoSM (2023). Malaysian Economic Indicators: Leading, Coincident & Lagging Indexes January 2023. Available at: https://v1.dosm.gov.my/

Delpachitra, S., & Van Dai, P. (2012). The determinants of TFP growth in middle income economies in ASEAN: Implication of financial crises. *International Journal of Business and Economics*, 11(1), 63.

Dickey, D. A. and Fuller. W. A. (1981), Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. *Econometrica*, 49, 1057-1072.

Dima, A. M., Begu, L., Vasilescu, M. D., & Maassen, M. A. (2018). The relationship between the knowledge economy and global competitiveness in the European Union. *Sustainability*, 10(6), 1706.

Dobrzanski, P., & Bobowski, S. (2020). The efficiency of R&D expenditures in ASEAN countries. *Sustainability*, 12(7), 2686.

Dobrzański, P., Bobowski, S., Chrysostome, E., Velinov, E., & Strouhal, J. (2021). Toward innovation-driven competitiveness across African countries: an analysis of efficiency of R&D expenditures. *Journal of Competitiveness*, 13(1).

Domar, E.D., 1946. Capital expansion, rate of growth, and employment. *Econometrica*, 14(2): 137–147. Available at: https://doi.org/10.2307/1905364.

Dong, F., Zhu, J., Li, Y., Chen, Y., Gao, Y., Hu, M., ... & Sun, J. (2022). How green technology innovation affects carbon emission efficiency: evidence from developed countries proposing carbon neutrality targets. *Environmental Science and Pollution Research*, 29(24), 35780-35799.

Dormann, C. F., Elith, J., Bacher, S., Buchmann, C., Carl, G., Carré, G., ... & Lautenbach, S. (2013). Collinearity: a review of methods to deal with it and a simulation study evaluating their performance. *Ecography*, 36(1), 27-46.

Dossani, R., & Kenney, M. (2007). The next wave of globalization: Relocating service provision to India. *World Development*, 35(5), 772-791.

Easterly, W., & Levine, R. (2001). What have we learned from a decade of empirical research on growth? It's Not Factor Accumulation: Stylized Facts and Growth Models. *The world bank economic review*, 15(2), 177-219.

Eggoh, J. C., & Khan, M. (2014). On the nonlinear relationship between inflation and economic growth. *Research in Economics*, 68(2), 133-143.

Eichner, A. S. (Ed.). (2023). *A guide to post-Keynesian economics*. Taylor & Francis.

Elfaki, K. E., & Ahmed, E. M. (2024). Digital technology adoption and globalization innovation implications on Asian Pacific green sustainable economic growth. Journal of Open Innovation: *Technology, Market, and Complexity*, 10(1), 100221.

Elson, A. (2021). *Global Currency Power of the US Dollar*. Springer International Publishing. Employment Rate for Malaysian Economic Development. *Institutions and Economies*, 53-79.

Emami Langroodi, F. (2021). Schumpeter's Theory of Economic Development: a study of the creative destruction and entrepreneurship effects on the economic growth. *Journal of Insurance and Financial Management*, 4(3).

Engle, R. F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica: Journal of the econometric society*, 987-1007.

Engle, R. F., & Granger, C. W. (1987). Co-integration and error correction: representation, estimation, and testing. *Econometrica*: *journal of the Econometric Society*, 251-276.

Fang, W., Liu, Z., & Putra, A. R. S. (2022). Role of research and development in green economic growth through renewable energy development: empirical evidence from South Asia. *Renewable Energy*, 194, 1142-1152.

Farajzadeh, Z., Ghorbanian, E., & Tarazkar, M. H. (2023). The impact of climate change on economic growth: Evidence from a panel of Asian countries. *Environmental Development*, 47, 100898.

Farinha, L., Ferreira, J. J., & Nunes, S. (2018). Linking innovation and entrepreneurship to economic growth. Competitiveness Review: *An International Business Journal*, 28(4), 451-475.

Farooq, O., Jabbouri, I., & Naili, M. (2024). The nexus between economic policy uncertainty and access to finance: a study of developing countries. *International Journal of Managerial Finance*, 20(1), 222-246.

Fassio, C. (2018). Export-led innovation: the role of export destinations. *Industrial and Corporate Change*, 27(1), 149-171.

Fernandez, M., & Joseph, R. (2020). Foreign direct investment in Indonesia: an analysis from investors perspective. *International Journal of Economics and Financial Issues*, 10(5), 102-112.

Fisher, M. J., & Marshall, A. P. (2009). Understanding descriptive statistics. *Australian critical care*, 22(2), 93-97.

Fioramonti, L., Coscieme, L., & Mortensen, L. F. (2019). From gross domestic product to wellbeing: How alternative indicators can help connect the new economy with the Sustainable Development Goals. *The Anthropocene Review*, 6(3), 207-222.

Friedman, M. (1983). Monetarism in Rhetoric and in Practice. *Bank of Japan Monetary and Economic Studies*, *1*(2), 1-14.

Frieden, J. A. (2016). Currency politics: The political economy of exchange rate policy. *Princeton University Press*.

Fukuda, K. (2020). Science, technology and innovation ecosystem transformation toward society 5.0. *International journal of production economics*, 220, 107460.

Gaies, B., Goutte, S., & Guesmi, K. (2020). Does financial globalization still spur growth in emerging and developing countries? Considering exchange rates. *Research in International Business and Finance*, 52, 101113.

Galadima, M. D., & Aminu, A. W. (2019). Positive and negative impacts of natural gas consumption on economic growth in Nigeria: a nonlinear ARDL approach. *African Journal of Economic and Sustainable Development*, 7(2), 138-160.

Gallo, C. (2002). Economic growth and income inequality: theoretical background and empirical evidence. London: Development Planning Unit, *University College London*.

Ganti, A. (2023). What Real Gross Domestic Product (Real GDP) Is, how to Calculate It, vs. Nominal. Retrieved from: https://www.investopedia.com/terms/r/realgdp.asp

Gatto, A., & Sadik-Zada, E. R. (2021). Revisiting the East Asian financial crises: Lessons from ethics and development patterns. In Economic Growth and Financial Development (pp. 23-31). *Springer, Cham*. ISBN: 978-3-030-79002-8

Gavurová, B., Halásková, M. H., & Korány, S. (2019). Research and Development Indicators of EU28 Countries from Viewpoint of Super-Efficiency DEA Analysis. Acta Universitatis *Agriculturae et Silviculturae Mendelianae Brunensis*, 67(1).

George, G., McGahan, A. M., & Prabhu, J. (2012). Innovation for inclusive growth: Towards a theoretical framework and a research agenda. Journal of management studies, 49(4), 661-683.

Giri, M., Bista, G., Singh, P. K., & Pandey, R. (2021). Climate change vulnerability assessment of urban informal settlers in Nepal, a least developed country. *Journal of Cleaner Production*, *307*, 127213.

Godil, D. I., Sharif, A., Ali, M. I., Ozturk, I., & Usman, R. (2021). The role of financial development, R&D expenditure, globalization and institutional quality in energy consumption in India: New evidence from the QARDL approach. *Journal of environmental management*, 285, 112208.

Gonzalo, J. (1994). Five Alternative Methods of Estimating Long-run Equilibrium Relationships. *Journal of Econometrics*, 60(1-2), 203-233.

Granger, C. (1969) Investigating Causal Relations by Econometric Models and Crossspectral Methods. *Econometrica*, 37 (3), 424–438.

Gregoriou, A., & Kontonikas, A. (2010). The long-run relationship between stock prices and goods prices: New evidence from panel cointegration. *Journal of International Financial Markets, Institutions and Money*, 20(2), 166-176.

Gruzina, Y., Firsova, I., & Strielkowski, W. (2021). Dynamics of human capital development in economic development cycles. *Economies*, *9*(2), 67.

Guerrero, M., Liñán, F., & Cáceres-Carrasco, F. R. (2021). The influence of ecosystems on the entrepreneurship process: a comparison across developed and developing economies. *Small Business Economics*, *57*(4), 1733-1759.

Gujarati, D. N., & Porter, D. C. (2015). Basic Econometrics, *McGraw-Hill*. New York.

Gujarati, D. N. (2021). Essentials of econometrics. *Sage Publications*.

Guzman, M., Ocampo, J. A., & Stiglitz, J. E. (2018). Real exchange rate policies for economic development. *World development*, 110, 51-62.

Habib, M., Abbas, J., & Noman, R. (2019). Are human capital, intellectual property rights, and research and development expenditures really important for total factor productivity? An empirical analysis. International Journal of Social Economics, 46(6), 756-774.

Haini, H. (2019). Internet penetration, human capital and economic growth in the ASEAN economies: Evidence from a trans-log production function. *Applied Economics Letters*, 26(21), 1774-1778.

Hamilton, J. D. (2020). Time series analysis. *Princeton university press*.

Hao, Y. (2022). Effect of Economic Indicators, Renewable Energy Consumption and Human Development on Climate Change: An Empirical Analysis Based on Panel Data of Selected Countries. *Frontiers in Energy Research*, 10, 841497.

Har, W.M., Lian, T.A., & Heng, L.C. (2008). Development Economics: Theories and Issues. Kuala Lumpur: Pustaka Prinsip.

Hartman, M., Martin, A. B., Espinosa, N., Catlin, A., & National Health Expenditure Accounts Team. (2018). National health care spending in 2016: spending and enrollment growth slow after initial coverage expansions. *Health Affairs*, *37*(1), 150-160.

Harris, D. J. (2007). The classical theory of economic growth. *The new Palgrave dictionary of economics*, *11*.

Haseeb, M., Kot, S., Hussain, H. I., & Jermsittiparsert, K. (2019). Impact of economic growth, environmental pollution, and energy consumption on health expenditure and R&D expenditure of ASEAN countries. *Energies,* 12(19), 3598.

Hashmi, S. M., Khushik, A. G., Gilal, M. A., & Yongliang, Z. (2021). The Impact of GDP and Its Expenditure Components on Unemployment Within BRICS Countries: Evidence of Okun's Law from Aggregate and Disaggregated Approaches. *SAGE Open*, 11(2), 21582440211023423.

Hasran, N. I. L. B., Saputra, J., & Haque, A. U. (2023). Is Interest Rate an Effective Instrument for Controlling Inflation and Its Effect on Investment Activities in Developing Countries?. In *Corporate Management Ecosystem in Emerging Economies: Global Perspectives* (pp. 367-401). Cham: Springer International Publishing.

Hausman, J. A. (1978). Specification tests in econometrics. *Econometrica: Journal of the econometric society*, 1251-1271.

Hayat, M. A., Ghulam, H., Batool, M., Naeem, M. Z., Ejaz, A., Spulbar, C., & Birau, R. (2021). Investigating the causal linkages among inflation, interest rate, and economic growth in Pakistan under the influence of COVID-19 pandemic: A wavelet transformation approach. *Journal of Risk and Financial Management*, 14(6), 277.

Hedlund-de Witt, A. (2012). Exploring worldviews and their relationships to sustainable lifestyles: Towards a new conceptual and methodological approach. *Ecological Economics,* 84, 74-83.

Helpman, E. (1997). R&D and productivity: the international connection.

Helpman, E. (2009). *The mystery of economic growth*. Harvard University Press.

Hendry, D. F., & Ericsson, N. R. (Eds.). (2003). Understanding Economic Forecasts. *MIT Press.*

Headey, D., Bezemer, D., & Hazell, P. B. (2010). Agricultural employment trends in Asia and Africa: Too fast or too slow?. *The World Bank Research Observer*, 25(1), 57-89.

Henry, C. M. (1987). Economic growth and economic development: A distinction without a difference. *Social and Economic Studies*, 67-84.

Hill, H., & Hill, S. (2005). Growth econometrics in the tropics: what insights for Southeast Asian economic development?. *The Singapore Economic Review*, 50(spec01), 313-343.

Hill, J. B. (2010). On tail index estimation for dependent, heterogeneous data. *Econometric Theory*, 26(5), 1398-1436.

Hippe, R., & Fouquet, R. (2024). The human capital transition and the role of policy. In *Handbook of cliometrics* (pp. 411-457). Cham: Springer International Publishing.

Hobbs, S., Paparas, D., & E. AboElsoud, M. (2021). Does foreign direct investment and trade promote economic growth? Evidence from Albania. *Economies*, 9(1), 1.

Holtz-Eakin, D., Newey, W., and Rosen, H. S. (1988). Estimating Vector Autoregressions with Panel Data. *Econometrica* 56 (6), 1371. doi:10.2307/ 1913103

Holmberg, J., & Sandbrook, R. (2019). Sustainable development: what is to be done?. In Policies for a small planet (pp. 19-38). *Routledge*.

Ho, C. H., Pham, N. N., & Nguyen, K. T. (2021). Economic growth, financial development, and trade openness of leading countries in ASEAN. The *Journal of Asian Finance, Economics and Business*, 8(3), 191-199.

Hsiao, C. (2007). Panel data analysis—advantages and challenges. *Test*, 16(1), 1-22.

Hu, Y., & Yao, J. (2019). Illuminating economic growth. *International Monetary Fund*.

Hussain, M. E., & Haque, M. (2017). Empirical analysis of the relationship between money supply and per capita GDP growth rate in Bangladesh. *Journal of Advances in Economics and Finance*, 2(1), 54-66.

Huynh, C. M. (2024). Climate change and agricultural productivity in Asian and Pacific countries: how does research and development matter?. Journal of Economic Studies, 51(3), 712-729.

Hyndman, R. J. (2006). Another look at forecast-accuracy metrics for intermittent demand. Foresight: *The International Journal of Applied Forecasting*, 4(4), 43-46.

Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of econometrics*, 115(1), 53-74.

Iqbal, A., Tang, X., & Rasool, S. F. (2022). Investigating the nexus between CO2 emissions, renewable energy consumption, FDI, exports and economic growth: evidence from BRICS countries. *Environment, Development and Sustainability*, 1-30.

Irshad, M., Hussain, M., & Baig, M. A. (2022). Macroeconomic variables the indicators for the economic growth of Pakistan. *Pakistan Social Sciences Review*, 6(2), 58-72.

IMF (2022). World Economic Outlook (October 2022). Available online at https://www.imf.org/external/datamapper/datasets/WEO

IMF Data Protal, World Economic Outlook (2023) Available at: https://www.imf.org/external/datamapper/NGDP_RPCH@WEO/OEMDC/ADVEC/WEOWORLD?year=2023

Ioannidis, J. P., Cripps, S., & Tanner, M. A. (2022). Forecasting for COVID-19 has failed. *International Journal of Forecasting*, 38(2), 423-438.

Iqbal, A., Tang, X., & Rasool, S. F. (2023). Investigating the nexus between CO2 emissions, renewable energy consumption, FDI, exports and economic growth: evidence from BRICS countries. *Environment, Development and Sustainability*, 25(3), 2234-2263.

Iqbal, A., Tang, X., & Rasool, S. F. (2023). Investigating the nexus between CO^2 emissions, renewable energy consumption, FDI, exports and economic growth: evidence from BRICS countries. *Environment, Development and Sustainability*, 25(3), 2234-2263.

Irwin, D. A. (2024). Does trade reform promote economic growth? A review of recent evidence. *The World Bank Research Observer*, lkae003.

Islam, M. S., & Alam, F. (2023). Influence of human capital formation on the economic growth in Bangladesh during 1990–2019: an ARDL approach. *Journal of the Knowledge Economy*, 14(3), 3010-3027.

Jaakkola, E. (2020). Designing conceptual articles: four approaches. *AMS review*, 10(1-2), 18-26.

Jahan, S., Mahmud, A. S., & Papageorgiou, C. (2014). What is Keynesian economics. *International Monetary Fund*, 51(3), 53-54.

Jahanger, A., Usman, M., Murshed, M., Mahmood, H., & Balsalobre-Lorente, D. (2022). The linkages between natural resources, human capital, globalization, economic growth, financial development, and ecological footprint: The moderating role of technological innovations. *Resources Policy*, 76, 102569.

James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). An introduction to statistical learning (Vol. 112, p. 18). New York: *springer*.

Jayasinghe, M., & Selvanathan, E. A. (2021). Energy consumption, tourism, economic growth and CO2 emissions nexus in India. *Journal of the Asia Pacific Economy*, 26(2), 361-380.

Jin, T., & Kim, J. (2018). What is better for mitigating carbon emissions–Renewable energy or nuclear energy? A panel data analysis. *Renewable and Sustainable Energy Reviews*, *91*, 464-471.

Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration—with appucations to the demand for money. *Oxford Bulletin of Economics and statistics*, 52(2), 169-210.

Johansen, S. (2009). Cointegration: Overview and development. *Handbook of financial time series*, 671-693.

Johnston, M. P. (2014). Secondary data analysis: A method of which the time has come. *Qualitative and quantitative methods in libraries*, *3*(3), 619-626.

Jolliffe, D., Kilic, T., Mahler, D. G., Veerappan, M., & Wollburg, P. (2021). *Under What Conditions Are Data Valuable for Development?*. Washington, DC: World Bank.

Jones, J. D. (1989). A comparison of lag–length selection techniques in tests of Granger causality between money growth and inflation: evidence for the US, 1959–86. *Applied Economics*, 21(6), 809-822.

Jordà, Ò. (2005). Estimation and Inference of Impulse Responses by Local Projections. *American Economic Review*, 95(1), 161-182.

Kalaitzi, A. S., & Chamberlain, T. W. (2020). Merchandise exports and economic growth: multivariate time series analysis for the United Arab Emirates. *Journal of Applied Economics*, 23(1), 163-182.

Kalaitzi, A. S., & Chamberlain, T. W. (2021). The validity of the export-led growth hypothesis: some evidence from the GCC. *The Journal of International Trade & Economic Development*, 30(2), 224-245.

Kalimeris, P., Bithas, K., Richardson, C., & Nijkamp, P. (2020). Hidden linkages between resources and economy: A "Beyond-GDP" approach using alternative welfare indicators. *Ecological Economics*, 169, 106508.

Kao, C. (1999). Spurious regression and residual-based tests for cointegration in panel data. *Journal of econometrics*, 90(1), 1-44.

Kawasaki, T., Wakashima, H., & Shibasaki, R. (2022). The use of e-commerce and the COVID-19 outbreak: A panel data analysis in Japan. *Transport Policy*, 115, 88-100.

Keilbar, G., & Zhang, Y. (2021). On cointegration and cryptocurrency dynamics. *Digital Finance*, 3, 1-23.

Keynes, J. M. (1937). The general theory of employment. *The quarterly journal of economics*, 51(2), 209-223.

Khan, S. A. R. (2019). The nexus between carbon emissions, poverty, economic growth, and logistics operations-empirical evidence from southeast Asian countries. *Environmental Science and Pollution Research*, 26(13), 13210-13220.

Khan, S. A. R., Sharif, A., Golpîra, H., & Kumar, A. (2019). A green ideology in Asian emerging economies: From environmental policy and sustainable development. *Sustainable development,* 27(6), 1063-1075.

Khan, S. A. R., Zhang, Y., Kumar, A., Zavadskas, E., & Streimikiene, D. (2020). Measuring the impact of renewable energy, public health expenditure, logistics, and environmental performance on sustainable economic growth. *Sustainable development*, 28(4), 833-843.

Khan, S., Khan, M. K., & Muhammad, B. (2021). Impact of financial development and energy consumption on environmental degradation in 184 countries using a dynamic panel model. *Environmental Science and Pollution Research*, 28, 9542-9557.

Khan, S., Yahong, W., & Zeeshan, A. (2022). Impact of poverty and income inequality on the ecological footprint in Asian developing economies: Assessment of Sustainable Development Goals. *Energy Reports*, 8, 670-679.

Khin, A. A., Low, M. P., Sin, M. S., Thambiah, S., & Yu, S. C. (2021). Sustainability of Women's Employment Rate for Malaysian Economic Development. *Institutions and Economies*, 53-79.

Khin, A. A., Fong, Y. C., Chan, K. C., Lee, Y. Q., & Wong, M. Y. (2017). Vector error correction models for major agricultural and mining commodities' prices and crude oil price changes in the world market. *Journal of Humanities, Language, Culture and Business*, 1(3), 121-130.

Kim, K., Kim, S., Park, Cyn-Young. (2020). Food Security in Asia and the Pacific amid the COVID-19 Pandemic. *Asian Development Bank*. http://hdl.handle.net/11540/12119.

Klyuev, M. V., & Dao, T. N. (2016). Evolution of exchange rate behavior in the ASEAN-5 countries. *International Monetary Fund*. Available at: https://www.imf.org/external/pubs/ft/wp/2016/wp16165.pdf

Kochhar, K., Kumar, U., Rajan, R., Subramanian, A., & Tokatlidis, I. (2006). India's pattern of development: What happened, what follows?. *Journal of monetary economics*, 53(5), 981-1019.

Koopmans, T.C., 1965. On the concept of optimal economic growth, Pontification Academia Scientiarum. The econometric approach to development planning. *Amsterdam: North-Holland*. pp: 225-287.

Korinek, M. A., Schindler, M. M., & Stiglitz, J. (2021). Technological progress, artificial intelligence, and inclusive growth. *International Monetary Fund*. WP/21/266.

Koyuncu, K., & Tavacioğlu, L. (2021). Forecasting Shanghai containerized freight index by using time series models. *Marine Science and Technology Bulletin*, 10(4), 426-434.

Kralisch, D., Ott, D., Lapkin, A. A., Yaseneva, P., De Soete, W., Jones, M., ... & Finkbeiner, M. (2018). The need for innovation management and decision guidance in sustainable process design. *Journal of Cleaner production*, 172, 2374-2388.

Kremers, J. J., Ericsson, N. R., & Dolado, J. J. (1992). The power of cointegration tests. *Oxford bulletin of economics and statistics*, 54(3), 325-348.

Kuznetsova, A., Selezneva, A., Askarov, A., Askarova, A., Gusmanov, R. (2021). Trends of labor market change in the countries of the European Union and Russia under conditions of digitalization of the economy. *Montenegrin Journal of Economics*, 17(10), 175-183. DOI:10.14254/1800- 5845/2021.17-1.13.

Kuo, C. Y. (2016). Does the vector error correction model perform better than others in forecasting stock price? An application of residual income valuation theory. *Economic Modelling*, 52, 772-789.

Kwiatkowski, D., Phillips, P. C., Schmidt, P., & Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root?. *Journal of econometrics*, 54(1-3), 159-178.

Laskar, M. R., & King, M. L. (1997). Modified Wald test for regression disturbances. *Economics Letters*, 56(1), 5-11.

Law, J. (2016). A Dictionary of Business and Management (6 ed.). *Oxford University Press*, DOI: 10.1093/acref/9780199684984.001.0001

Lazarus, E., Lewis, D. J., Stock, J. H., & Watson, M. W. (2018). HAR inference: Recommendations for practice. *Journal of Business & Economic Statistics*, 36(4), 541-559.

Leon-Gonzalez, R. (2021). Forecasting macroeconomic variables in emerging economies. *Journal of Asian Economics*, *77*, 101403.

Levin, A., Lin, C. F., & Chu, C. S. J. (2002). Unit root tests in panel data: asymptotic and finite-sample properties. *Journal of econometrics*, 108(1), 1-24.

Li, B., & Li, Y. (2022). On a chemotaxis-type Solow-Swan model for economic growth with capital-induced labor migration. *Journal of Mathematical Analysis and Applications*, *511*(2), 126080.

Li, H., Liu, Z., & Rebelo, I. (1998). Testing the neoclassical theory of economic growth: evidence from Chinese provinces. *Economics of Planning*, *31*(2), 117-132.

Li, S., & Yang, B. (2008). Region-based multi-focus image fusion. Image Fusion: *Algorithms and Applications*, 343.

Li, Z., Gallagher, K. P., & Mauzerall, D. L. (2020). China's global power: Estimating Chinese foreign direct investment in the electric power sector. *Energy Policy*, 136, 111056.

Li, W., & Ullah, S. (2022). Research and development intensity and its influence on renewable energy consumption: evidence from selected Asian economies. *Environmental Science and Pollution Research*, 29(36), 54448-54455.

Liang, S., & Tan, Q. (2024). Can the digital economy accelerates China's export technology upgrading? Based on the perspective of export technology complexity. *Technological Forecasting and Social Change*, 199, 123052.

Ioannidis, J. P., Cripps, S., & Tanner, M. A. (2022). Forecasting for COVID-19 has failed. *International journal of forecasting*, 38(2), 423-438.

Lüutkepohl, H., Saikkonen, P., & Trenkler, C. (2001). Maximum eigenvalue versus trace tests for the cointegrating rank of a VAR process. *The Econometrics Journal*, 4(2), 287-310).

Lütkepohl, H. (2013). Vector autoregressive models. In Handbook of research methods and applications in empirical macroeconomics (pp. 139-164). *Edward Elgar Publishing.*

Maclnnis, D. J. (2011). A framework for conceptual contributions in marketing. *Journal of Marketing*, 75(4), 136–154.

Maddala, G. S., & Wu, S. (1999). A comparative study of unit root tests with panel data and a new simple test. *Oxford Bulletin of Economics and statistics*, 61(S1), 631-652.

Mahadevan, R., & Asafu-Adjaye, J. (2007). Energy consumption, economic growth and prices: A reassessment using panel VECM for developed and developing countries. *Energy policy*, 35(4), 2481-2490.

Mahmood, H. (2022). The spatial analyses of consumption-based CO2 emissions, exports, imports, and FDI nexus in GCC countries. *Environmental Science and Pollution Research*, 29(32), 48301-48311.

Maitra, S. (2019). Time-series Analysis with VAR & VECM: Statistical approach: Modeling Time-series Stochastic Data.

Majid, M. R., Pampanga, D. G., Zaman, M., Medugu, I. N., & Amer, M. S. (2020). Urban livability indicators for secondary cities in Asean Region. *Planning Malaysia*, *18*.

Malaysian Investment Development Authority (MIDA), (2023). *Research and Development*, Available at: https://www.mida.gov.my/industries/services/research-development-rd/

Mariyono, J. (2020). Improvement of economic and sustainability performance of agribusiness management using ecological technologies in Indonesia. *International Journal of Productivity and Performance Management*, 69(5), 989-1008.

Maneejuk, P., & Yamaka, W. (2021). The impact of higher education on economic growth in ASEAN-5 countries. *Sustainability*, 13(2), 520.

Manion, M., & Evan, W. M. (2001). Chapter 4: Three industrial revolutions. *International Journal of Risk Assessment and Management*, 2(1/2), 71–80. https://doi.org/10.1504/IJRAM. 2001.001501.

Mankiw, N. G., Romer, D., & Weil, D. N. (1992). A Contribution to The Empirics of Economic Growth. *The Quarterly Journal of Economics*, 107(2), 407-437.

Mankiw, N. G. (1995). Real business cycles: A new Keynesian perspective. *In Essential Readings in Economics* (pp. 328-341). Palgrave, London.

Mansoor, A., Shoukat, Q., Bibi, S. H. A. G. U. F. T. A., Iqbal, K., Saeed, R. O. M. A. N. A., & Zaman, K. (2018). The relationship between money supply, price level and economic growth in Pakistan: Keynesian versus monetarist view. *Review of Economic and Business Studies*, *11*(2), 49-64.

Marino, A., & Pariso, P. (2020). Comparing European countries' performances in the transition towards the Circular Economy. *Science of the Total Environment*, 729, 138142.

Matyushok, V., Krasavina, V., Berezin, A., & García, J. S. (2021). The global economy in technological transformation conditions: A review of modern trends. *Economic Research-Ekonomska Istraživanja*, 34(1), 1471-1497.

Mayevsky, V. I., Malkov, S. Y., & Rubinstein, A. A. (2019). Analysis of the relationship between issuing money, inflation and economic growth with the help of the SMR-model. *Voprosy Ekonomiki*, (8), 45-66.

Mehmood, U., Askari, M. U., & Saleem, M. (2022). The assessment of environmental sustainability: The role of research and development in ASEAN countries. *Integrated Environmental Assessment and Management*, 18(5), 1313-1320.

Mengesha, Z. D., & Singh, L. (2023). Human capital accumulation and economic growth of Ethiopian economy. *African Journal of Science, Technology, Innovation and Development*, 15(2), 211-226.

Méndez-Morales, E. A., & Yanes-Guerra, C. A. (2021). Financial system specialization and private research and development expenditure: research for OECD countries. *Journal of Economics, Finance and Administrative Science*, 26(51), 41-60.

Meyer, D. F., & Sanusi, K. A. (2019). A causality analysis of the relationships between gross fixed capital formation, economic growth and employment

in South Africa. *Studia Universitatis Babes-Bolyai Oeconomica*, 64(1), 33-44.

Meyer, D. F., & Hassan, A. S. (2020). Analysis of the impact of exchange rate volatility on the South African Government bond market. *International Journal of Economics and Finance*, *12*(2), 271-289.

Meyer, D. F. (2021). A comparative analysis of the impact of merchandise exports versus services exports on economic growth for the SACU region. *In Forum Scientiae Oeconomia*, 9(1), 5-23). Wydawnictwo Naukowe Akademii WSB.

Mikayilov, J. I., Galeotti, M., & Hasanov, F. J. (2018). The Impact of Economic Growth on CO_2 Emissions in Azerbaijan. *Journal of Cleaner Production*, 197, 1558-1572.

Ministry of Education (2020). Higher Education Acceleration and Transformation Project, Available at: https://documents1.worldbank.org/curated/en/167251608726128779/Stakeholder-Engagement-Plan-SEP-Higher-Education-Acceleration-and-Transformation-Project-P168961.docx

Mishra, S. B., &Alok, S. (2022). Handbook of research methodology.

Mishchenko, V., Naumenkova, S., Mishchenko, S., & Ivanov, V. (2018). Inflation and economic growth: The search for a compromise for the Central Bank's monetary policy. *Banks & bank systems*, 13(2), 153-163.

Mitić, P., Fedajev, A., Radulescu, M., & Rehman, A. (2023). The relationship between CO2 emissions, economic growth, available energy, and employment in SEE countries. *Environmental Science and Pollution Research*, 30(6), 16140-16155.

Ministry of Electronics and Information Technology, Government of India (2023). Retrieved on 20-05-2023 at: https://www.meity.gov.in/ongoing-projects-under-rd-ccbt

Miyamoto, K. (2003). Human capital formation and foreign direct investment in developing countries. *Organisation for Economic Co-operation and Development (OECD) Paper*, (211).

Mohiuddin, M., Rashid, M. M., Al Azad, M. S., & Su, Z. (2019). Back-shoring or re-shoring: determinants of manufacturing offshoring from emerging to least developing countries (LDCs). *International Journal of Logistics Research and Applications*, 22(1), 78-97.

Muhamad, S., Sulaiman, N. F. C., & Saputra, J. (2018). The role of human capital and innovation capacity on economic growth in ASEAN-3. *Journal Ekonomi Malaysia*, 52(1), 281-294.

Mukhtarov, S. (2020). The effects of oil prices on macroeconomic variables: Evidence from Azerbaijan. *International Journal of Energy Economics and Policy*.

Morina, F., Hysa, E., Ergün, U., Panait, M., & Voica, M. C. (2020). The effect of exchange rate volatility on economic growth: Case of the CEE countries. *Journal of Risk and Financial Management*, *13*(8), 177.

Moudatsou, A., & Kyrkilis, D. (2011). FDI and Economic Growth: Causality for the EU and ASEAN. *Journal of Economic Integration*, 554-577.

Murdifin, I, & Mangkona, SA (2017). Effect of Composite Stock price Index, Exchange Rate and Interest Rate Share Price of Mining Companies Listed in Indonesia Stock Exchange, IRA, *International journal of Management and Social Science,* 09(1), 27-35.

Musarat, M. A., Alaloul, W. S., & Liew, M. S. (2021). Impact of inflation rate on construction projects budget: A review. *Ain Shams Engineering Journal*, *12*(1), 407-414.

Morina, F., Hysa, E., Ergün, U., Panait, M., & Voica, M. C. (2020). The effect of exchange rate volatility on economic growth: Case of the CEE countries. *Journal of Risk and Financial Management*, 13(8), 177.

Morina, F., Ergün, U., & Balomenou, C. (2021). The Impact of Renewable Energy Policies and Financial Development on CO 2 Emissions and Economic Growth in EU Countries. *The Changing Financial Landscape* (pp. 97-107). Springer, Cham.

Mulaydinov, F. M. (2019). Econometric Modelling of the Innovation Process in Uzbekistan. *Forum of young scientists*, (3 (31)), 35-43.

Muo, I., & Azeez, A. A. (2019). Green entrepreneurship: Literature review and agenda for future research. *International Journal of Entrepreneurial Knowledge*, 7(2).

Myint, H., & Krueger, A. O. (2016). Economic development. Retrieved from https://www.britannica.com/topic/economicdevelopment (Accessed: 14 April 2023).

Nair, M., Pradhan, R. P., & Arvin, M. B. (2020). Endogenous dynamics between R&D, ICT and economic growth: Empirical evidence from the OECD countries. *Technology in Society*, 62, 101315.

Narayan, P. K., & Liu, R. (2015). A unit root model for trending time-series energy variables. *Energy Economics*, 50, 391-402.

National Science and Technology Development Agency (NSTDA) (2022). Available at: https://pcieerd.dost.gov.ph/2-uncategorised/59-technology-business-incubation-program

Nawaz, M. A., Hussain, M. S., Kamran, H. W., Ehsanullah, S., Maheen, R., & Shair, F. (2021). Trilemma association of energy consumption, carbon emission, and economic growth of BRICS and OECD regions: quantile regression estimation. *Environmental Science and Pollution Research*, *28*(13), 16014-16028.

N'Dri, A. B., & Su, Z. (2023). Towards a successful learning process of companies from developing countries involved in offshore outsourcing: proposal for an integrative analytical framework. *Critical Perspectives on International Business*, 19(3), 355-398.

Ngiik, T. I., Kueh, J., Yau, J., & Liwan, A. (2021). Impact of Government Expenditure, Exchange Rate and Unemployment Rate on Economic Growth of Malaysia. *Global Business & Management Research*, 13(2).

Ngo, T., Trinh, H. H., Haouas, I., & Ullah, S. (2022). Examining the bidirectional nexus between financial development and green growth: International evidence through the roles of human capital and education expenditure. *Resources Policy*, 79, 102964.

Nguyen, C. H. (2020). The impact of foreign direct investment, aid and exports on economic growth in Vietnam. *The Journal of Asian Finance, Economics and Business (JAFEB)*, *7*(10), 581-589.

Nieto, F. H. (1998). Ex-post and ex-ante prediction of unobserved economic time series: a case study. *Journal of Forecasting*, 17(1), 35-58.

Nitami, S. A., & Hayati, B. (2021). Relationship Between Crude Oil Price Fluctuations, Economic Growth, Inflation, and Exchange Rate in Indonesia 1967-2019. *AFEBI Economic and Finance Review*, *6*(2), 83-97.

O'brien, R. M. (2007). A caution regarding rules of thumb for variance inflation factors. *Quality & quantity*, 41, 673-690.

OECD (2007). International Investment Perspectives: Freedom of Investment in a Changing World, ISBN 978-92-64-03748-9. Available at: https://www.oecd.org/daf/inv/investmentstatisticsandanalysis/38818788.pdf

OECD (2002). Measuring the Information Economy, Organisation for Economic Co-Operation and Development. Available at: https://www.oecd.org/sti/ieconomy/1835738.pdf

OECD (2023). OECD Data - Employment rate 2023. Available at: https://stats.oecd.org/ Index.aspx?DatasetCode=LFS_SEXAGE_I_R (accessed 21 September 2023)

Ogbonna, O. E., & Ichoku, H. E. (2023). Symmetric or asymmetric: how is Nigeria's bilateral trade balance responding to oil price and exchange rate changes?. *Journal of Economic Studies*, 50(3), 464-479.

Okun, A. M. (1962). Potential GNP: Its measurement and significance. *In Proceedings of the Business and Economic Statistics Section of American Statistical Association*, 190, 89–104.

Olaoye, I. J., Ayinde, O. E., Ajewole, O. O., & Adebisi, L. O. (2021). The role of research and development (R&D) expenditure and governance on economic growth in selected African countries. *African Journal of Science, Technology, Innovation and Development*, *13*(6), 663-670.

Omar, M. A., & Inaba, K. (2020). Does financial inclusion reduce poverty and income inequality in developing countries? A panel data analysis. *Journal of economic structures*, *9*(1), 1-25.

Onwubuariri, S. E., Oladeji, S. I., & Bank-Ola, R. F. (2021). Inflation and economic growth in Nigeria: an ARDL bound testing approach. *Sapientia foundation journal of education, sciences and gender studies*, *3*(1).

Organization for Economic Cooperation and Development (2007), Definitions and Sources, *World Investment Report 2007*: Transnational Corporations, Extractive Industries and Development.

Osei, M. J., & Kim, J. (2020). Foreign direct investment and economic growth: Is more financial development better?. *Economic Modelling*, 93, 154-161.

Ouliaris, S. (2012). Economic models: Simulations of reality. *International Monetary Fund*. Available at: https://www.imf.org/external/pubs/ft/fandd/basics/models.htm

Ozili, P. K. (2022). Financial inclusion and sustainable development: an empirical association. *Journal of Money and Business*, (ahead-of-print).

Pal, K., & Mittal, R. (2011). Impact of macroeconomic indicators on Indian capital markets. *The Journal of Risk Finance*, 12(2), 84-97.

Palmer, A., Montano, J. J., & Sesé, A. (2006). Designing an artificial neural network for forecasting tourism time series. *Tourism management*, 27(5), 781-790.

Pamela, Q., & Indrawati, L. R. (2022). Effect of Inflation, Exports, and Employment on Economic Growth in Central Java. *Research Horizon*, 2(5), 501-510.

Pandey, A., Brauer, M., Cropper, M. L., Balakrishnan, K., Mathur, P., Dey, S., ... & Dandona, L. (2021). Health and economic impact of air pollution in the states of India: The Global Burden of Disease Study 2019. *The Lancet Planetary Health*, *5*(1), e25-e38.

PASTIC-Pakistan Scientific and Technological Information Centre (2023). Retrieved on 20-05-2023 at: http://pastic.gov.pk/searchrdprojects.aspx?par=onlin&cmenu=rd

Pascual, K. C. A., Dionisio, C. P., & Capulla, R. (2020). The relationship of real Gross Domestic Product (GDP), inflation, and unemployment in the Philippines (1970-2011). *International Journal of Research*, 9(2), 81-102.

Pedroni, P. (1999). Critical values for cointegration tests in heterogeneous panels with multiple regressors. *Oxford Bulletin of Economics and statistics*, 61(S1), 653-670.

Pedroni, P. (2004). Panel cointegration: asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. *Econometric theory*, 20(3), 597-625.

Pegkas, P., Staikouras, C., & Tsamadias, C. (2019). Does research and development expenditure impact innovation? Evidence from the European Union countries. *Journal of Policy Modeling*, 41(5), 1005-1025.

Pesaran, M. H., & Shin, Y. (1995). *An autoregressive distributed lag modelling approach to cointegration analysis (Vol. 9514)*. Cambridge, UK: Department of Applied Economics, University of Cambridge.

Pesaran, M. H. (2012). On the interpretation of panel unit root tests. *Economics Letters*, 116(3), 545-546.

Petrakis, P. E. (2020). Theoretical approaches to economic growth and development. *An Interdisciplinary Perspective. Switzerland: National and Kapodistrian University of Athens*.

Petrović, P., & Lobanov, M. M. (2020). The impact of R&D expenditures on CO2 emissions: evidence from sixteen OECD countries. *Journal of Cleaner Production*, 248, 119187.

Pham, T. A. T., Nguyen, T. T., Nasir, M. A., & Huynh, T. L. D. (2023). Exchange rate pass-through: A comparative analysis of inflation targeting & non-targeting ASEAN-5 countries. *The Quarterly Review of Economics and Finance*, 87, 158-167.

Pheang, P., Liu, J., Sirisrisakulchai, J., Chaiboonsri, C., & Sriboonchitta, S. (2017). Foreign direct investment, exports and economic growth in ASEAN region: Empirical analysis from panel data. *Robustness in Econometrics*, 691-705.

Phillips, P. C., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika*, 75(2), 335-346.

Pindyck, S., & Rubinfeld, L. (1998). Econometric models and economic forecasts.

Popelo, O., Garafonova, O., Tulchynska, S., Derhaliuk, M., & Berezovskyi, D. (2021). Functions of public management of the regional development in the conditions of digital transformation of economy. *Revista Amazonia Investiga*, *10*(43), 49-58.

Poumie, B., & Claude, D. M. (2021). Does Foreign Capital Really Matter for Employment? Evidence from Agricultural Dominance African Countries. *Asian Journal of Economic Modelling*, 9(2), 88-104.

Pradhan, R. P., Arvin, M. B., Nair, M., Bennett, S. E., & Bahmani, S. (2024). Some determinants and mechanics of economic growth in middle-income countries: The role of ICT infrastructure development, taxation and other macroeconomic variables. *The Singapore Economic Review*, 69(01), 297-333.

Qamruzzaman, M., Mehta, A. M., Khalid, R., Serfraz, A., & Saleem, H. (2021). Symmetric and asymmetric effects of financial innovation and FDI on exchange rate volatility: Evidence from South Asian countries. *The Journal of Asian Finance, Economics and Business*, *8*(1), 23-36.

Ragmoun, W. (2023). Institutional quality, unemployment, economic growth and entrepreneurial activity in developed countries: a dynamic and sustainable approach. *Review of International Business and Strategy*, 33(3), 345-370.

Rahman, M. M. (2021). The dynamic nexus of energy consumption, international trade and economic growth in BRICS and ASEAN countries: A panel causality test. *Energy*, 229, 120679.

Rahman, P., Zhang, Z., & Musa, M. (2023). Do technological innovation, foreign investment, trade and human capital have a symmetric effect on economic growth? Novel dynamic ARDL simulation study on Bangladesh. *Economic Change and Restructuring*, 56(2), 1327-1366.

Rajnoha, R., & Lesnikova, P. (2022). Sustainable competitiveness: How does global competitiveness index relate to economic performance accompanied by the sustainable development?. *Journal of Competitiveness*, 14(1), 136-154. https://doi.org/10.7441/joc.2022.01.08.

Rakhmatillo, E., Anvar, K., & Sukhrob, M. (2021). Foreign direct investment, economic growth and employment: var method for Uzbekistan. *Journal of Contemporary Issues in Business and Government*, 27(2), 1-10.

Ramzan, M. (2021). Impact of inflation and unemployment on economic growth of Pakistan. *European Journal of Business and Management Research*, 6(4), 282-288.

Ratnawati, K. (2020). The impact of financial inclusion on economic growth, poverty, income inequality, and financial stability in Asia. *The Journal of Asian Finance, Economics and Business*, 7(10), 73-85.

Razmi, A., Rapetti, M., & Skott, P. (2012). The real exchange rate and economic development. *Structural change and economic dynamics*, 23(2), 151-169.

Redmond, T., & Nasir, M. A. (2020). Role of natural resource abundance, international trade and financial development in the economic development of selected countries. *Resources Policy*, 66, 101591.

Ribeiro, R. S., McCombie, J. S., & Lima, G. T. (2020). Does real exchange rate undervaluation really promote economic growth?. *Structural Change and Economic Dynamics*, 52, 408-417.

Rodriguez, V., & Soeparwata, A. (2012). ASEAN benchmarking in terms of science, technology, and innovation from 1999 to 2009. *Scientometrics*, 92(3), 549-573.

Romer, P. M. (1994). The origins of endogenous growth. *Journal of Economic perspectives*, 8(1), 3-22. DOI: 10.1257/jep.8.1.3

Romer, P. M. (1990), Endogenous Technological Change, *Journal of Political Economy*, 98, S71–S102.

Rosnawintang, R., Tajuddin, T., Adam, P., Pasrun, Y. P., & Saidi, L. O. (2021). Effects of crude oil prices volatility, the internet and inflation on economic growth in ASEAN-5 countries: A panel autoregressive distributed lag approach. *International Journal of Energy Economics and Policy*, 11(1), 15-21.

Ruranga, C., Ruturwa, D. S., & Rwema, V. (2020). Impact of exports and imports on economic growth in Rwanda: 1961-2018.

Sahin, B. E. (2019). Impact of high technology export on economic growth: An analysis on Turkey. *Journal of Business Economics and Finance*, 8(3), 165-172.

Saidu, B.M., B.A. Ahmed and A.H. Jakada, (2018). The determinants of long-term economic growth in Nigeria. *Asian Economic and Financial Review*, 8(1): 1–7.Available at: https://doi.org/10.18488/journal.aefr.2018.81.1.7.

Saidi, S., Mani, V., Mefteh, H., Shahbaz, M., & Akhtar, P. (2020). Dynamic linkages between transport, logistics, foreign direct Investment, and economic growth: Empirical evidence from developing countries. *Transportation Research Part A: Policy and Practice*, 141, 277-293.

Saleem, A., Sial, M. H., & Cheema, A. R. (2023). Does an asymmetric nexus exist between exports and economic growth in Pakistan? Recent evidence from a nonlinear ARDL approach. *Economic Change and Restructuring*, 56(1), 297-326.

Saluja, M. S., Bhatia, N. K., & Patel, N. (2013). A cointegration and VECM approach in explaining relationship of FDI with current and capital account of India. *International Journal of Advance Research in Computer Science and Management Studies*, 1(6).

Sánchez-Sellero, P., & Bataineh, M. J. (2022). How R&D cooperation, R&D expenditures, public funds and R&D intensity affect green innovation?. *Technology Analysis & Strategic Management*, 34(9), 1095-1108.

Sandbrook, D. (2019). *Who dares wins: Britain, 1979-1982*. Penguin UK.

Sarafidis, V., & Wansbeek, T. (2021). Celebrating 40 years of panel data analysis: Past, present and future. *Journal of Econometrics*, 220(2), 215-226.

Sasana, H. (2022). Effect Analysis of FDI, Exports, Exchange Rates, on Indonesia's Economic Growth 1991-2020. *Journal Of Humanities, Social Sciences and Business*, 2(1), 1-17.

Saungweme, T., & M Odhiambo, N. (2021). Public debt and inflation dynamics: Empirical evidence from Zimbabwe. *Croatian Review of Economic, Business and Social Statistics*, 7(2), 14-30.

Schumpeter, J. A. (1942), Capitalism, Socialism and Democracy, *Harvard University Press*, Cambridge, MA.

Schumpeter, J. A. (1946). John Maynard Keynes 1883-1946. *The American Economic Review*, 36(4), 495-518.

Schumpeter, J., Backhaus, U. (2003). The Theory of Economic Development. In: Backhaus, J. (eds) Joseph Alois Schumpeter. The European Heritage in Economics and the Social Sciences, 1. *Springer, Boston*, MA. https://doi.org/10.1007/0-306-48082-4_3

Seah, S., Ha, H. T., Martinus, M., & Thao, P. T. P. (2021). The state of Southeast Asia: 2021 survey report.

Sekaran, U., Bougie, R. (2016). *Research Methods for Business: a skill-building Approach, 7th Ed.* (7th). Chichester: *John Wiley & Sons. Inc.*

Seyoum, B. (2013). Export-import theory, practices, and procedures. *Routledge*.

Shahbaz, M., Sharma, R., Sinha, A., & Jiao, Z. (2021). Analyzing nonlinear impact of economic growth drivers on CO2 emissions: Designing an SDG framework for India. *Energy Policy*, 148, 111965.

Shahbaz, M., Song, M., Ahmad, S., & Vo, X. V. (2022). Does economic growth stimulate energy consumption? The role of human capital and R&D expenditures in China. *Energy Economics*, *105*, 105662.

Shahid, M. K., Khin, A. A., Seong, L. C., Shahbaz, M., & Ahmad, F. (2024). Mapping the Relationship of Research and Development Expenditures and Economic Growth through Bibliometric Analysis: A Theoretical Perspective. *Journal of the Knowledge Economy*, 1-27. https://doi.org/10.1007/s13132-024-01781-8.

Shahid, M. K., Khin, A. A., & Seong, L. C. (2023). Systematic Review of Research and Development Expenditures and Sustainable Economic Development in ASEAN Countries. In *CoMBInES-Conference on Management, Business, Innovation, Education and Social Sciences*, 3(1), 140–156. Available at: https://journal.uib.ac.id/index.php/combines/article/view/7684

Sharif, A., Shahbaz, M., & Hille, E. (2019). The transportation-growth nexus in USA: fresh insights from pre-post global crisis period. *Transportation Research Part A: Policy and Practice*, 121, 108-121.

Shang, M., Peng, M. Y. P., Anser, M. K., Imran, M., Nassani, A. A., Binsaeed, R. H., & Zaman, K. (2024). Evaluating the U-shaped environmental kuznets curve in China: The impact of high technology exports and renewable energy consumption on carbon emissions. *Gondwana Research*, 127, 272-287.

Shen, Y. (2020). The Interactive Effect of Science and Technology Finance Development and Regional Economic Growth in the Yangtze River Economic Belt: Analysis Based on Panel Vector Autoregressive (PVAR) Model of Interprovincial Data. *J. Phys. Conf. Ser*. 1624, 022026. doi:10.1088/ 1742-6596/1624/2/022026

Shkarlet, S., Dubyna, M., Shtyrkhun, K., & Verbivska, L. (2020). Transformation of the paradigm of the economic entities development in digital economy. *WSEAS transactions on environment and development*, 16(8), 413-422.

Sijabat, R. (2023). The association between foreign investment and gross domestic product in ten ASEAN countries. *Economies*, 11(7), 188.

Simonova, M., Lyachenkov, Y., Kostikova, E. (2021). Regional Labor Market: Supply and Demand in the Context of Digitalization. In Ashmarina S., Mantulenko V. (eds) Current Achievements, Challenges and Digital Chances of Knowledge Based Economy. Lecture Notes in Networks and Systems, 133. *Springer, Cham*. https://doi.org/10.1007/978- 3-030-47458-4_93.

Siddiqui, S., & Roy, P. (2021). Asymmetric Effects of Exchange Rate and Its Relationship with Foreign Investments: A Case of Indian Stock Market. *Vision*, *25*(4), 415-427.

Siggiridou, E., Koutlis, C., Tsimpiris, A., & Kugiumtzis, D. (2019). Evaluation of Granger causality measures for constructing networks from multivariate time series. *Entropy*, 21(11), 1080.

Sinha, A., & Sengupta, T. (2019). Impact of natural resource rents on human development: what is the role of globalization in Asia Pacific countries?. *Resources Policy*, 63, 101413.

Soete, L., Verspagen, B., & Ziesemer, T. H. (2022). Economic impact of public R&D: an international perspective. *Industrial and Corporate Change*, 31(1), 1-18.

Solow, R.M., 1956. A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, 70(1): 65-94.

Song, C. Q., Chang, C. P., & Gong, Q. (2021). Economic growth, corruption, and financial development: Global evidence. *Economic Modelling*, 94, 822-830.

Song, L., & Zhou, Y. (2020). The COVID-19 pandemic and its impact on the global economy: what does it take to turn crisis into opportunity?. *China & World Economy*, *28*(4), 1-25.

Spyros, R. (2020). Measuring economic development and the impact of economic globalisation. *Studies in Business and Economics*, 15(3), 185-207.

Srinivasan, P., Kalaivani, M., & Ibrahim, P. (2010). FDI and Economic Growth in the ASEAN Countries: Evidence from Cointegration Approach and Causality Test. *IUP Journal of Management Research*, 9(1).

Sriyakul, T., Chienwattanasook, K., & Chankoson, T. (2022). Does Industrialization and Renewable Energy Consumption Determine Economic Growth? Empirical Evidence from ASEAN Countries. *International Journal of Economics and Finance Studies*, 14(03), 264-279.

Standing, G. (2008). The ILO: An agency for globalization?. *Development and change*, 39(3), 355-384.

Studenmund, A. H. (2014). Using econometrics, a practical guide. *Pearson education limited*.

Su, K., Wu, J., & Lu, Y. (2022). With trust we innovate: Evidence from corporate R&D expenditure. Technological Forecasting and Social Change, 182, 121834.

Suki, N. M., Sharif, A., Afshan, S., & Suki, N. M. (2020). Revisiting the environmental Kuznets curve in Malaysia: the role of globalization in sustainable environment. *Journal of Cleaner Production*, 264, 121669.

Sukmawati, F. N., & Haryono, N. A. (2021). Cointegration of Macroeconomics Variables and Dow Jones Industrial Average Index on the Composite Stock Price Index in 2015-2019. *Journal of Business and Management Review*, 2(3), 178-191.

Sultana, T., Dey, S. R., & Tareque, M. (2022). Exploring the linkage between human capital and economic growth: A look at 141 developing and developed countries. *Economic Systems*, 46(3), 101017.

Swan, T. W. (1956). Economic growth and capital accumulation. *Economic record*, *32*(2), 334-361.

Tran, T., Do, H., Vu, T., & Do, N. (2020). The factors affecting green investment for sustainable development. *Decision Science Letters*, *9*(3), 365-386.

Taylor, C. A., & Theil, H. (1988). Modeling the accuracy of certain regional predictions. *Regional Science and Urban Economics*, 18(4), 453-462.

Tahir, M., Estrada, M. A. R., & Afridi, M. A. (2019). Foreign inflows and economic growth: An empirical study of the SAARC region. *Economic Systems*, 43(3-4), 100702.

Terluin, I. J. (2003). Differences in economic development in rural regions of advanced countries: an overview and critical analysis of theories. *Journal of rural studies*, 19(3), 327-344.

The ASEAN Secretariat Jakarta (2021). Key ASEAN Figure, available at: https://www.aseanstats.org/wp-content/uploads/2021/12/ASEAN-KEY-FIGURES-2021-FINAL-1.pdf

Tien, N. H. (2021). Relationship between inflation and economic growth in Vietnam. Turkish *Journal of Computer and Mathematics Education* (TURCOMAT), 12(14), 5134-5139.

TRADING ECONOMICS (2024). *India GDP from agriculture.* https://tradingeconomics.com/india/gdp-from-agriculture

Tulchynska, S., Vovk, O., Popelo, O., Saloid, S., & Kostiunik, O. (2021). Innovation and investment strategies to intensify the potential modernization and to increase the competitiveness of microeconomic systems. *International Journal of Computer Science & Network Security*, 21(6), 161–168. https://doi.org/10.22937/IJCSNS.2021.21.6.22

Tung, L.T. and Hoang, L.N. (2023). Impact of R&D expenditure on economic growth: evidence from emerging economies. *Journal of Science and Technology Policy Management*, ahead-of-print. https://doi.org/10.1108/JSTPM-08-2022-0129

Ijaz-Uddin, (2021). Impact of inflation on economic growth in Pakistan. *Economic Consultant*, 34(2).

Uddin, I., & Rahman, K. U. (2023). Impact of corruption, unemployment and inflation on economic growth evidence from developing countries. *Quality & Quantity*, 57(3), 2759-2779.

UNCTAD (2022). Gross domestic product – UNCTAD Handbook of Statistics 2022. Available at https://gross domestic product – *UNCTAD Handbook of Statistics 2022* (accessed 15 September 2023).

UNCTAD (2022). Foreign direct investment – *UNCTAD Handbook of Statistics 2022*. Available at https://unctad.org/system/files/official-document/tdstat47_FS09_en.pdf (accessed 15 September 2023).

UNCTAD (2018). UNCTAD Commodity Price Index. *Methodological note. UNCTAD/STAT/CPB/MN/1*. *Geneva*. Available at https://unctad.org/system/files/official-document/statcpbmn1_en.pdf (accessed 21 September 2023).

UIS, U. (2022). Releases New Data for SDG 9.5 on Research and Development. Available at https://uis.unesco.org/en/news/uis-releases-new-data-sdg-9-5-research-and-development (accessed 21 September 2023).

Vandeput, N. (2019). Forecast KPIs: RMSE, MAE, MAPE & Bias. *Data Science for Supply Chain Forecast, 15*.

Verbeek, M. (2008). *A guide to modern econometrics*. John Wiley & Sons.

Vladimirov, I.S., Kamchatova, E.Y., Burlakov, V.V. (2021). Digitalization of the Labor Market in the Fourth Industrial Revolution. In Ashmarina S.I., Mantulenko V.V. (eds) Digital Economy and the New Labor Market: Jobs, Competences and Innovative HR Technologies. IPM 2020. *Lecture Notes in Networks and Systems*, 161, 275-282. doi: 10.1007/978-3-030-60926-9_35.

Wang, Q., & Zhang, F. (2021). The effects of trade openness on decoupling carbon emissions from economic growth–evidence from 182 countries. *Journal of cleaner production*, 279, 123838.

Wang, B., Khalid, S., & Mahmood, H. (2024). R&D spending and economic policy uncertainty in Asian countries: An advanced panel data estimation study. *Journal of the Knowledge Economy*, 15(1), 4710-4729.

Wei, X., Mohsin, M., & Zhang, Q. (2022). Role of foreign direct investment and economic growth in renewable energy development. *Renewable Energy*, 192, 828-837.

Wei, L., Lin, B., Zheng, Z., Wu, W., & Zhou, Y. (2023). Does fiscal expenditure promote green technological innovation in China? Evidence from Chinese cities. *Environmental Impact Assessment Review*, 98, 106945.

Wooldridge, J. M. (2010). Econometric analysis of cross section and panel data. *MIT press*.

Yang, Y., & Mallick, S. (2014). Explaining cross-country differences in exporting performance: The role of country-level macroeconomic environment. *International Business Review*, 23(1), 246-259.

Yang, H. C., Syarifuddin, F., Chang, C. P., & Wang, H. J. (2022). The impact of exchange rate futures fluctuations on macroeconomy: Evidence from ten trading market. *Emerging Markets Finance and Trade*, *58*(8), 2300-2313.

Yang, C. H., Lee, C. F., & Chang, P. Y. (2023). Export-and import-based economic models for predicting global trade using deep learning. *Expert Systems with Applications*, 218, 119590.

Yanyun, Z., Mingqian, Z. (2004). R&D and Economic Growth-Panel Data Analysis in ASEAN+3 Countries. *Seoul Conference 2004*, Korea and the World Economy III.

Yasmeen, H., Tan, Q., Zameer, H., Vo, X. V., & Shahbaz, M. (2021). Discovering the relationship between natural resources, energy consumption, gross capital formation with economic growth: can lower financial openness change the curse into blessing. *Resources Policy*, 71, 102013.

Yussif, A. R. B., Onifade, S. T., Ay, A., Canitez, M., & Bekun, F. V. (2024). Modeling the volatility of exchange rate and international trade in Ghana: empirical evidence from GARCH and EGARCH. *Journal of Economic and Administrative Sciences*, 40(2), 308-324.

Zafar, M. W., Shahbaz, M., Hou, F., & Sinha, A. (2019). From nonrenewable to renewable energy and its impact on economic growth: the role of research & development expenditures in Asia-Pacific Economic Cooperation countries. *Journal of cleaner production*, *212*, 1166-1178.

Zghidi, N., Mohamed Sghaier, I., & Abida, Z. (2016). Does economic freedom enhance the impact of foreign direct investment on economic growth in North African countries? A panel data analysis. *African Development Review*, 28(1), 64-74.

Zhang, X., Xue, T., & Stanley, H. E. (2018). Comparison of econometric models and artificial neural networks algorithms for the prediction of Baltic dry index. *IEEE Access*, 7, 1647-1657.

Zhang, D., Mohsin, M., Rasheed, A. K., Chang, Y., & Taghizadeh-Hesary, F. (2021). Public spending and green economic growth in BRI region: mediating role of green finance. *Energy Policy*, *153*, 112256.

Zhang, P. (2021). Target interactions and target aspiration level adaptation: how do government leaders tackle the "environment-economy" nexus?. *Public Administration Review*, 81(2), 220-230.

Zhao, Z. Y., Xie, M., & West, M. (2016). Dynamic dependence networks: Financial time series forecasting and portfolio decisions. *Applied Stochastic Models in Business and Industry*, 32(3), 311-332.

Zheng, Z., Wan, X., & Huang, C. Y. (2023). Inflation and income inequality in a Schumpeterian economy with heterogeneous wealth and skills. *Economic Modelling*, 121, 106193.

Zhang, C., Waris, U., Qian, L., Irfan, M., & Rehman, M. A. (2024). Unleashing the dynamic linkages among natural resources, economic complexity, and sustainable economic growth: Evidence from G-20 countries. *Sustainable Development*. https://doi.org/10.1002/sd.2845

Zhu, W., Ahmad, F., Draz, M. U., Ozturk, I., & Rehman, A. (2022). Revisiting the nexus between exchange rate, exports and economic growth: further evidence from Asia. *Economic research-Ekonomska istraživanja*, 35(1), 7128-7146.

Zhu, Y., Bashir, S., & Marie, M. (2022). Assessing the Relationship between Poverty and Economic Growth: Does Sustainable Development Goal Can be Achieved?. *Environmental Science and Pollution Research*, *29*(19), 27613-27623.

Zoramawa, L. B., Machief, P. E., & Umar, S. (2020). An analysis of the impact of non-oil exports on economic growth: Evidence from Nigeria. *Journal of Research in Emerging Markets*, 2(1), 15.