DETERMINANTS FOR THE INNOVATION ACTIVITIES IN MALAYSIA AND SELECTED COUNTRIES

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BY

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A final year project submitted in partial fulfilment of the requirement for the degree of

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DECLARATION

I hereby declare that:

(1) This undergraduate FYP is the end result of my own work and that due acknowledgement has been given in the references to ALL sources of information be they printed, electronic, or personal.

(2) No portion of this FYP has been submitted in support of any application for any other degree or qualification of this or any other university, or other institutes of learning.

(3) Sole contribution has been made by me in completing the FYP.

(4) The word count of this research report is 10712 words.

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LIST OF ABBREVIATION

EG	Economic Growth
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GP	Government Policies
ICT	Information and Communication Technology
IS	Industry Structure
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Square
PA	Patent Application
R&D	Research and Development
RDE	Research and Development Expenditure as a Percentage of Gross Domestic Product
SPSS	Statistical Packages for Social Sciences
TAM	Technology Acceptance Model
TEL	Tertiary Education Level

Preface

In the journey towards the culmination of my academic pursuit, I present this final year project as a testament to my dedication, perseverance, and passion for knowledge. This project represents the culmination of years of learning, exploration, and growth, encapsulating the essence of my academic journey.

Undertaking this project has been an enriching experience, one that has allowed me to delve deep into the realms of research, analysis, and critical thinking. It has provided me with an invaluable opportunity to apply the theoretical concepts and methodologies learned throughout my academic tenure to address real-world issues and challenges.

The genesis of this project lies in a quest for understanding and discovery. Driven by a curiosity to explore the intricate dynamics of innovation activities, particularly in the context of Malaysia and selected countries, I embarked on a journey of exploration. Through meticulous research, data analysis, and scholarly inquiry, I endeavoured to unravel the determinants that shape innovation landscapes and influence Research and Development (R&D) expenditure.

As I present this final year project, I do so with a sense of pride, accomplishment, and anticipation for the journey that lies ahead. It is my sincere hope that this project contributes to the body of knowledge in its respective field and serves as a catalyst for further inquiry, exploration, and discovery.

Abstract

This study delves into the determinants of innovation activities in Malaysia, the United States, China, South Korea, and Singapore, with a specific focus on Research and Development (R&D) expenditure as a percentage of Gross Domestic Product (GDP). Innovation plays a crucial role in driving economic growth, societal progress, and global competitiveness, making it imperative to understand the factors that influence innovation landscapes across diverse national contexts.

Findings reveal significant variations in R&D expenditure as a percentage of GDP across the selected countries, reflecting differences in economic development levels, policy frameworks, and industrial structures. Regression analysis is employed to ascertain the relationship between independent variables and R&D expenditure, yielding insights into the drivers of innovation activities.

Results indicate that economic growth, government policies supportive of innovation, a conducive industry structure, higher tertiary education levels, and patent applications are positively associated with R&D expenditure as a percentage of GDP. These findings underscore the multifaceted nature of innovation ecosystems and the importance of holistic policy approaches in fostering innovation and economic growth.

Overall, this study contributes empirical evidence on the determinants of innovation activities in diverse national contexts. It offers valuable insights for policymakers, businesses, and stakeholders seeking to promote innovation and economic development. By understanding the factors that drive innovation, policymakers can formulate effective strategies to foster innovation ecosystems and drive sustainable economic growth.

CHAPTER 1: RESEARCH OVERVIEW

1.1 Research Background

In the ever-evolving landscape of global innovation, nations such as Malaysia, the United States, China, South Korea, and Singapore have stood out as key contributors to research and development (R&D) activities. The pursuit of innovation has become integral to economic growth, shaping the trajectory of these countries on the world stage. As we delve into the historical evolution of innovation activities, it becomes apparent that understanding the intricacies of R&D expenditure is essential for anticipating and addressing future challenges.

The journey of innovation in these selected countries has been marked by notable milestones, trends, and challenges. In the case of Malaysia, a country with a rapidly growing economy, the emphasis on innovation has been a crucial component of its development strategies, which can be clearly shown through the intense competition among the small and medium manufacturing enterprises in Malaysia (Rosli & Sidek, 2013). The United States, with its longstanding commitment to technological advancement, has consistently played a pioneering role in shaping global innovation trends, especially in the extent of STI (science, technology, and innovation) (Colglazier & Lyons, 2014). China's rapid economic ascent has been characterized by a strategic focus on innovation, evident in its substantial R&D investments and technological achievements that accompanied by a sharp rise in foreign direct investment (FDI) inflows; for instance, China is now the world's top beneficiary of foreign direct investment (FDI) in the developing world, with inflows rising from US$ 1.91 billion in 1983 to US$ 41 billion in 2000. (UNCTAD, 2001). South Korea, renowned for its technological prowess, has undergone a transformative journey from recovery to innovation-driven growth, as they successfully managed and overcame the two major economic downturns with the aid of industrial restructuring policies and the suitable reactions from both public and private sectors (Koo, 2013). Meanwhile, Singapore, with its small size but remarkable economic success, has strategically positioned itself as a hub for innovation and research as demonstrated in the creative inner-city environment and keeping up with technological advancements (Wong, Millar, & Choi, 2006). Each of these countries has faced unique challenges, whether in terms of resource allocation, fostering a culture of innovation, or addressing the ethical dimensions of technological advancements.

Milestones in the evolution of innovation activities include breakthroughs in science, technology, and industry, as well as policy initiatives aimed at promoting R&D. Trends have encompassed shifts in funding patterns, international collaborations, and the growing importance of knowledge-based economies. Recognizing and analysing these milestones and trends provides a foundation for understanding the current state of innovation in each country. Challenges also have played a pivotal role in shaping the innovation landscape. Issues such as balancing economic development with environmental sustainability, ensuring inclusivity in technological advancements, and navigating the complexities of intellectual property rights have been central concerns. Moreover, the impact of global events and crises has prompted nations to reassess their innovation strategies and resilience.

This intricate tapestry of historical evolution, milestones, trends, and challenges lay the groundwork for our research focus. The specific examination of R&D expenditure as a percentage of GDP in Malaysia, the United States, China, South Korea, and Singapore is driven by the need to unravel the determinants influencing innovation activities. By doing so, we aim to contribute valuable insight to both academic and practical strategies for fostering innovation in an increasingly interconnected and dynamic global environment.

1.2 Research Problem

Building upon the nuanced exploration of the historical evolution, milestones, trends, and challenges in the field of research and development (R&D) expenditure and innovation, this section delves into the specific issues that propel the initiation of our research. The motivation to undertake this study is rooted in both positive and negative aspects, reflecting the complex dynamics inherent in the pursuit of innovation across Malaysia, the United States, China, South Korea, and Singapore.

The research is driven by the motivation to investigate the correlation between R&D expenditure and economic growth, acknowledging the widely recognized link between increased research and development activities and a nation's economic prosperity. Countries with higher R&D investments tend to witness significant advancements in technology, innovation, and productivity. This study aims to delve into historical data to identify periods of substantial R&D investment and subsequent economic growth in the selected countries. Additionally, it will conduct a comparative analysis to discern patterns and best practices that can inform strategies for fostering sustained economic development.

1.3 Research Objectives & Research Questions

1.3.1 Research Objectives

The research objectives of this study are described in two sections, which are general objective and specific objectives.

1.3.1.1 General Objective

- To examine the determinants for the innovation activities in Malaysia, the United States, China, South Korea, and Singapore.

The recognition and exploration of the key factors influencing innovation serve as the foundation pillar for this research objective. The goal is to give a thorough grasp of the foundations that support R&D spending and innovation in a variety of national contexts by comprehending these crucial elements. It also allows us to dissect the multifaceted nature of R&D expenditure, going beyond mere financial allocations to comprehend the underlying factors that spur innovation.

1.3.1.2 Specific Objective

- To examine the impact of economic growth of the country towards R&D expenditure as a percentage of GDP.
- To examine the impact of government policies towards R&D expenditure as a percentage of GDP.

- To examine the impact of industry structure towards R&D expenditure as a percentage of GDP.
- To examine the impact of tertiary education level towards R&D expenditure as a percentage of GDP.
- To examine the impact of patent application towards R&D expenditure as a percentage of GDP.

1.3.2 Research Questions

- What is the impact of economic growth of the country on R&D expenditure as a percentage of GDP?
- What is the impact of government policies on R&D expenditure as a percentage of GDP?
- What is the impact of industry structure on R&D expenditure as a percentage of GDP?
- What is the impact of tertiary education level on R&D expenditure as a percentage of GDP?
- What is the impact of patent application on R&D expenditure as a percentage of GDP?

1.4 Research Significance

The finding of this research can offer valuable guidance for policymakers in the selected countries. Understanding the impact of government policies on innovation activities provides actionable insights for policy improvements, fostering an environment conducive to research and development. Businesses and industries also can benefit from the research by gaining insights into the factors influencing R&D expenditure. This knowledge can inform strategic decision-making, helping organizations align their innovation strategies with the determinants identified in the study.

Furthermore, the research contributes to discussions on enhancing global competitiveness by identifying key determinants of innovation. Policymakers and businesses can leverage this information to strengthen their innovation ecosystems and position their countries competitively in the global market. Besides that, the examination of environmental implications and sustainable practices in innovation contributes to discussions on responsible and eco-friendly research and development. Businesses and policymakers can use this information to implement practices that align with environmental sustainability goals.

Moreover, educational institutions can use the research findings to tailor programs that align with the identified determinants of innovation. This contributes to the development of a skilled workforce capable of driving research and development activities.

CHAPTER 2: LITERATURE REVIEW

2.1 Underlying Theories

2.1.1 Technology Acceptance Model (TAM)

Originated by Davis (1989), the Technology Acceptance Model (TAM) focuses on the acceptance and adoption of technological innovations. TAM posits that perceived ease of use and perceived usefulness significantly impact an individual’s or organization’s decision to adopt a technology. Ajzen and Fishbein (1975) explained that the psychology theory of reasoned action (TRA), which aims to explain behaviour, is the foundation of theory of reasoned action (TAM). TAM had two main predictors: behavioural intention (BI), which TRA believed to be strongly correlated with actual behaviour, and perceived ease of use (EU) and perceived usefulness (U).

Applied to the context of R&D expenditure, TAM serves as a lens through which we can understand how the perceived utility and accessibility of innovative technologies influence a country’s willingness to invest in research and development. As a matter of fact, TAM has gained so much traction that it is mentioned in many studies that address individuals' acceptance of technology (Lee, Kozar, & Larsen, 2003). On the other hand, some researchers argue that TAM may have drawn more straightforward and expeditious study, so detracting from the actual issue of technology acceptance (Lee et al., 2003). Since there is still much to learn about the assumptions, benefits, and drawbacks of the Technology adoption Model (TAM), anyone wishing to investigate user adoption of technology must have a thorough understanding of it.

2.1.2 Innovation Diffusion Theory

Introduced by Rogers (1962), the Innovation Diffusion Theory explores how new ideas, products, or practices spread within a society. The theory classifies individuals into adopter categories based on their willingness to embrace innovation, ranging from early adopters to laggards. Regarding change theories, Innovation Diffusion theory approaches the analysis of changes in an opposing manner. It views change as essentially about the development or "reinvention" of goods and behaviours, so they become better matches for the requirements of individuals and communities, as opposed to focused on convincing individuals to change.

When innovations spread, the inventions themselves undergo change rather than people (Robinson, 2009). Diffusion, on the other hand, is the process by which an invention spreads over time among the constituents of a social system via specific channels (Rogers, 2003). However, a significant challenge persists in effectively managing the outcomes generated from research and development (R&D) endeavours, particularly within the government R&D sector (Wonglimpiyarat & Yuberk, 2005). In the context of this study, Innovation Diffusion Theory aids in understanding the diffusion patterns of R&D expenditure practices across different countries and industries, shedding light on the factors influencing the rate of adoption.

2.2 Review of Variables

2.2.1 Research and Development (R&D) Expenditure as a Percentage of Gross Domestic Product (GDP)

R&D expenditure as a percentage of GDP refers to the proportion of a country's Gross Domestic Product (GDP) allocated specifically to Research and Development (R&D) activities (UNESCO Institute for Statistics, 2023). The four primary sectors of government, higher education, business activity, and private non-profit are all comprised of capital and ongoing expenditures. Basic, applied, and experimental development are all included in R&D. This metric quantifies the investment in R&D as a percentage of the overall economic output, providing a relative measure of a nation's commitment to fostering innovation and technological advancement. However, not every R&D project will result in a successful innovation. A portion of the funds may have been wasted on insignificant projects or unsuccessful technologies. Only a small portion of R&D efforts will result in innovation. Consequently, it makes more sense to use R&D spending as a substitute for internal innovation initiatives (Paula & Silva, 2021).

2.2.2 Economic Growth of the Country

The gradual increase in a nation's wealth over time is known as economic growth. While the phrase is occasionally used to discuss short-term in nature economic success, in the context of economic theory, it usually refers to a long-term increase in wealth. (Cornwall, 2023). In fact, according to Schumpeter (2003), innovation-related activities undertake directly impact economic growth in a capitalist economy. Romer (1990) similarly characterizes technological change as the main driver of economic growth and lays the foundation for his endogenous growth theory mainly on capital expenditures for research and development. Romer believes that research and development (R&D) produces knowledge that keeps capital from experiencing declining returns to scale as a factor of production. Grossman and Helpman (1990) also believe that R&D investments are essential for economic expansion. By figuring out the actual growth rate of the gross domestic product, one may monitor the dynamics of the level of economic activity over time and across different economies. Moreover, the impact of inflation on the trends of the extent of economic activity at the national level is not taken into consideration by the real economic growth rate (Sokolov-Mladenović, Cvetanović, & Mladenović, 2016).

2.2.3 Government Policies

Government, known as the assembly of public-sector actors, continues to play a significant role in fostering and maintaining innovation. Innovation is still a key factor determining the strength of national economies, especially when it receives active and effective support from governmental entities (Link & Scott, 2010). Government may support sustainable development and technological transformation by establishing clear legislative objectives and rules, but at the same time allowing businesses to employ a range of strategies to meet those goals (Bossink, 2002). There are notable variations in the sources of new technology across industrial sectors, including the costs of innovation, the relative significance of outside suppliers of equipment and materials, the sizes of large and small businesses, and the ratio of full-time research and development teams to temporary innovative activities (Pavitt & Walker, 1976). Hence, different sectors have different requirements for successful innovation. Government initiatives aimed at promoting innovation will therefore probably have varying effects on various industries. For instance, to guarantee the efficacy of technological innovation, Malaysian policymakers have developed and implemented several strategies and policies related to technological innovation. The government began working to advance the nation's science and technology in the middle of the 1980s. National Science, Technology, and Innovation Policy 1 (NSTIP1) and National Science, Technology, and Innovation Policy 2 (NSTIP2) are the two main policies that comprise technological innovation policies in general in order to ensure the ongoing advancement innovation of science and technology (Bekhet & Latif, 2017).

2.2.4 Industry Structure

According to Atikian (2013), industry structure can be explained by the production of human material provisions and the composition of a nation's economic activity. In general terms, industries may be categorized into three main groups according to the stage of production they are in or the type of value that they are adding to natural resources. Based on the explanation of Jain (2023), there are three types of industries. Firstly, the primary industries are those that deal with the reproduction of living things and the exploitation of natural resources or raw materials from the nature. They manufacture goods that are offered for sale to the public. For instance, agriculture, forestry, mining, fishing, farming, and crop production.

Secondly, secondary industries utilize raw materials mined in the primary sector and transform them into the final product, which is produced by the manufacturing and construction sectors. Either the final consumer consumes the manufactured goods, or other businesses use them as raw materials for processing or production. Thirdly, in order to support the operations of various primary and secondary industries, the tertiary sector offers services and facilitates the free movement of commodities and services in the market.

2.2.5 Tertiary Education Level

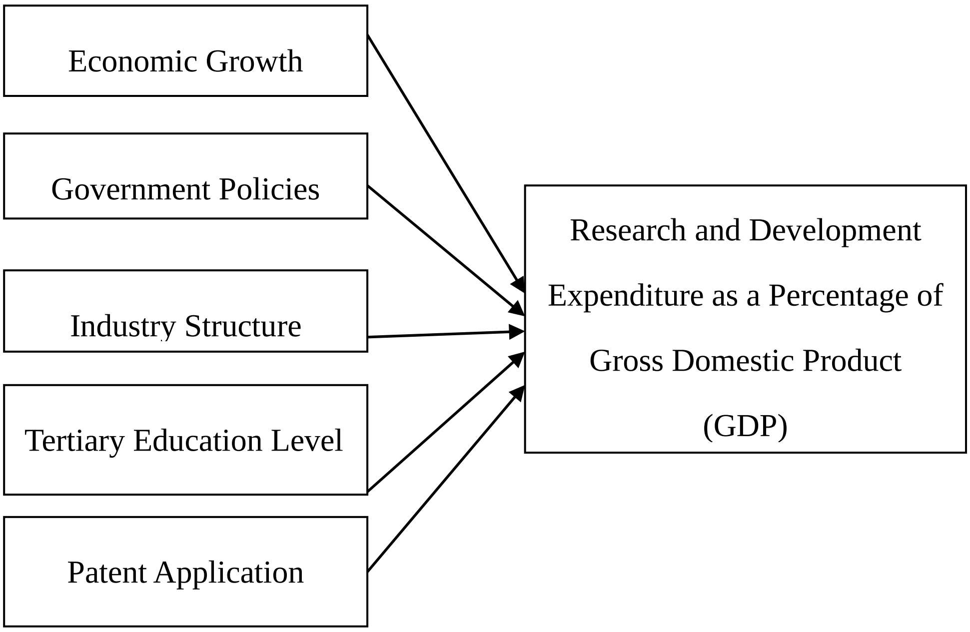
According to World Bank Group (2018), tertiary education can be defined as the post-secondary private or public institutions such as universities, colleges, and vocational schools that offer advances academic or professional courses. Completion can happen after completing the necessary amount of cumulative course hours, after passing the required exam or exams, or after both (Delaney & Yu, 2012). Many nations have seen major changes and adjustments to their higher education systems in recent years. These changes have included the introduction of new institutional models, adjustments to funding and governance structures, the creation of mechanisms for assessment and accreditation, modifications to curricula, and advancements in technology (Salmi, 2001). According to several research, acquiring the necessary human capital for economic development was largely facilitated by education and training in many countries (Kim, 2010; Mallick, Das, & Pradhan, 2016; Marquez-Ramos & Mourelle, 2019; Chakraborty & Maity, 2020). Improving social welfare and economic efficiency also requires education. Through increasing the value and productivity of their labour, education helps the impoverished escape poverty and hunger. Even though there is a greater pool of graduates from higher education, not all of them have the regionally relevant skills necessary for effective entry into the labour market as not all tertiary education environments are changing at the same rate. Publicly funded institutions are likewise more burdened by greater student populations, and many low-resource countries struggle to keep up with the growing expenses of higher education without compromising the quality of their curricula (World Bank Group, 2018).

2.2.6 Patent Application

If a company's capacity for innovation is critical to the advancement of its region and country, then learning how to enhance that capacity is imperative. Scholars and practitioners recognize the fundamental connection between innovation and patents and R&D (Paula & Silva, 2021). One of the dimensions of innovation outputs that takes into account patents and other intellectual property rights (IPRs) is knowledge and technology outputs. R&D expenditure is taken into account in the human and capital research dimension of innovation inputs (Dutta, Lanvin, & Wunsch-Vincent, 2019). Several national indicators of innovation inputs and outputs are used to calculate the Global Innovation Index (GII), one of the most widely used measures of a country's innovativeness. According to an investigation carried out by Nguyen and Doytch (2022), they asserted that they look at how innovations and economic growth are related, as evidenced by the quantity of new patents. They focus on patents in the ICT industry for a global sample of 43 economies between 1998 and 2016. Three conclusions may be drawn from the results. Firstly, there is no evidence that the total number of patents affects the expansion of the manufacturing sector; on the other hand, there is a positive correlation between the total number of patents and economic growth. Second, more developed nations have a larger correlation between total patents and economic growth. ICT patents have a significant positive impact on the development of industrialized nations while also having a negative impact on the expansion of emerging economies. Third, compared to all patents, ICT patents have a noteworthy and beneficial long-term effect on economic growth.

2.3 Conceptual Framework

Figure 2.3: Proposed Conceptual Framework



Source: Developed for the research

2.4 Hypotheses Development

H1: Economic growth of the country has a positive significant impact on R&D expenditure as a percentage of GDP.

It is posited that nations experiencing robust economic growth are more likely to allocate a greater proportion of their GDP to R&D activities. A thriving economy provides the necessary financial resources and conducive conditions for increased investment in innovation.

H2: Government policies has a positive significant impact on R&D expenditure as a percentage of GDP.

Government policies wield substantial influence over a country's innovation landscape. Policies such as research incentives, grants, and favourable regulatory environments can act as catalysts for increased R&D investments, contributing to a higher percentage of GDP allocated to these activities.

H3: Industry structure has a positive significant impact on R&D expenditure as a percentage of GDP.

Different industries exhibit varied propensities for R&D spending. The composition of a country's industrial sectors can thus impact the overall allocation of resources to R&D, influencing the percentage of GDP devoted to these activities.

H5: Tertiary education level of the country has a positive significant impact on R&D expenditure as a percentage of GDP.

Tertiary education institutions are crucial hubs for knowledge creation. Countries with higher tertiary education levels are likely to have a more skilled workforce, fostering innovation and, consequently, leading to a higher percentage of GDP allocated to R&D.

H6: Patent application has a positive significant impact on R&D expenditure as a percentage of GDP.

Patent applications are tangible indicators of a country's innovation output. A positive correlation suggests that higher R&D investments are associated with increased patent applications, reflecting a thriving innovation ecosystem.

CHAPTER 3: METHODOLOGY

3.0 Introduction

This chapter outlines the methodology employed to investigate the determinants of innovation activities, particularly focusing on research and development (R&D) expenditure, in Malaysia and selected countries. To provide insights into the approach taken to address the research objectives and hypothesis, this chapter will outline the research design, data collection method, proposed analysis tool, and scale measurement of the study.

3.1 Research Design

3.1.1 Descriptive Research

Descriptive research will be utilized to provide a comprehensive overview of the variables relevant to the study. Key variables include R&D expenditure as a percentage of GDP, economic growth indicators, government policies, industry structure, population demographics, tertiary education levels, and patent applications. Descriptive research methods will involve summarizing and presenting thee variables, capturing their current state and trends within the selected countries. This will enable the researcher to gain insights into the existing landscape of innovation activities and identify any patterns or disparities across different regions.

3.1.2 Causal Research

Causal research aims to determine the causal relationships between variables, particularly focusing on the impact of various factors on R&D expenditure. This involves exploring whether changes in independent variables, such as economic growth, government policies, industry structure, population demographics, tertiary education levels, and patent applications, lead to changes in the dependent variable, R&D expenditure as a percentage of GDP. By establishing causality, the research seeks to identify the drivers that influence investment in research and development activities. Causal research methods in this study include regression analysis to assess the strength and direction of these relationships.

3.1.3 Quantitative Research

Quantitative research methods will be employed to collect and analyse numerical data related to the variables under this study. This involves the systematic collection of quantitative data, such as R&D expenditure figure, GDP growth rates, government policy indicators, industry data, demographic statistics, educational attainment levels, and patent application numbers. Statistical techniques will then be applied to analyse the data, quantify relationships between variables, and draw empirical conclusions. Quantitative research able to test hypotheses, make predictions, and derive generalizable insights about the determinants of innovation activities in Malaysia and selected countries.

3.2 Data Collection Methods

3.2.1 Secondary Data

Since the research subject and hypotheses focus on the variables influencing R&D expenditure as a percentage of GDP in Malaysia and selected countries, which involve data analysis, the primary data collection technique is not applicable in this study. We gathered the data for this analysis from World Bank indicators, Bureau of Labor Statistics of the U. S. Department of Labor and Singapore Department of Statistics. The indicator is the source of the dependent variable, which is the R&D expenditure as a percentage of GDP (research and development expenditure, % of GDP), and the independent variables, which are economic growth (GDP growth, annual %), government policies (general government final consumption expenditure, % of GDP), industry structure (Industry including construction, value added, % of GDP), population (population, total), tertiary education level (school enrolment, tertiary, % gross), and patent application (patent applications, residents). This study uses an annual time series spanning 25 years, from 1995 to 2020. However, the data of R&D expenditure as a percentage of GDP in Malaysia are not stated by government for year 1997, 1999, 2001, 2003, 2005, 2007, 2013, 2017 and 2019. Hence, the mentioned years of data are representing the average amount between the year preceding and the year following the mentioned years.

Table 3.2.1: Data Sources

Variables	Description	Sources
R&D expenditure as a percentage of GDP	Research and Development Expenditure (% of GDP)	World Bank
Economic Growth	GDP growth (annual %)	World Bank
Government Policies	General Government Final Consumption Expenditure (% of GDP)	World Bank
Industry Structure	Industry (including construction), value added (% of GDP)	World Bank
Tertiary Education Level	school enrolment, tertiary (% gross)	World Bank, Bureau of Labor Statistics of the U. S. Department of Labor, Singapore Department of Statistics
Patent Application	patent applications, residents	World Bank

Source: Developed for the research

3.3 Proposed Data Analysis Tool

3.3.1 Statistical Packages for Social Sciences (SPSS)

Statistical Package for the Social Sciences is a software package used for statistical analysis. It provides tools for data management, data cleaning, and statistical analysis, which is widely used by researchers, analysts, and statisticians across various country. In this study, SPSS is used to run tests such as descriptive analysis, correlation analysis, Ordinary Least Square Regression, and residual diagnosis, for the variables' data sets of Malaysia, China, Korea, Singapore, and United States.

3.3.2 Descriptive Analysis

Descriptive analysis involves summarizing and organizing data to provide insights into its characteristics without making inferences about the whole population. This study analyses indicators such as mean, standard deviation, maximum, minimum, skewness and kurtosis statistics.

3.3.3 Correlation Analysis

A statistical method employed in the study to assess the relationship between two variables and measure the strength of linear correlation.

Table 3.3.3: Correlation Coefficient Values

Range of correlation coefficient value	Level of correlation
0.00-0.19	Very weak
0.20-0.39	Weak
0.40-0.59	Moderate
0.60-0.79	Strong
0.80-1.00	Very strong

Source: (De Vaus, 2002)

3.3.4 Ordinary Least Squares (OLS) Regression

The statistical technique known as ordinary least squares (OLS) regression is used to determine a linear regression model's parameter. To minimize the sum of squared differences between observed and anticipated values, the coefficients must be found (Verma, 2023). The model can be represented as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \varepsilon_1$$

From this model, Y is the dependent variable. $X_1, X_2, \ldots, X_n$ are the independent variables while $\beta_0, \beta_1, \ldots, \beta_n$ are the coefficients that need to be estimated. ε_1 represents the error term, which accounts for the variability in Y that cannot be explained by the independent variables.

3.3.5 Residual Diagnosis

3.3.5.1 Normality Test (Jarque-Bera)

The Jarque-Bera test is a statistical test used to assess the normality of data by examining the skewness and kurtosis of a dataset. The formula of Jarque-Bera test is as below:

$$n\left[\frac{s^2}{6} + \frac{(k-3)^2}{24}\right]$$

where n is the sample size, s is the skewness coefficient and k is the kurtosis coefficient. The decision rule for the Jarque Bera test involves comparing the test statistic to a critical value, which is 5.991 at a significance level of 0.05. At the 5% significance level, the null hypothesis that the data is normally distributed is rejected if the Jarque-Bera test statistic is higher than the critical value (Studenmund, 2014).

H_0 (null hypothesis): The residuals are normally distributed.
H_A (alternative hypothesis): The residuals are not normally distributed.

3.3.5.2 Breusch-Godfrey Serial Correlation Lagrange Multiplier (LM) Test

The Breusch-Godfrey Serial Correlation Lagrange Multiplier (LM) Test is a diagnostic test used to detect serial correlation in time series data. It is a combined test for random individual effects and serial correlation. The test statistic is calculated by regressing the residuals on a constant, the independent variable and lagged residuals up to a certain order. The null hypothesis of the test is that there is no serial correlation in the data. If the p-value of Lag statistic is not more than 0.05, the null hypothesis is rejected.

H_0 (null hypothesis): The residuals have no serial correlation.
H_A (alternative hypothesis): The residuals have serial correlation.

3.3.5.3 Heteroscedasticity White Test

A statistical test for identifying heteroscedasticity, a regression model's assumption of constant variance breached. Regressing the squared residuals on the independent variables, their squares, and their cross-products is the method used in this chi-square distribution test. The decision rule of this test is to reject null hypothesis when the probability value of F-statistic value is not more than the p-value of 0.05.

H_0 (null hypothesis): The residuals have no heteroscedasticity.
H_A (alternative hypothesis): The residuals have heteroscedasticity.

3.3.5.4 Multicollinearity Test

According to (Studenmund, 2014), multicollinearity occurs when one independent variable is a precise linear combination of other independent variables, thus violating Classical Assumption VI. To identify multicollinearity, Variance Inflation Factors (VIF) will be employed. The null hypothesis where the residuals have no multicollinearity will be rejected if the VIF value exceeds 5 (Shrestha, 2020).

H_0 (null hypothesis): The residuals do not have multicollinearity.
H_A (alternative hypothesis): The residuals have multicollinearity.

3.4 Scale Measurement

There are a total of six variables, which includes research and development expenditure as a percentage of GDP (RDE), economic growth (EG), government policies (GP), industry structure (IS), tertiary education level (TEL), and patent application (PA).

Each variable's scale measurement is shown as below:

Table 3.4: Scale Measurement of Variable

Variables	Measurement
R&D expenditure as a percentage of GDP	Percentage of GDP (%)
Economic Growth	Annual Percentage (%)
Government Policies	Percentage of GDP (%)
Industry Structure	Percentage of GDP (%)
Tertiary Education Level	Percentage, gross (%)
Patent Application	Number, by residents

Source: Developed for the research

CHAPTER 4: DATA ANALYSIS

4.0 Introduction

This chapter consists of a total of seven analysis, which include descriptive analysis, correlation, Ordinary Least Square Regression, normality test (Jarque-Bera), Breusch-Godfrey Serial Correlation Lagrange Multiplier (LM) Test, Heteroscedasticity White Test, and Multicollinearity Test for the country Malaysia, China, Korea, Singapore and United States accordingly.

4.1 Descriptive Analysis

4.1.1 Malaysia

Table 4.1.1: Descriptive Analysis SPSS Result (Malaysia)

Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
RDE	0.22	1.42	0.8322	0.32202	0.035	0.464	-1.027	0.902
EG	-7.4	10.0	4.472	3.9847	-1.862	0.464	3.547	0.902
GP	9.8	13.8	12.144	1.0809	-0.425	0.464	-0.593	0.902
IS	35.9	48.5	42.516	3.8236	-0.059	0.464	-1.411	0.902
TEL	10.1	46.4	32.921	9.2463	-0.556	0.464	0.169	0.902
PA	179	1353	759.16	425.568	-0.141	0.464	-1.732	0.902

Source: SPSS

Based on the result of Malaysia above, the mean for the dependent variable, which is research and development expenditure as a percentage of GDP (RDE) is 0.8322, and standard deviation of 0.32202. For the independent variables, economic growth (EG) has a mean of 4.472 and standard deviation of 3.9847, while government policy (GP) has a mean of 12.144 and standard deviation of 1.0809. The mean and standard deviation value for industry structure (IS) is 42.516 and 3.8236 respectively. For the variable tertiary education level (TEL), the mean value is 32.921 and standard deviation is 9.2463; meanwhile, the mean value for patent applications (PA) is 759.16 and standard deviation is 425.568.

4.1.2 China

Table 4.1.2: Descriptive Analysis SPSS Result (China)

Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
RDE	0.6	2.4	1.492	0.5715	-0.198	0.464	-1.285	0.902
EG	2.2	14.2	8.676	2.3573	-0.172	0.464	2.018	0.902
GP	13.2	17.1	15.504	1.0159	-0.388	0.464	-0.583	0.902
IS	37.8	47.6	44.332	3.0424	-1.021	0.464	-0.384	0.902
TEL	5.3	62.2	26.788	18.1292	0.595	0.464	-0.946	0.902
PA	11628	1393815	448615.24	501688.913	0.864	0.464	-0.891	0.902

Source: SPSS

Based on the result of China above, the mean for the dependent variable, which is research and development expenditure as a percentage of GDP

(RDE) is 1.492, and standard deviation of 0.5715. For the independent variables, economic growth (EG) has a mean of 8.676 and standard deviation of 2.3573, while government policy (GP) has a mean of 15.504 and standard deviation of 1.0159. The mean and standard deviation value for industry structure (IS) is 44.332 and 3.0424 respectively. For the variable tertiary education level (TEL), the mean value is 26.788 and standard deviation is 18.1292; meanwhile, the mean value for patent applications (PA) is 448615.24 and standard deviation is 501688.913.

4.1.3 Korea

Table 4.1.3: Descriptive Analysis SPSS Result (Korea)

Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
RDE	2.0	4.8	3.164	0.9304	0.305	0.464	-1.450	0.902
EG	-5.1	11.5	4.092	3.2884	-0.346	0.464	2.043	0.902
GP	10.2	18.0	13.636	2.0914	0.101	0.464	-0.673	0.902
IS	32.5	35.4	33.984	0.8952	-0.186	0.464	-0.962	0.902
TEL	53.7	103.1	89.212	13.2433	-1.149	0.464	0.607	0.902
PA	50596	180477	121530.12	41046.266	-0.339	0.464	-1.284	0.902

Source: SPSS

Based on the result of Korea above, the mean for the dependent variable, which is research and development expenditure as a percentage of GDP (RDE) is 3.164, and standard deviation of 0.9304. For the independent variables, economic growth (EG) has a mean of 4.092 and standard deviation of 3.2884, while government policy (GP) has a mean of 13.636 and standard deviation of 2.0914. The mean and standard deviation value for industry structure (IS) is 33.984 and 0.8952 respectively. For the variable tertiary education level (TEL), the mean value is 89.212 and standard deviation is 13.2433; meanwhile, the mean value for patent applications (PA) is 121530.12 and standard deviation is 41046.266.

4.1.4 Singapore

Table 4.1.4: Descriptive Analysis SPSS Result (Singapore)

Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
RDE	1.3	2.6	1.972	0.2654	-0.500	0.464	1.911	0.902
EG	-3.9	14.5	4.752	4.1451	0.014	0.464	0.353	0.902
GP	8.8	12.2	10.056	0.8935	0.923	0.464	0.500	0.902
IS	23.2	32.5	27.736	3.4039	0.002	0.464	-1.754	0.902
TEL	41.4	93.1	64.756	18.8300	0.212	0.464	-1.689	0.902
PA	224	1778	911.96	488.440	0.463	0.464	-1.100	0.902

Source: SPSS

Based on the result of Singapore above, the mean for the dependent variable, which is research and development expenditure as a percentage of GDP (RDE) is 1.972, and standard deviation of 0.2654. For the independent variables, economic growth (EG) has a mean of 4.752 and standard deviation of 4.1451, while government policy (GP) has a mean of 10.056 and standard deviation of 0.8935. The mean and standard deviation value for industry structure (IS) is 27.736 and 3.4039 respectively. For the variable tertiary education level (TEL), the mean value is 64.756 and standard deviation is 18.83; meanwhile, the mean value for patent applications (PA) is 911.96 and standard deviation is 488.44.

4.1.5 United States

Table 4.1.5: Descriptive Analysis SPSS Result (United States)

Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
RDE	2.5	3.5	2.708	0.2448	1.789	0.464	3.703	0.902
EG	-2.8	4.8	2.256	1.8751	-1.387	0.464	2.430	0.902
GP	13.9	16.8	14.880	0.8377	0.847	0.464	0.134	0.902
IS	17.5	24.4	20.372	1.8185	0.390	0.464	-0.672	0.902
TEL	67.0	93.9	82.774	8.2614	-0.726	0.464	-0.595	0.902
PA	106892	295327	223656.56	58770.018	-0.476	0.464	-0.916	0.902

Source: SPSS

Based on the result of United States above, the mean for the dependent variable, which is research and development expenditure as a percentage of GDP (RDE) is 2.708, and standard deviation of 0.2448. For the independent variables, economic growth (EG) has a mean of 2.256 and standard deviation of 1.8751, while government policy (GP) has a mean of 14.88 and standard deviation of 0.8377. The mean and standard deviation value for industry structure (IS) is 20.372 and 1.8185 respectively. For the variable tertiary education level (TEL), the mean value is 82.774 and standard deviation is 8.2614; meanwhile, the mean value for patent applications (PA) is 223656.56 and standard deviation is 58770.018.

4.2 Correlation

4.2.1 Malaysia

Table 4.2.1: Correlation Analysis SPSS Result (Malaysia)

Correlations

	RDE	EG	GP	IS	TEL	PA
RDE	1					
EG	-0.044	1				
GP	.694**	0.016	1			
IS	-.810**	0.266	-.501*	1		
TEL	.891**	-0.174	.603**	-.741**	1	
PA	.932**	-0.062	.691**	-.818**	.855**	1

Source: SPSS

Based on the table above, it shows that Malaysia has a negatively very weak correlation between research and development expenditure as a percentage of GDP (RDE) and economic growth (EG). There is also a positively strong correlation between research and development expenditure as a percentage of GDP (RDE) with government policy (GP), and very negatively strong correlation with industry structure (IS). Meanwhile, there are positively very strong correlations between research and development expenditure as a percentage of GDP (RDE) with tertiary education level (TEL) and patent applications (PA).

4.2.2 China

Table 4.2.2: Correlation Analysis SPSS Result (China)

Correlations

	RDE	EG	GP	IS	TEL	PA
RDE	1					
EG	-.466*	1				
GP	.507**	-.700**	1			
IS	-.712**	.820**	-.761**	1		
TEL	.942**	-.614**	.568**	-.872**	1	
PA	.879**	-.700**	.613**	-.920**	.974**	1

Source: SPSS

Based on the table above, it shows that China has negatively and positively moderate correlations between research and development expenditure as a percentage of GDP (RDE) with economic growth (EG) and government policy (GP) respectively. Also, research and development expenditure as a percentage of GDP (RDE) has a negatively strong correlation with industry structure (IS) and positively very strong correlation with tertiary education level (TEL) and patent applications (PA).

4.2.3 Korea

Table 4.2.3: Correlation Analysis SPSS Result (Korea)

Correlations

	RDE	EG	GP	IS	TEL	PA
RDE	1					
EG	-.445*	1				
GP	.955**	-.506**	1			

IS	-0.273	0.198	-.476*	1		
TEL	.611**	-0.287	.743**	-.536**	1	
PA	.944**	-0.387	.950**	-0.355	.786**	1

Source: SPSS

Based on the table above, it shows that Korea has a negatively moderate correlation between research and development expenditure as a percentage of GDP (RDE) and economic growth (EG). Besides that, research and development expenditure as a percentage of GDP (RDE) has positively very strong correlations with government policies (GP) and patent applications (PA). While the relationship between research and development expenditure as a percentage of GDP (RDE) and industry structure (IS) is negatively weak correlation, and tertiary education level (TEL) is positively strong correlation.

4.2.4 Singapore

Table 4.2.4: Correlation Analysis SPSS Result (Singapore)

Correlations

	RDE	EG	GP	IS	TEL	PA
RDE	1					
EG	-0.196	1				
GP	0.341	-.448*	1			
IS	-0.359	0.313	-0.025	1		
TEL	0.305	-0.273	0.040	-.952**	1	
PA	0.343	-0.334	0.239	-.908**	.959**	1

Source: SPSS

The table above shows that Singapore has negatively very weak correlation between research and development expenditure as a percentage of GDP (RDE) with economic growth (EG) and has positively weak correlation with tertiary education level (TEL) respectively. There are also positively weak correlations between research and development expenditure as a percentage of GDP (RDE) with government policies (GP) and patent application (PA); while a negatively weak correlation with industry structure (IS).

4.2.5 United States

Table 4.2.5: Correlation Analysis SPSS Result (United States)

Correlations

	RDE	EG	GP	IS	TEL	PA
RDE	1					
EG	-.613**	1				
GP	-0.048	-.530**	1			
IS	-.781**	.572**	-0.185	1		
TEL	.515**	-.447*	.463*	-.796**	1	
PA	.661**	-.448*	0.118	-.926**	.839**	1

Source: SPSS

The table above shows that United States has a negatively strong correlation between research and development expenditure as a percentage of GDP (RDE) and economic growth (EG). Meanwhile, the relationship between research and development expenditure as a percentage of GDP (RDE) and government policies (GP) is negatively very weak correlation; in contrast, it has negatively strong correlation with industry structure (IS). Plus, research and development expenditure as a percentage of GDP (RDE) has positively moderate and positively strong correlations with tertiary education level (TEL) and patent applications (PA) respectively.

4.3 Ordinary Least Squares Regression (OLS)

4.3.1 Malaysia

Table 4.3.1: OLS Regression Statistic SPSS Result (Malaysia)

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.958[a]	0.917	0.895	0.10419	1.480

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	C	0.433	0.554		0.782	0.444		
	EG	0.007	0.006	0.091	1.250	0.226	0.822	1.216
	GP	0.030	0.028	0.100	1.082	0.293	0.508	1.968
	IS	-0.015	0.011	-0.181	-1.445	0.165	0.279	3.584
	TEL	0.013	0.005	0.361	2.742	0.013	0.252	3.971
	PA	0.000	0.000	0.412	2.355	0.029	0.143	7.003

Source: SPSS

$$\mathrm{RDE} = 0.433 + 0.007\mathrm{EG} + 0.03\mathrm{GP} - 0.015\mathrm{IS} + 0.013\mathrm{TEL} + 0.000\mathrm{PA}$$

[0.782] [1.250] [1.082] [-1.445] [2.742] [2.355]

$R^2 = 0.917$ $Adjusted\ R^2 = 0.895$ Durbin-Watson=1.480

In this OLS model of Malaysia, it indicates that approximately 91.7% of the variance in the dependent variable (RDE) is explained by the independent variables included in the model.

A one-percent increase in the EG on average has positive relationship effect increasing the RDE by 0.007% statistically significance at α 0.05 level. A one-percent increase in the GP on average has positive relationship effect on increasing the RDE by 0.03% statistically significant at α 0.05 level. A one-percent increase in IS on average has negative relationship on decreasing RDE by 0.015% statistically significant at α 0.05 level. A one-percent increase in TEL on average has positive relationship on increasing RDE by 0.013% statistically significant at α 0.05 level. The coefficient for PA is 0.000, indicating that it does not significantly contribute to explaining the variation in RDE.

4.3.2 China

Table 4.3.2: OLS Regression Statistic SPSS Result (China)

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.981[a]	0.962	0.952	0.1252	1.584

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF

1	C	-7.955	1.814		-4.384	0.000		
	EG	-0.010	0.021	-0.040	-0.467	0.646	0.268	3.732
	GP	0.133	0.042	0.236	3.185	0.005	0.364	2.750
	IS	0.141	0.032	0.749	4.438	0.000	0.070	14.236
	TEL	0.048	0.007	1.510	6.909	0.000	0.042	23.880
	PA	-8.59E-08	0.000	-0.075	-0.282	0.781	0.028	35.729

Source: SPSS

$$\text{RDE} = -7.955 - 0.01\text{EG} + 0.133\text{GP} + 0.141\text{IS} + 0.048\text{TEL} - 8.59 \times 10^{-8}\text{PA}$$

[-4.384] [-0.467] [3.185] [4.438] [6.909] [-0.282]

$R^2 = 0.962$ $Adjusted\ R^2 = 0.952$ Durbin-Watson=1.584

In this OLS model of China, it indicates that approximately 96.2% of the variance in the dependent variable (RDE) is explained by the independent variables included in the model.

A one-percent increase in the EG on average has negative relationship effect decreasing the RDE by 0.01% statistically significance at α 0.05 level. A one-percent increase in the GP on average has positive relationship effect on increasing the RDE by 0.133% statistically significant at α 0.05 level. A one-percent increase in IS on average has positive relationship on increasing RDE by 0.141% statistically significant at α 0.05 level. A one-percent increase in TEL on average has positive relationship on increasing RDE by 0.048% statistically significant at α 0.05 level. A one-number increase in PA on average has negative relationship on decreasing RDE by 8.59×10^{-8} % statistically significant at α 0.05 level.

4.3.3 Korea

Table 4.3.3: OLS Regression Statistic SPSS Result (Korea)

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.988[a]	0.976	0.969	0.1637	1.276

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	C	-5.819	2.441		-2.383	0.028		
	EG	0.010	0.013	0.036	0.783	0.443	0.620	1.613
	GP	0.363	0.071	0.816	5.132	0.000	0.051	19.619
	IS	0.129	0.054	0.125	2.385	0.028	0.473	2.116
	TEL	-0.018	0.005	-0.251	-3.697	0.002	0.279	3.588
	PA	9.611E-06	0.000	0.424	2.659	0.016	0.051	19.733

Source: SPSS

$$\text{RDE} = -5.819 + 0.01\text{EG} + 0.363\text{GP} + 0.129\text{IS} - 0.018\text{TEL} + 9.611 \times 10^{-6}\text{PA}$$

[-2.383] [0.783] [5.132] [2.385] [-3.697] [2.659]

$R^2 = 0.976$ $Adjusted\ R^2 = 0.969$ Durbin-Watson=1.276

In this OLS model of Korea, it indicates that approximately 97.6% of the variance in the dependent variable (RDE) is explained by the independent variables included in the model.

A one-percent increase in the EG on average has positive relationship effect increasing the RDE by 0.01% statistically significance at α 0.05 level. A one-percent increase in the GP on average has positive relationship effect on increasing the RDE by 0.363% statistically significant at α 0.05 level. A one-percent increase in IS on average has positive relationship on increasing RDE by 0.129% statistically significant at α 0.05 level. A one-percent increase in TEL on average has negative relationship on decreasing RDE by 0.018% statistically significant at α 0.05 level. A one-number increase in PA on average has positive relationship on increasing RDE by 9.611×10^{-6}% statistically significant at α 0.05 level.

4.3.4 Singapore

Table 4.3.4: OLS Regression Statistic SPSS Result (Singapore)

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.522[a]	0.272	0.081	0.2544	0.687

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	C	2.632	2.281		1.154	0.263		
	EG	0.008	0.015	0.118	0.501	0.622	0.692	1.445
	GP	0.140	0.091	0.473	1.549	0.138	0.411	2.431
	IS	-0.066	0.051	-0.841	-1.276	0.217	0.088	11.348
	TEL	-0.001	0.016	-0.099	-0.085	0.933	0.028	35.525
	PA	0.000	0.001	-0.400	-0.402	0.692	0.039	25.793

Source: SPSS

$$\text{RDE} = 2.632 + 0.008\text{EG} + 0.140\text{GP} - 0.066\text{IS} - 0.001\text{TEL} + 0.000\text{PA}$$

[1.154] [0.501] [1.549] [-1.276] [-0.085] [-0.402]

$R^2 = 0.272$ $Adjusted\ R^2 = 0.081$ Durbin-Watson=0.687

In this OLS model of Singapore, it indicates that approximately 27.2% of the variance in the dependent variable (RDE) is explained by the independent variables included in the model.

A one-percent increase in the EG on average has positive relationship effect increasing the RDE by 0.008% statistically significance at α 0.05 level. A one-percent increase in the GP on average has positive relationship effect on increasing the RDE by 0.14% statistically significant at α 0.05 level. A one-percent increase in IS on average has negative relationship on decreasing RDE by 0.066% statistically significant at α 0.05 level. A one-percent increase in TEL on average has negative relationship on decreasing RDE by 0.001% statistically significant at α 0.05 level. The coefficient for PA is 0.000, indicating that it does not significantly contribute to explaining the variation in RDE.

4.3.5 United States

Table 4.3.5: OLS Regression Statistic SPSS Result (United States)

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.906[a]	0.820	0.773	0.1166	1.231

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	C	7.420	1.120		6.624	0.000		
	EG	-0.075	0.020	-0.573	-3.743	0.001	0.404	2.477
	GP	-0.186	0.049	-0.638	-3.827	0.001	0.340	2.942
	IS	-0.111	0.039	-0.828	-2.827	0.011	0.110	9.073
	TEL	0.014	0.008	0.460	1.774	0.092	0.141	7.099
	PA	-2.799E-06	0.000	-0.672	-2.021	0.058	0.085	11.698

Source: SPSS

$$\text{RDE} = 9.775 - 0.075\text{EG} - 0.186\text{GP} - 0.111\text{IS} + 0.014\text{TEL} - 2.799 \times 10^{-6}\text{PA}$$

[6.624] [-3.743] [-3.827] [-2.827] [1.774] [-2.021]

$R^2 = 0.820$ $Adjusted\ R^2 = 0.773$ Durbin-Watson=1.231

In this OLS model of United States, it indicates that approximately 82% of the variance in the dependent variable (RDE) is explained by the independent variables included in the model.

A one-percent increase in the EG on average has negative relationship effect decreasing the RDE by 0.075% statistically significance at α 0.05 level. A one-percent increase in the GP on average has negative relationship effect on decreasing the RDE by 0.186% statistically significant at α 0.05 level. A one-percent increase in IS on average has negative relationship on decreasing RDE by 0.111% statistically significant at α 0.05 level. A one-percent increase in TEL on average has positive relationship on increasing RDE by 0.014% statistically significant at α 0.05 level. A one-number increase in PA on average has negative relationship on decreasing RDE by 2.799×10^{-6}% statistically significant at α 0.05 level.

4.4 Residual Diagnosis

4.4.1 Normality Test (Jarque-Bera)

4.4.1.1 Malaysia

Table 4.4.1.1: Standardized Residual Statistic SPSS Result (Malaysia)

Descriptive Statistics

	N	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
Standardized Residual	25	0.874	0.464	1.576	0.902
Valid N (listwise)	25				

Source: SPSS

Jarque-Bera Statistic=5.2951

H_0 (null hypothesis): The residuals are normally distributed.

H_A (alternative hypothesis): The residuals are not normally distributed.

Since the Jarque-Bera test statistic is lesser than the critical value, which is 5.991 at a significance level of 0.05, thus H_0 is accepted, H_A is rejected. The residuals are normally distributed.

4.4.1.2 China

Table 4.4.1.2: Standardized Residual Statistic SPSS Result (China)

Descriptive Statistics

	N	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
Standardized Residual	25	0.473	0.464	-0.698	0.902
Valid N (listwise)	25				

Source: SPSS

Jarque-Bera Statistic =15.1772

H_0 (null hypothesis): The residuals are normally distributed.

H_A (alternative hypothesis): The residuals are not normally distributed.

Since the Jarque-Bera test statistic is greater than the critical value, which is 5.991 at a significance level of 0.05, thus H_0 is rejected, H_A is accepted. The residuals are not normally distributed.

4.4.1.3 Korea

Table 4.4.1.3: Standardized Residual Statistic SPSS Result (Korea)

Descriptive Statistics

	N	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
Standardized Residual	25	-0.209	0.464	-0.098	0.902
Valid N (listwise)	25				

Source: SPSS

Jarque-Bera Statistic =10.1795

H_0 (null hypothesis): The residuals are normally distributed.

H_A (alternative hypothesis): The residuals are not normally distributed.

Since the Jarque-Bera test statistic is greater than the critical value, which is 5.991 at a significance level of 0.05, thus H_0 is rejected, H_A is accepted. The residuals are not normally distributed.

4.4.1.4 Singapore

Table 4.4.1.4: Standardized Residual Statistic SPSS Result (Singapore)

Descriptive Statistics

	N	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
Standardized Residual	25	0.323	0.464	0.458	0.902
Valid N (listwise)	25				

Source: SPSS

Jarque-Bera Statistic =7.1657

H_0 (null hypothesis): The residuals are normally distributed.

H_A (alternative hypothesis): The residuals are not normally distributed.

Since the Jarque-Bera test statistic is greater than the critical value, which is 5.991 at a significance level of 0.05, thus H_0 is rejected, H_A is accepted. The residuals are not normally distributed.

4.4.1.5 United States

Table 4.4.1.5: Standardized Residual Statistic SPSS Result (United States)

Descriptive Statistics

	N	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
Standardized Residual	25	0.463	0.464	0.192	0.902
Valid N (listwise)	25				

Source: SPSS

Jarque-Bera Statistic =9.1066

H_0 (null hypothesis): The residuals are normally distributed.

H_A (alternative hypothesis): The residuals are not normally distributed.

Since the Jarque-Bera test statistic is greater than the critical value, which is 5.991 at a significance level of 0.05, thus H_0 is rejected, H_A is accepted. The residuals are not normally distributed.

4.4.2 Breusch-Godfrey Serial Correlation Lagrange Multiplier (LM) Test

4.4.2.1 Malaysia

Table 4.4.2.1: Serial Correlation LM Test SPSS Result (Malaysia)

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	C	1.061	0.578		1.834	0.084
	EG	0.008	0.006	0.368	1.519	0.147
	GP	0.011	0.023	0.134	0.470	0.644
	IS	-0.020	0.011	-0.870	-1.839	0.083
	TEL	-0.011	0.005	-0.999	-2.143	0.047
	PA	-1.540E-05	0.000	-0.073	-0.140	0.890
	Lag	0.334	0.212	0.341	1.573	0.134

Source: SPSS

H_0 (null hypothesis): The residuals have no serial correlation.

H_A (alternative hypothesis): The residuals have serial correlation.

Since the p-value, which is 0.134, is greater than 0.05, H_0 is accepted and H_A is rejected. The residuals have no serial correlation.

4.4.2.2 China

Table 4.4.2.2: Serial Correlation LM Test SPSS Result (China)

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	C	0.052	2.085		0.025	0.980
	EG	0.003	0.022	0.057	0.124	0.903
	GP	0.013	0.053	0.102	0.238	0.815
	IS	-0.006	0.035	-0.162	-0.174	0.864
	TEL	0.001	0.008	0.151	0.125	0.902
	PA	-7.464E-08	0.000	-0.331	-0.228	0.823
	Lag	0.243	0.256	0.242	0.949	0.356

Source: SPSS

H_0 (null hypothesis): The residuals have no serial correlation.

H_A (alternative hypothesis): The residuals have serial correlation.

Since the p-value, which is 0.356, is greater than 0.05, H_0 is accepted and H_A is rejected. The residuals have no serial correlation.

4.4.2.3 Korea

Table 4.4.2.3: Serial Correlation LM Test SPSS Result (Korea)

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	C	0.430	2.390		0.180	0.859
	EG	0.009	0.013	0.209	0.723	0.480
	GP	-0.040	0.069	-0.558	-0.582	0.568
	IS	-0.002	0.052	-0.012	-0.040	0.968

TEL	-0.001	0.006	-0.091	-0.206	0.840
PA	2.178E-06	0.000	0.601	0.593	0.561
Lag	0.496	0.269	0.495	1.848	0.082

Source: SPSS

H_0 (null hypothesis): The residuals have no serial correlation.

H_A (alternative hypothesis): The residuals have serial correlation.

Since the p-value, which is 0.082, is greater than 0.05, H_0 is accepted and H_A is rejected. The residuals have no serial correlation.

4.4.2.4 Singapore

Table 4.4.2.4: Serial Correlation LM Test SPSS Result (Singapore)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	C	0.007	1.566		0.004	0.997
	EG	-0.009	0.010	-0.189	-0.896	0.383
	GP	-0.085	0.064	-0.363	-1.334	0.200
	IS	0.034	0.036	0.546	0.933	0.364
	TEL	-0.005	0.011	-0.450	-0.450	0.659
	PA	0.000	0.000	0.780	0.905	0.378
	Lag	0.651	0.167	0.722	3.905	0.001

Source: SPSS

H_0 (null hypothesis): The residuals have no serial correlation.

H_A (alternative hypothesis): The residuals have serial correlation.

Since the p-value, which is 0.001, is lesser than 0.05, H_0 is rejected and H_A is accepted. The residuals have serial correlation.

4.4.2.5 United States

Table 4.4.2.5: Serial Correlation LM Test SPSS Result (United States)

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	C	0.182	1.106		0.165	0.871
	EG	0.040	0.030	0.713	1.320	0.204
	GP	0.058	0.078	0.466	0.745	0.467
	IS	-0.031	0.047	-0.484	-0.663	0.516
	TEL	-0.009	0.014	-0.694	-0.619	0.544
	PA	9.931E-07	0.000	0.512	0.566	0.579
	Lag	0.652	0.309	0.598	2.109	0.050

Source: SPSS

H_0 (null hypothesis): The residuals have no serial correlation.

H_A (alternative hypothesis): The residuals have serial correlation.

Since the p-value is same as 0.05, H_0 is accepted and H_A is rejected. The residuals have no serial correlation.

4.4.3 Heteroscedasticity White Test

4.4.3.1 Malaysia

Table 4.4.3.1: Heteroscedasticity White Test SPSS Result (Malaysia)

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	0.002	5	0.000	2.521	.065[b]

Residual	0.003	19	0.000		
Total	0.005	24			

Source: SPSS

H_0 (null hypothesis): The residuals have no heteroscedasticity.

H_A (alternative hypothesis): The residuals have heteroscedasticity.

Since the p-value is greater than α 0.05 level, H_0 is accepted and H_A is rejected. The residuals have no heteroscedasticity.

4.4.3.2 China

Table 4.4.3.2: Heteroscedasticity White Test SPSS Result (China)

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	0.000	5	0.000	0.372	.861[b]
	Residual	0.004	19	0.000		
	Total	0.004	24			

Source: SPSS

H_0 (null hypothesis): The residuals have no heteroscedasticity.

H_A (alternative hypothesis): The residuals have heteroscedasticity.

Since the p-value is greater than α 0.05 level, H_0 is accepted and H_A is rejected. The residuals have no heteroscedasticity.

4.4.3.3 Korea

Table 4.4.3.3: Heteroscedasticity White Test SPSS Result (Korea)

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	0.003	5	0.001	0.781	.576[b]
	Residual	0.015	19	0.001		
	Total	0.018	24			

Source: SPSS

H_0 (null hypothesis): The residuals have no heteroscedasticity.

H_A (alternative hypothesis): The residuals have heteroscedasticity.

Since the p-value is greater than α 0.05 level, H_0 is accepted and H_A is rejected. The residuals have no heteroscedasticity.

4.4.3.4 Singapore

Table 4.4.3.4: Heteroscedasticity White Test SPSS Result (Singapore)

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	0.039	5	0.008	1.643	.197[b]
	Residual	0.090	19	0.005		
	Total	0.130	24			

Source: SPSS

H_0 (null hypothesis): The residuals have no heteroscedasticity.

H_A (alternative hypothesis): The residuals have heteroscedasticity.

Since the p-value is greater than α 0.05 level, H_0 is accepted and H_A is rejected. The residuals have no heteroscedasticity.

4.4.3.5 United States

Table 4.4.3.5: Heteroscedasticity White Test SPSS Result (United States)

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	0.002	5	0.000	1.752	.171[b]
	Residual	0.004	19	0.000		
	Total	0.005	24			

Source: SPSS

H_0 (null hypothesis): The residuals have no heteroscedasticity.

H_A (alternative hypothesis): The residuals have heteroscedasticity.

Since the p-value is greater than α 0.05 level, H_0 is accepted and H_A is rejected. The residuals have no heteroscedasticity.

4.4.4 Multicollinearity Test

4.4.4.1 Malaysia

Table 4.4.4.1: Multicollinearity Test SPSS Result (Malaysia)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	C	0.433	0.554		0.782	0.444		
	EG	0.007	0.006	0.091	1.250	0.226	0.822	1.216
	GP	0.030	0.028	0.100	1.082	0.293	0.508	1.968
	IS	-0.015	0.011	-0.181	-1.445	0.165	0.279	3.584
	TEL	0.013	0.005	0.361	2.742	0.013	0.252	3.971
	PA	0.000	0.000	0.412	2.355	0.029	0.143	7.003

Source: SPSS

H_0 (null hypothesis): The residuals do not have multicollinearity.

H_A (alternative hypothesis): The residuals have multicollinearity.

Since the VIF for the variables of economic growth (EG), government policies (GP), industry structure (IS), and tertiary education level (TEL) are less than 5, thus the null hypothesis are accepted, indicated that these residuals of EG, GP, IS and TEL do not have multicollinearity.

4.4.4.2 China

Table 4.4.4.2: Multicollinearity Test SPSS Result (China)

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	C	-7.955	1.814		-4.384	0.000		
	EG	-0.010	0.021	-0.040	-0.467	0.646	0.268	3.732
	GP	0.133	0.042	0.236	3.185	0.005	0.364	2.750
	IS	0.141	0.032	0.749	4.438	0.000	0.070	14.236
	TEL	0.048	0.007	1.510	6.909	0.000	0.042	23.880
	PA	-8.59E-08	0.000	-0.075	-0.282	0.781	0.028	35.729

Source: SPSS

H_0 (null hypothesis): The residuals do not have multicollinearity.

H_A (alternative hypothesis): The residuals have multicollinearity.

Since the VIF for the variables of economic growth (EG) and government policies (GP) are less than 5, thus the null hypothesis is accepted, indicated that these residuals of EG and GP do not have multicollinearity.

4.4.4.3 Korea

Table 4.4.4.3: Multicollinearity Test SPSS Result (Korea)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	C	-5.819	2.441		-2.383	0.028		
	EG	0.010	0.013	0.036	0.783	0.443	0.620	1.613
	GP	0.363	0.071	0.816	5.132	0.000	0.051	19.619
	IS	0.129	0.054	0.125	2.385	0.028	0.473	2.116
	TEL	-0.018	0.005	-0.251	-3.697	0.002	0.279	3.588
	PA	9.611E-06	0.000	0.424	2.659	0.016	0.051	19.733

Source: SPSS

H_0 (null hypothesis): The residuals do not have multicollinearity.

H_A (alternative hypothesis): The residuals have multicollinearity.

Since the VIF for the variables of economic growth (EG), industry structure (IS), and tertiary education level (TEL) are less than 5, thus the null hypothesis is accepted, indicated that these residuals of EG, IS and TEL do not have multicollinearity.

4.4.4.4 Singapore

Table 4.4.4.4: Multicollinearity Test SPSS Result (Singapore)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	C	2.632	2.281		1.154	0.263		
	EG	0.008	0.015	0.118	0.501	0.622	0.692	1.445
	GP	0.140	0.091	0.473	1.549	0.138	0.411	2.431
	IS	-0.066	0.051	-0.841	-1.276	0.217	0.088	11.348
	TEL	-0.001	0.016	-0.099	-0.085	0.933	0.028	35.525
	PA	0.000	0.001	-0.400	-0.402	0.692	0.039	25.793

Source: SPSS

H_0 (null hypothesis): The residuals do not have multicollinearity.

H_A (alternative hypothesis): The residuals have multicollinearity.

Since the VIF for the variables of economic growth (EG) and government policies (GP) are less than 5, thus the null hypothesis is accepted, indicated that these residuals of EG and GP do not have multicollinearity.

4.4.4.5 United States

Table 4.4.4.5: Multicollinearity Test SPSS Result (United States)

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	C	7.420	1.120		6.624	0.000		
	EG	-0.075	0.020	-0.573	-3.743	0.001	0.404	2.477
	GP	-0.186	0.049	-0.638	-3.827	0.001	0.340	2.942
	IS	-0.111	0.039	-0.828	-2.827	0.011	0.110	9.073
	TEL	0.014	0.008	0.460	1.774	0.092	0.141	7.099
	PA	-2.799E-06	0.000	-0.672	-2.021	0.058	0.085	11.698

Source: SPSS

H_0 (null hypothesis): The residuals do not have multicollinearity.

H_A (alternative hypothesis): The residuals have multicollinearity.

Since the VIF for the variables of economic growth (EG), government policies (GP) and tertiary education level (TEL) are less than 5, thus the null hypothesis is accepted, indicated that these residuals of EG, GP and TEL do not have multicollinearity.

CHAPTER 5: DISCUSSION, CONCLUSION, AND IMPLICATIONS

5.1 Discussions of Major Findings

Based on the Ordinary Least Square (OLS) regression result in this study, it indicates the most significant determinant that influence research and development expenditure as a percentage of GDP in each country.

For Malaysia, government policies are the most significant independent variables towards the dependent variable, where a one-percent increase in the government policies on average has positive relationship effect on increasing the R&D expenditure as a percentage of GDP (RDE) by 0.03%. This result was supported by (Malaysian Investment Development Authority, 2023), as Malaysia vigorously promotes a variety of industries in their R&D initiatives, creating relationships between companies, R&D organizations, and universities via incentives including In-House R&D, Contract R&D Company, and R&D Status. The authority also stated that the 12th Malaysia Plan (12MP) objective of 2.5% gross domestic expenditure on research and development by 2025—with a long-term ambition of 3.5% by 2030—is being pursued by the government through increased investments in R&D.

In China, industry structure has the most significant effect towards R&D expenditure as a percentage of GDP, as a one-percent increase in the industry structure (IS) on average has positive relationship effect on increasing the RDE by 0.141%. China's R&D spending as a percentage of GDP was around 2.56% in 2022. This expansion is visible across a number of industries, with Chinese businesses outperforming American businesses in fostering R&D and competitiveness, especially in cutting-edge fields like electronics and electrical equipment (Long & Atkinson, 2023).

Besides that, for Korea, government policies are the most significant variable towards the innovation actives expenditure because a one-percent increase in the GP on average has positive relationship effect on increasing the RDE by 0.363%. It has been suggested that one of the policies to boost total factor productivity and revive domestic R&D is to increase tax support for top private companies (Seung-yeon, 2022). In addition, competitiveness in science and technology is used to assess the efficacy of the Korean government's industrial R&D spending, with an emphasis on economic results including competitiveness, income generation, and the ability to create jobs (Hyunok, 2022).

As for Singapore, government policies also affect R&D expenditure as a percentage of GDP the most where a one-percent increase in the GP on average has positive relationship effect on increasing the RDE by 0.14%. According to (The Business Times, 2020), a Singaporean financial newspaper under SPH Media, the government has pledged to invest S$25 billion, or almost 1% of the nation's GDP in its upcoming five-year plan for research, innovation, and entrepreneurship. With this investment, Singapore hopes to become more competitive in important industries by developing its scientific basis, growing its enterprise and innovation platforms, and commercializing its technologies. Furthermore, Singapore continues to devote a sizeable percentage of its budget to development expenditures, with around 25% set aside for investment and development. This shows a strong commitment to promoting innovation and developing capacities for future growth (Ministry of Finance Singapore, 2023).

In the United States, tertiary education level is the most significant variable towards the innovation actives expenditure in the country, where a one-percent increase in the tertiary education level (TEL) on average has positive relationship effect on increasing the RDE by 0.14%. In 2015, the OECD countries allocated 0.4% of GDP on average to higher education research and development (HERD); Denmark, Switzerland, and Sweden contributed more than twice as much.

5.2 Implications of the Study (Policy)

Regularly stating the components of Gross Domestic Product (GDP) is a fundamental practice necessary for obtaining a comprehensive understanding of the economic landscape, particularly in relation to research and development (R&D) expenditures. By consistently articulating the different parts of GDP-consumption, investment, government expenditure, and net exports, policymakers and analysts can accurately gauge the contributions of R&D to overall economic activity and growth trajectories.

Within the realm of R&D expenditures, there exists a nuanced array of elements that warrant clear definition and delineation. These elements encompass a spectrum of activities ranging from basic research, aimed at expanding scientific knowledge without immediate practical application, to applied research, which seeks to utilize scientific insights to solve specific real-world problems, to development, which involves the translation of research findings into tangible innovations and products. Each of these facets of R&D plays a distinct yet interconnected role in driving innovation and economic progress.

Furthermore, establishing transparent criteria for the classification of R&D activities is paramount. Such criteria may include assessing the level of innovation inherent in the research endeavour, the degree of technical uncertainty involved, and the systematic approach adopted in problem-solving. These criteria serve a s guiding principles in distinguishing bona fide innovation activities from other forms of economic endeavours, thereby enabling more accurate measurement and analysis.

In terms of measurement, evaluating R&D expenditures entails a multifaceted approach that encompasses financial investments in personnel, equipment, materials, and overhead costs associated with R&D endeavours. This comprehensive assessment provides policymakers and stakeholders with valuable insights into the allocation and utilization of resources in pursuit of innovation.

By establishing clear criteria and robust measurement methodologies for R&D expenditures, stakeholders can effectively track and evaluate the impact of R&D on economic growth and development. In doing so, they can make informed decisions and formulate targeted policies aimed at fostering a conducive environment for innovation-driven prosperity. Thus, the regular articulation of GDP components and the precise definition and measurement of R&D activities are integral components of a holistic approach to understanding and promoting economic growth.

5.3 Limitations of the Study

The study faces several limitations. Firstly, it is based on small sample size of only 25 years for the country Malaysia, Chia, Korea, Singapore and United States, potentially missing long-term trends. Secondly, using tertiary education enrolment as a proxy for human capital may not precisely represent the final graduation rates. Additionally, the study lacks the specific points and views, such as specific government policies promoting R&D and particular industry structure. Moreover, data availability poses challenges, especially in accurately capturing private sector R&D spending. The study relies on government R&D expenditure as a proxy for overall R&D investment, as data on private sector R&D spending is often difficult to obtain.

5.4 Recommendations for Future Research

Future research should incorporate several enhancements to deepen understanding of Research and Development (R&D) dynamics. Firstly, including patent applications from both residents and non-residents would provide a more comprehensive view of global innovation trends, enriching our understanding of the innovation landscape. Secondly, employing more specific measures of R&D outcomes, such as assessing the originality and impact of patents, could offer deeper insights into the quality of innovation. Additionally, future studies should strive to incorporate data on R&D expenditure from both private and government sectors to better assess overall investment in innovation. Lastly, considering industry-specific factors and dynamics in R&D analysis would provide valuable insights into unique challenges and opportunities, enabling tailored interventions to promote innovation-driven growth across diverse industries.

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