HOW RESEARCH AND DEVELOPMENT EXPENDITURE AFFECTS ECONOMIC GROWTH

BY

CHIEW YEW YI

A research project submitted in partial fulfillment of the requirement for the degree of

BACHELOR OF ECONOMICS (HONOURS)
GLOBAL ECONOMICS

UNIVERSITI TUNKU ABDUL RAHMAN

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DECLARATION

We hereby declare that:

(1) This undergraduate research project is the end result of our 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 research project 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) Equal contribution has been made by each group member in completing the research project.

(4) The word count of this research report is ________10348_________________.

Name of Student:	Student ID:	Signature:
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Date: ___04/05/2023____________________

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LIST OF ABBREVIATIONS

GDP	Gross Domestic Production
RNDE	Research and Development Expenditure
RRND	Researchers in Research and Development
PA	Patent Applications
INF	Inflation
R&D	Research and development
EXP	Export
FDI	Foreign Direct Investment
GFCF	Gross Fixed Capital Formation
OLS	Ordinary Least Squares
FEM	Fixed Effect Model
REM	Random Effect Mode

ABSTRACT

Research and development (R&D), which fosters innovation, productivity, and competitiveness, is vital for modern economic progress. It defines the meticulous and creative work done to either produce new knowledge, products, and processes or to improve those that currently exist.This study explores whether the research and development is a better driver of economy and compares the development levels of different countries around the world and the data from 2005 to 2019. Therefore, in the new stage of promoting high-quality economic development, it is urgent to clarify the actual effect and impact mechanism of the research and development towards the country economy, deeply analyse the internal mechanism of how the research and development affects GDP growth from Research and development expenditure, researchers in researchers in research and development and patent applications. The contribution and positive and negative effects produced by the level, thus providing possible path support for how the research and development can better drive global economic growth.

Chapter 1: Research Overview

1.0 Introduction

This chapter included an overview of this study. In Section 1.1, the background of the study is being discussed. Section 1.2 consists of the problem statement, we discussed the motivation of this study, stated what points of view we can enter regarding to the nexus of research and development (R&D) and economic growth. The research objective and research questions are included in sections 1.3 and 1.4, respectively, in which we discussed the aim of doing this research and the questions we intend to answer with the study. Then, in section 1.5, the significance of the study will be discussed, what knowledge can we contribute to the academy. In section 1.6, the chapter layout will be shown. Lastly, this chapter will sum up in section 1.7, the conclusion.

1.1 Background

Research and development (R&D), which fosters innovation, productivity, and competitiveness, is vital for modern economic progress. It defines the meticulous and creative work done to either produce new knowledge, products, and processes or to improve those that currently exist. In order to advance technology and the state of the art, which ultimately encourages economic progress and social welfare, R&D is essential(Sarpong et al., 2023). The World Intellectual Property Organization (WIPO) reported that worldwide R&D spending totaled $1.9 trillion in 2017. This exemplifies the importance of R&D as a catalyst for innovation and economic expansion. The research also emphasizes that the top five nations for R&D expenditure are the United States, China, Japan, Germany, and South Korea. R&D investment has been gradually rising in recent years(WIPO, 2017).

There are three components that we can examine the outlines of R&D level of particular country. First and foremost, the R&D ratio is a crucial indicator of a nation's dedication to research and development. It is computed by dividing the overall economy's output by the amount spent on research and development. The R&D ratio for the European Union in 2019 was 2.12%, according to the United

Nations Economic Commission for Europe (UNECE) (2020), showing a comparatively high level of R&D spending. In 2018, the R&D ratio in the United States was 2.8%, which is higher than the 1.7% average for the world(UNECE, 2020). Other than that, the outcomes of R&D investments in innovation may be well predicted by patent applications. A patent is a type of legal protection that grants innovators temporary exclusivity over their creations. Patent applications can offer information about a country's and a company's creative activity. For instance, the top five patent applicants in 2019 were all R&D-intensive technological companies: Huawei, Samsung, Mitsubishi Electric, Qualcomm, and LG Electronics, according to the WIPO (2020)(WIPO, 2020). Additionally, the total number of researchers in a nation reveal the amount of human capital dedicated to R&D. For performing cutting-edge research and development, which might eventually result in new discoveries and technical breakthroughs, highly qualified researchers are crucial. In 2019, the United States had the most researchers per million residents, followed by Switzerland, Denmark, Israel, and Finland(UNESCO, 2021).

1.1 Global trend of R&D

The expected overall cost of R&D in 2019 was $2.2 trillion, an increase of 5.2% from the previous year. Various factors, such as technological advancements, escalating competition, and rising demand for cutting-edge goods and services, are behind this increase in R&D spending. With China, Japan, and South Korea ranking as the top three nations for R&D investment, Asia is becoming more and more significant in terms of R&D spending. Over the past ten years, R&D spending has grown significantly in China in particular, with the government's effort to establish itself as a global technology leader playing a significant role. R&D investment worldwide continues to be dominated by healthcare and technology. The healthcare industry concentrates on creating new medicines and medical equipment to treat a variety of disorders, whereas the technology industry concentrates on creating novel goods and services that have the potential to upend established markets.

Global R&D investment has been significantly impacted by the COVID-19 epidemic. R&D investment has increased in certain industries, including healthcare and biotechnology, while it has decreased in others, like the automobile and aerospace industries. As a result of the pandemic, businesses have had to discover new ways to invent and develop products in a distant working environment, which has expedited the trend towards digital R&D and collaboration. The transition to digital R&D, which is characterized by the employment of cutting-edge technologies like artificial intelligence, machine learning, and big data analytics, is another important development. This trend is being pushed by the requirement to quicken the speed of innovation and enhance R&D process effectiveness(IQVIA, 2020).

1.1.2 Factors that Influence the Relationship between R&D Ratio and GDP

Numerous researchers have looked into the relationship between R&D and economic expansion. Since the 18th century, the macroeconomic research on topics has ranked the concept of economic growth first. Along with the growing body of literature, it is evident that both theoretical and empirical analysis has been done on how various factors, primarily population and capital, affect economic growth. The relevance of the link between economic growth and research and development activities is also emphasized, in addition to the significance of technology given to economic growth, notably by endogenous Growth Theories from the early 1990s. However, it is apparent that there has been an increase in studies looking to understand the connection between these two phenomena, particularly since the 2000s.

According to (Grossman & Helpman, 1991), the effectiveness of R&D is a key component in determining how it affects economic growth. They made the case that the caliber of research inputs, such as the degree of human capital and subject-matter expertise, determines the quality of the research output. The degree of skill, knowledge, and creativity in the research area are also important factors in determining the quality of research, in addition to the quantity of R&D funding. As a result, increased R&D spending is not necessarily enough to spur innovation and economic growth. To improve research outcomes, governments must concentrate on creating a conducive research climate, boosting human capital, and raising research quality in addition to investing in R&D.

Investment in human capital, according to (Richard R. Nelson & Edmund S. Phelps, 1966), is still a vital component in the spread of technology and the expansion of the economy. The information, skills, and capacities that people gain via education and training are referred to as human capital. Investment in human capital boosts productivity, creativity, and technology diffusion, all of which are beneficial for economic growth. R&D spending and innovation levels are often greater in nations with higher levels of human capital investment.

However, there are many different ways in which R&D and economic growth are related, and these connections are not always clear-cut. An important consideration for assessing the effect of R&D on economic growth is the R&D ratio, which is calculated by dividing R&D spending by total economic output. The link between R&D and GDP is not necessarily linear and is influenced by a number of variables, including the standard of the research, the amount of human capital present, the kind of economy, and the institutional and legislative framework. On the other side, countries with inadequate institutional and policy frameworks, low levels of human capital, and resource-based economies may have less of an impact from R&D on economic growth.

The key determinants of how R&D affects economic growth are its quality, investments in human capital, and the institutional and regulatory environment. In order to improve research outcomes, policymakers must concentrate on creating a conducive research climate, fostering human capital, and raising research quality. The link between R&D and economic growth is complicated and varied.

1.2 Problem statement

Spending on research and development (R&D) and GDP growth are widely agreed upon to have a positive link, despite the connection being complex, multidimensional, and depending on a wide range of different variables. In spite of the extensive research that has been done on this topic, the results are still dependent on the circumstances. In addition, it is predicted that the link between R&D and GDP will vary among nations and regions due to disparities in the economic structures, degrees of development, and regulatory frameworks that are present in each country and area. It is vital to investigate the relationship between the amount spent on research and development (R&D) and the growth of a nation's or region's gross domestic product (GDP), as this will allow one to establish the primary factors that motivate and limit growth driven by R&D.

The fact that the R&D-GDP relationship is both a complex and multifaceted phenomenon that is influenced by a wide range of factors, such as the level and quality of R&D investment, the scope and nature of technological innovation, the institutional and policy framework, and the macroeconomic environment, is one of the primary challenges that arise when attempting to study the relationship between the two. It is required to use a comprehensive and interdisciplinary approach that incorporates concepts drawn from economics, innovation studies, and political science in order to gain an understanding of the relationship between R&D and GDP.

The potential that the R&D-GDP relationship will be different across a large number of countries and locations offers additional challenge for researchers looking into it. This is owing to the fact that the economic structures, levels of development, and political systems that are unique to a nation all have an effect on the efficiency with which R&D investment results in economic growth. For instance, countries that have a sizeable manufacturing sector may benefit more from research and development expenditures in novel technologies that boost production efficiency, whereas countries with a service-based economy may benefit more from research and development investments in novel business models and service delivery techniques. It is possible that research and development spending and GDP are more closely associated in countries that have solid institutional and policy contexts than in those that have slack frameworks.

In light of these challenges, the primary purpose of this study is to investigate the link between R&D investment and the growth of GDP across a wide range of countries and regions.

To be more specific, the purpose of this study is to address the following research questions:

1. What is the link between the amount spent on research and development and the rate at which a nation's or region's GDP grows in the various nations and areas?
2. How can politicians in different nations and places design effective legislation and plans of action to assist R&D-led expansion while also taking into mind the context-dependent R&D-GDP relationship?

In order to address the aforementioned research concerns, the aforementioned study will make use of data collected from cross sections and an approach to least squares known as Ordinary Least Square (OLS), . Ordinary Least Square (OLS) is a method that brings together econometric modeling, case studies, and comparative analysis. In order to accurately portray the diversity of geographical locations, income levels, and economic structures around the world, the research will include a large number of countries, such as developed and developing nations, countries with high incomes and countries with low incomes, as well as economies based on manufacturing and services. In order to construct a theoretical framework for grasping the relationship between R&D and GDP, as well as its drivers and barriers, the study will also depend on concepts from the literature on innovation studies and economics. This will allow the study to develop a theoretical framework for understanding the link between R&D and GDP. The overarching objective of the project is to expand participants' understanding of the deep and subtle relationship between R&D expenditure and GDP development, as well as to offer information to policymakers in a variety of countries and locations.

1.3 Research questions

-Does R&D expenditure affects GDP growth across different countries?
-How can countries effectively navigate other factors in order to maximize the benefits of R&D investment?

1.4 Research Objectives

-To examine the relationship between R&D expenditure and GDP growth across different countries
-To identify the heterogeneous effects of R&D expenditure on GDP growth across different income levels and economic structures countries

1.5 Significance of study

The significance of the study lies in the fact that it is able to provide vital insights on the relationship between expenditure on research and development and economic growth. As was said before, research and development is often recognized as an essential factor in what are known as innovation, productivity, and competitiveness. By investing in research and development, nations and businesses alike have the opportunity to create innovative products, services, and processes that will stimulate economic expansion and the creation of new jobs. Research and development (R&D) and economic growth do, however, have a convoluted relationship that differs significantly among countries and regions. As a result, it is very necessary to carry out an inquiry into this connection that is both more extensive and comprehensive.

The findings of this study might have significant implications for policymakers and business leaders in government and industry who are interested in fostering economic growth through increased spending on research and development. If the research shows that there is a significant positive correlation between R&D investment and GDP growth, for example, policymakers could be persuaded to increase funding for research and development in order to stimulate economic expansion. On the other hand, if the study finds that there is just a small or no association between R&D investment and GDP growth, then policymakers may need to look about alternate strategies to boost the economy, such as investing in the development of infrastructure or improving human resources.

In addition to providing direction for policymakers, the findings of this study may also be of use to business leaders who are considering making investments in research and development (R&D) as a means of boosting their company's competitiveness and profitability. If companies have a better understanding of the relationship between expenditure on research and development (R&D) and economic growth, they will be better able to select where to deploy their resources and how to prioritize R&D projects.

In addition, the fact that the research focused on countries that have different economic systems, wealth levels, and geographical distributions is extremely important. This is because it offers a more in-depth comprehension of the link between R&D investment and economic expansion. Previous study has focused mostly on high-income nations like the United States, Japan, and European nations. However, the relationship between research and development (R&D) and economic growth may be diverse in nations with lower incomes or nations with different economic systems. This research can provide a more all-encompassing perspective on the relationship between research and development (R&D) and economic growth by looking at a diverse variety of countries.

1.6 Chapter Layout

The remaining parts of this paper are organized as follows. Chapter 2 will be reviewing related research done by researchers and discussing the linkage between the dependent variable and independent variables. In Chapter 3, the research methods will be discussed, as well as the data collected. Chapter 4 discusses the results that we get from the data analysis. Finally, Chapter 5 will include the discussion on the result findings, a conclusion for the whole study, the implications for policies design, limitations and recommendations for future study.

1.7 Conclusion

In this chapter, we have discussed the research background and problem statement. The research objectives and questions were also being developed at the end of this chapter. Last but not least, the significance of this study is being highlighted. In the next chapter, we are going to look into the relevant research which has been done previous researchers.

Chapter 2.0: Literature review

2.0 Introduction

Many researchers have investigated the nexus between R&D expenditure and economic growth, but the outcomes of the studies are ambiguous. In Section 2.1, we have a brief introduction of the dependent variable we used in the study. In Section 2.2, we looked into the empirical results of literature that study the linkage between R&D expenditure and economic growth. In Section 2.3, to identify the control variables for this study, we looked into the outcomes of research that study other determinants of economic growth. In Section 2.4, the conceptual framework of this study has been proposed. In Section 2.5, we developed the hypothesis of this research. Lastly, in section 2.6, we summarize what we learned from the existing literature.

2.1 Research and development

The production function displays the maximum output that can be produced using specific input levels and the available technical know-how. A higher level of output can be attained simply by increasing production factors quantitatively or by anticipating future advancements in the capacity for technical knowledge. Only inventions and innovations—which entail exploring new knowledge and applying it to current production techniques—can sustain new advancements in technical know-how capacity. The most crucial component in the production of innovations, new knowledge, and inventions is research and development work(Begg et al., 1994). Therefore, R&D spending should receive enormous attention from nations looking to boost economic growth performance.

R&D spending can be viewed as an investment in new knowledge and technology that will eventually result in more efficient methods to utilize currently available resources. If the larger level of R&D investments is successful, higher growth rates may be expected. The potential benefits of new ideas may not always accrue to individuals who actually come up with them due to spillover effects, and this condition means that, assuming no political intervention is available, the private sector will be socially less likely to execute R&D operations at an optimal level. In order to support the R&D activities of the private sector, this circumstance may justify a variety of state interventions, including indirect ones like tax incentives and intellectual property rights protection as well as direct ones like supply and finance conveniences(OECD, 2008).

2.2 Research and development & Economic growth

2.2.1 R&D expenditure and Researchers in R&D

According to (Kadir et al., 2019), using panel data, this study examines the connection between R&D and economic development in 33 OECD nations. Gross domestic spending on R&D and government research, however, has a detrimental effect on economic expansion. The widespread assumption that R&D spending will have a favorable effect on economic growth is not supported by these data. According to the authors, each investment in R&D spending benefits from the potential for producing new technologies and contributes to the expansion of the national economy.

A panel causality analysis is used in another study for OECD nations with higher income levels to examine the connection between R&D spending, innovation, and economic development. The results of this study show that R&D and innovation, R&D and economic growth, and economic growth and innovation all have a strong and favorable link (Guloglu & Tekin, 2012).

The theoretical foundations of growth models are provided by (Gene M. Grossman & Elhanan Helpman, 1991) to explain the structural economic transition in Africa. The study contends that the endogenous growth model holds the key to comprehending economies' long-term growth through the development of knowledge. Long-term benefits on growth are produced by both public and private investments in knowledge and research and development (R & D).Endogenous growth models have a lot of potential for transforming the structure of African economies. As a consequence, they advise that boosting R&D spending and hiring more researchers can benefits the economy change.

Another analysis uses panel data causation for the years 1997 to 2008 for each of the 34 countries under consideration to assess the relationships between R&D and growth. The findings of the causality test done on the group of 34 countries show that R&D spending do in fact lead to economic development(GENÇ & ATASOY, 2010).

Another article investigates the connection between R&D (Research and Development) spending and Turkey's national economic growth. The vast R&D efforts of industrialized nations have been credited by the majority of modern economists as the cause of their ongoing success. The subject of the relationship between economic development and R&D investment is extremely essential given Turkey's aspirational economic ambitions. The relationship between R&D expenditure and economic growth in Turkey from 1990 to 2013 was thoroughly investigated in this study. The study shows that there is no causal relationship between the investigated series(Tuna et al., 2015).

Aside from that, (Frank R. Lichtenberg, 1992) included 74 nations in his analysis as he looked at the connection between private and public sector R&D spending and economic growth for the years 1964 to 1989. The study comes to the conclusion that although spending on R&D in the private sector has a positive influence on growth, spending on R&D in the public sector has no beneficial impact on economic growth and occasionally even has a negative one.

Other than that, (Ildırar et al., 2016) contributes to this line of inquiry in two ways. First, he updates previous estimates of the impact of R&D spending on economic expansion. On the other hand, there are several R&D spending categories, and each one has a varied impact on economic expansion. In this study, the impact of various R&D investment types on economic development for the chosen OECD nations is investigated using a GMM framework and data from the years 2003 to 2014. As a result, it has been determined that all R&D expenditures have a positive and considerable impact on economic growth in a number of OECD nations.

Apart from that, (Zhong et al., 2011)conducted a study on the efficiency of R&D expenditures in China. The findings demonstrate that China's investment in R&D over the past 20 years has not produced adequate outcomes or aided in economic growth.

Furthermore, (Pop Silaghi et al., 2014) empirically quantifies the contribution of both private and public research and development to the growth of CEE countries between 1998 and 2008. They use the Arellano-Bond's Generalized Methods of Moments (GMM) to implement a dynamic panel model. According to their research, a 1% increase in company R&D intensity accelerates economic development in these nations by 0.05% over the long and short terms. It is discovered that public R&D is statistically negligible. The contribution of company R&D to economic development is reduced when human capital is included in the regression, although it is still substantial. Even if several robustness tests are carried out, the majority of the outcomes suggest a substantial R&D coefficient.

Similar research looks at 1990–2011 data for 15 selected OECD countries and uses a panel data model to look at the relationship between R&D spending and economic growth. According to the findings of this study, the seven OECD countries of Canada, Finland, France, Italy, Portugal, Turkey, and the United States all had positive effects from R&D investment on economic growth. It is also asserted, nevertheless, that any unanticipated rise in R&D investment has a detrimental effect on economic development in Germany, the Netherlands, Spain, and England. However, the findings from the panel encompassing all of the nation’s demonstrate that R&D spending boosts real per capita income (Ildırar et al., 2016).

Apart from that, (Sequeira, 2008) describes the steady-state and transition of the external influence of modern technology on the accumulation of human capital in an endogenous growth model. To compare the quantitative effects of R&D policy with the quantitative effects of human capital policy in wealth and welfare, we numerically solve the model. The calibration experiment demonstrates that, despite the fact that R&D subsidies now generally have a positive impact on growth, wealth, and welfare, human capital policy is simultaneously the most effective at boosting income and welfare and the least expensive for the government for realistic parameter choices.

Another study uses the endogenous growth theory framework to create a model that replicates the key features of the contemporary ICT-based economy, where the accumulation of human capital is crucial. In particular, a multi-sectoral growth model in discrete time with an infinite horizon, endogenous growth, embodied technological progress, horizontal differentiation, "lab-equipment" specification of R&D, and with the accumulation of human capital are taken into consideration to account for the crucial role that latter plays when new technologies are present. In this concept, human capital accumulation is the true engine of growth because, in contrast to the productivities of the other sectors, the productivity of education has an effect on the economy's long-term growth. The interaction between ICT and human capital is one of the variables driving present economic performance (Mattalia, 2012).

In another study, (Bayarçelik & Taşel, 2012) used the endogenous economic development theory to explore the connection between innovation and economic growth in Turkey. The relationship between researchers working in R&D departments, R&D spending, patents as markers of innovation, and GDP as the measure of economic growth is examined using a model created in accordance with this conceptual framework. These relationships are examined using a panel regression model for chemical companies listed on the Istanbul Stock Exchange (ISE) between 1998 and 2010. The results showed that R&D spending and the number of R&D researchers had a positive and substantial relationship in impacting economic growth.

2.2.2 Patents application

According to (Nguyen & Doytch, 2022), they look into how inventions affect economic growth as indicated by the quantity of new patents. They concentrate on patents in the ICT industry for a worldwide sample of 43 economies from 1998 to 2016. There are three outcomes. First, there is little evidence that total patents have an impact on the expansion of the manufacturing sector, total patents and economic growth have mutually causal relationships. Second, sophisticated economies have a larger correlation between total patents and economic growth. ICT patents simultaneously have a big beneficial impact on the growth of advanced countries and a considerable detrimental impact on the growth of emerging economies. Third, compared to overall patents, ICT patents have a favorable and considerable long-term influence on economic growth.

Another study uses data from 1995 to 2019 using the dynamic system-generalized technique of moment to examine the effects of technology advancement and transport infrastructure on GDP in the European Union (EU). The findings also show that infrastructure investments in goods transportation and innovation both directly raise GDP. The conditional impact study shows that innovation and freight and rail infrastructure work together to increase GDP. In order to attain economic efficiency, European nations must emphasize and increase technical innovation (Acheampong et al., 2023).

Another research looked at the consequences of changes in the effective patent rights between 1981 and 2000 within panels of up to 54 manufacturing industries in up to 72 countries. Stronger patent rights were associated with faster development in industries that rely more on patents. Between 1991 and 1995, there was an increase in the number of effective patent rights from Turkey to Singapore, and this increase was linked to the average growth of the industries. Through the accumulation of factors and higher productivity, patent protection has been associated with faster growth. Alternative patent rights and patent intensity measurements had little impact on their results (Hu & Png, 2013).

Apart from that, since in the age of technical advancement became the most effective tool for countries greater economic development and expansion. (Samuel Gyedu et al., 2022) intended to investigate how technology advancements have affected economic growth in 72 selected nations between 1990 and 2020. They discovered a statistically significant causation and favorable connections between the technology accomplishment index and GDP growth using the ARDL model. As a result, technical advancements are related to macroeconomic aspects and economic growth, which means that in order to achieve better growth.

This research empirically examines the significance of both the amount and quality of invention on economic growth and is another attempt by (Hasan & Tucci, 2010) to relate innovation to economic growth using globally patents' data based on a sample of 58 different countries for the years 1980–2003. According to the findings, nations that host businesses with high-quality patents also see faster economic growth. Furthermore, there is some evidence to suggest that nations with higher levels of patenting also experience higher rates of economic expansion.

2.3 Other factors and Economic Growth

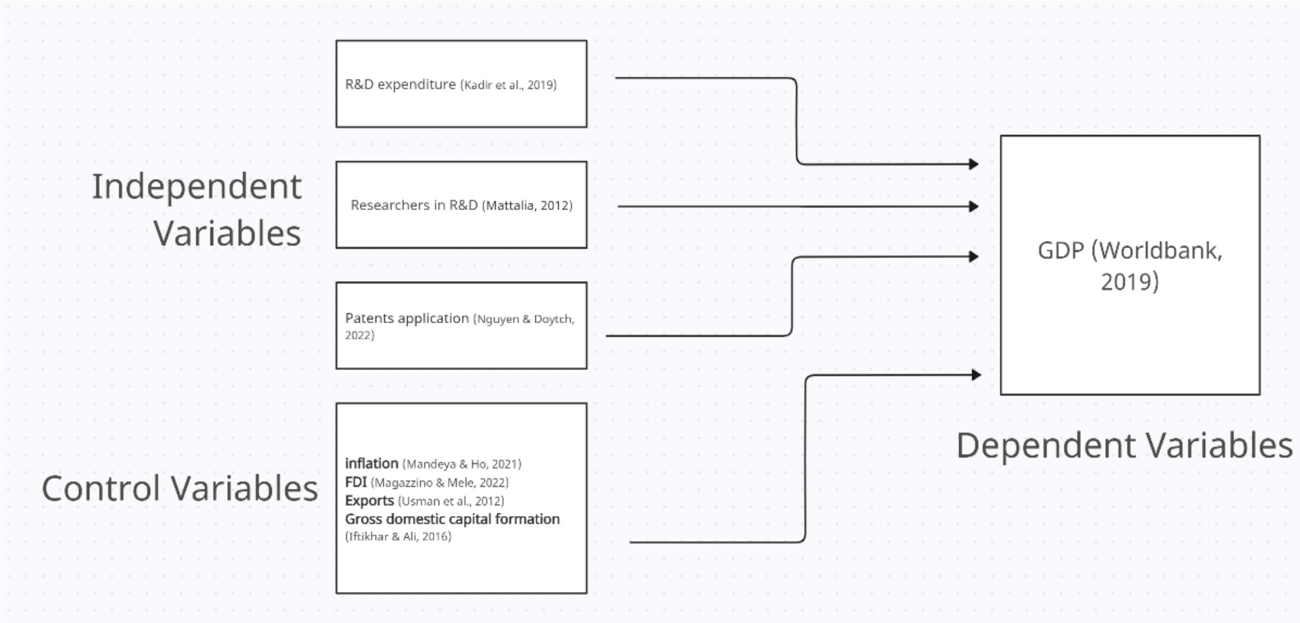
According to (Mandeya & Ho, 2021), using quarterly data spanning the years 1961Q1 to 2019Q4, they examined the impact of inflation and **inflation** uncertainty on economic growth in South Africa utilizing (ARDL) estimation methodology. According to their research, South Africa's economic growth is negatively impacted by inflation uncertainty both in the short and long terms. Additionally, (APERGIS, 2005) conducts an empirical investigation into the relationship between **inflation** uncertainty and economic growth using panel data analysis and the GARCH methodology with data from OECD economies spanning the years 1969 to 1999. The main conclusions demonstrate that inflation uncertainty has a detrimental impact on economic growth.

Other than that, by the paper conducted by (Magazzino & Mele, 2022) look into the interconnection between **FDI** and economic growth within Malta in the periods from years 1971–2017. Given that any statistically significant causal association between FDI and economic development arises, the results of the causality tests demonstrate that the neutrality hypothesis is true. Artificial Neural Networks (ANNs) algorithm was used for robustness checks. This process can forecast how FDI will alter in relation to Maltese economic expansion. With empirical findings, pertinent policy recommendations emerged. Furthermore, another research uses time series data to look at the link between **FDI** and economic development in Malaysia from 1970 to 2005. The empirical analysis and ordinary least square (OLS) regressions are employed. The findings indicate a strong correlation between Malaysia's economic expansion and foreign direct investment inflows(Mun et al., 2009).

On the other hand, according to (Usman et al., 2012)'s study, which looked at the major effects of **exports**, government spending, and education spending on economic growth in Luxemburg's mature economy—the largest exporter in the world. The time period is based on an annual basis from 1975 to 2009 using the straightforward ordinary least squares approach to determine the significant relationship between export and growth while taking into account the economy of Luxemburg. According to experimental findings, government expenditures, educational spending, and exports all significantly contribute to economic development. A unit increase in exports causes a positive shift of.17 in economic growth, according to data on exports. Besides, (J. Bhagwati & T. N. Srinivasan, 1979) demonstrated that **exports** increase economic growth by leveraging economies of scale and enlarging the competition for productivity. A nation must invest a sizable amount of money in research and development in order to provide the market with cutting-edge products while growing its exports and reaping the benefits over a longer period of time.

In addition, (Iftikhar & Ali, 2016) examined the connection between Pakistan's economic development, exports, and **gross domestic capital formation**. The study examines the existence of a long-term link between Pakistan's gross domestic capital creation, exports, and economic development using Johnson's co-integration approach. The findings indicated that exports, gross domestic capital creation, and economic growth are all correlated with one another. Gross domestic capital creation and export have been shown to have an impact on the steady state level of GDP in Granger causality tests based on Error Correction Models. Another study uses a Panel Vector Autoregressive (PVAR) technique to examine the impact of energy use, natural resource use, and **gross capital formation** on economic development in 124 countries between 1980 and 2018. Different results from the Panel VAR analysis were obtained for the groupings of different income level countries. The findings indicate that whereas capital formation has a negative influence on economic growth in low-income nations, it has a positive impact in high-income countries. According to the findings of the causality tests, there is a unidirectional causal relationship between GDP and gross capital creation in all panels. These results indicated that the impacts of gross capital creation on GDP depend on the income levels of the various nations(Topcu et al., 2020).

2.4 Conceptual Framework



2.5 Hypothesis Development

H1: There is a positive relationship between research and development expenditure and Gross Domestic Production growth.
H2: There is a negative relationship between research and development expenditure and Gross Domestic Production growth.
H3: There is a positive moderating effect of research and development expenditure and Gross Domestic Production growth.

2.6 Conclusion

This review looked at research on other control variables as well as the connection between research and development expenditure and economic growth. By using various methodologies, different results have been found in various sampling regions. Due to the growing concerns surrounding the effects bringing by research development, this field of study is crucial. Therefore, more research is needed to develop a deeper understanding of the relationship between these variables in order to provide policymakers with a clearer picture so they can make better decisions.

Chapter 3: METHODOLOGY

3.0 Introduction

This part will discuss the research design, data collection methods, sampling design, research instrument, and scale of measurement of the effect of the research and development expenditure on economic growth.

In methodology, secondary data will be used to analyze the relationship between variables, and the result will be obtained to confirm the hypothesis and build a model to explain the relationship between variables. The dependent variable and independent variables as mentioned in Chapter 2 are gained from the World Bank. The econometric tool will be chosen in this part to proceed to Chapter 4, and the analysis tool will be chosen is EViews. The scale measurement and the measurement of each variable are listed, and the type of tests and analysis will be conducted in Chapter 4 will be discussed in this section.

3.1 Research Design

The research here is more biased towards the attributes and data of social phenomena and changes in the operation, a method to study things from the inherent stipulations of variables. Thus, it can be concluded that the relationship between the dependent variable and the independent variable affects each other. Quantitative research relies more on the description and understanding of the meaning, characteristics, metaphors, and symbols of things. It is based on generally recognized axioms, a set of deductive logic, and a large number of facts. things to study.

3.2 Data Collection Methods

3.2.1 Secondary Data

The primary data collection method is not used in this research study since the research topic and hypotheses are on how the research and development expenditure affects economic growth, which requires massive data analysis. In obtaining data from existing sources such as the World Bank, the secondary data collection method is used (World Bank, n.d.). The indicators related to the research and development (R&D) and economic growth (GDP growth). These variables include countries' levels of research and development. These indicators' data can be found in the World Bank. Indicators such as "Research and development expenditure," "Researchers in Research and Development," and “Patent Applications” can be used to evaluate the level of country level of research and development. This research study will use secondary data from numerous other sources in addition to the World Bank. These sources include academic journals about the R&D and economic growth.

Table 3.2.1: Description of Variables

Variables	Description	Sources
Research and development expenditure (RNDE)	Expenditures percentage on research and development (R&D) of GDP.	World Bank
Researchers in R&D (RRND)	Total number of researchers engaged in Research &Development (R&D)	World Bank
Patent applications (PA)	Total amount of inventions	World Bank
GDP growth (GDP)	Annual percentage growth rate of GDP	World Bank

Inflation (INF)	Annual growth rate of the GDP implicit deflator shows the rate of price change	World Bank
Foreign direct investment (FDI)	Direct investment equity flows in the reporting economy	World Bank
Export (EXP)	Total value of goods and services provided to the rest of the world	World Bank
Gross fixed capital formation (GFCF)	Net acquisitions of valuables	World Bank

3.3 Sampling Design

3.3.1 Target Population

The target population for this study focuses on how the research and development expenditure affects economic growth. Each continent chose at least one country to represent the target population based on different demographic aspects. The countries chosen are Argentina, Brazil, China, Denmark, Germany, Greece, India, Japan, Mexico, South Africa, Thailand, Türkiye, United Kingdom, United States. These countries selected are from different income levels, including developing and developed countries.

3.3.2 Sampling Size

In this study examining the relationship between the research and development expenditure affects economic growth, the data period considers 15 years as it provides a large enough time frame to capture trends and changes in the economy. There are 14 countries and 15 years of data between 2005 to 2019 with a total of variables including GDP growth, Research and development expenditure, Researchers in research and development, Patent applications, FDI, Inflation, Exports, and Gross fixed capital formation in each country have been chosen.

Therefore, if there are complete data for all variables for all countries and years, there would be a total of 1680 observations in this study.

3.4 Research Instrument

A statistical analysis software called EViews will be applied to econometric analysis in this study. This software can use econometric methods and techniques to observe the quantitative laws of socio-economic relations and economic activities and obtain results. From the obtained results, it can be summarized and tested whether the hypotheses are valid. For this research, all of the tests on the panel data are run by EViews.

3.5 Data Analysis

Since the data is selected from multiple countries with time series, to estimate the regression analysis of panel data to select the best model from one of the three tests, there are pooled least square, fixed effect test, and random effect test. The Redundant Fixed Effect Test, Hausman Test, and Test Lagrange Multiplier are used to select which model is the best. Before the model selection, the descriptive analysis will be tested by each country.

3.6 Scale Management

As mentioned in Chapter 2, the factors that are listed affect GDP growth and will act as the variable to use to examine the econometric software tools. It includes GDP growth, Research and development expenditure, Researchers in research and development, Patent applications, FDI, Inflation, Exports, and Gross fixed capital formation. The scale measurement of each variable is shown below:

Table 3.6: Measurement of Variables

Variables	Measurement

Research and development expenditure (RNDE)	% of GDP
Researchers in R&D (RRND)	per million people
Patent applications (PA)	Total amount of inventions annually
GDP growth (GDP)	annual %
Inflation (INF)	annual %
Foreign direct investment (FDI)	net BoP, current US$
Export (EXP)	current US$
Gross fixed capital formation (GFCF)	current US$

3.6.1 Descriptive analysis

An essential initial step in doing statistical analyses is a descriptive analysis. It provides a sense of the data's distribution, aids in the detection of errors and outliers, and makes it possible to find correlations between variables, making it suitable for additional statistical analysis.

3.6.2 Correlation

A statistical technique used in research to determine the link between two variables and gauge the strength of the linear connection is correlation analysis.

3.6.3Unit Root Test

To assess if trending data should be initially differenced or regressed on deterministic functions of time to make the data stationary, unit root tests can be utilized.

3.6.4 Redundant Fixed Effect Test & Hausman Test & Breusch-Pagan Lagrange Multiplier Test

Between the redundant fixed effect test and the ordinary least square , the more effective model has been determined. If there are large random effects in panel data models, the Breusch-Pagan Lagrange Multiplier Test is employed to determine this. The Hausman Test, on the other hand, is utilized to distinguish between models with fixed and random effects. With panel data, both of these tests are frequently used.

3.6.5 Ordinary Least Square

The ordinary least squares (OLS) approach is a linear regression method for estimating model parameters that are unknown. The approach is based on reducing the sum of squared residuals between the real (observed values of the dependent variable) and model-predicted values.

3.6.6 Fixed Effect Model

When the model parameters are constants or non-random variables, the model is referred to as a fixed effects model in statistics. In contrast, all or part of the model parameters are random variables in mixed models and models with random effects.

3.6.7 Random Effect model

A mixed model is a specific example of a random effects model. Compare this to the definitions of biostatistics, where "fixed" and "random" effects are used to denote the population-average and subject-specific effects, respectively.

3.7 Residual Diagnosis

3.7.1 Normality Test

A normality test assesses whether a sample of data is representative of a population that has a normal distribution. Usually, it is done to make sure that the research's data exhibit a normal distribution.

3.7.2 Autocorrelation

A time series' autocorrelation measures how similar it is to a lagged version of itself across successive time periods. The link between a variable's present value and its previous values is measured by autocorrelation.

3.7.3 Multicollinearity test

When two independent variables are significantly correlated, multicollinearity may be present. It may also occur if two independent variables yield identical and repeated findings or if an independent variable is calculated using data from other variables in the data set.

3.7.4 Heteroscedasticity Test

It determines if the values of the independent variables have any impact on the variance of the errors resulting from a regression. A 2 test was used. The test may be run using the model's fitted values, model predictors, and a subset of the independent variables.

3.8 Conclusion

In conclusion, the samplings in this study are secondary data collected from the World Bank with the period of 2005 to 2019. The statistical tool used in this research is EViews to conduct several tests. The tests included descriptive analyses, panel data models, residual diagnostics that obverse the correlation, distribution, and significance. The result and interpretation of those tests will be clarified in Chapter 4.

Chapter 4: Data Analysis

4.0 Introduction

In Chapter 4, the content will relate to the data analysis of the research and development expenditure affect to the economic growth. As the test mentioned in Chapter 3, there are a few sections that will be discussed in the part which are the descriptive analyses, unit root test, model selection of the regression and residual diagnosis. Those tests will be conducted by the software of econometric analysis tool, which is called EViews. The analysis and interpretation are written with the following parts after computing the data in EViews.

4.1 Descriptive analysis

Table 4.1: Description Statistics

	RRND	RNDE	PA	INF	GFCF	GDP	FDI	EXP01
Mean	2358.778	1.486108	38968.76	4.522046	7.92E+11	2.796854	-6.96E+09	6.42E+11
Median	1211.121	1.118080	10939.50	3.210945	2.70E+11	2.367847	-4.80E+09	2.81E+11
Maximum	7846.658	3.367880	336340.0	53.55678	6.12E+12	14.23086	2.18E+11	2.66E+12
Minimum	134.9126	0.200800	16.00000	-1.735888	2.11E+10	-10.14931	-3.45E+11	4.62E+10
Std. Dev.	2133.660	1.000920	71174.71	5.891828	1.24E+12	3.702037	7.44E+10	7.06E+11
Skewness	0.777312	0.556844	2.639848	4.251825	2.310485	-0.043313	-0.726928	1.374228
Kurtosis	2.388965	1.760100	9.332567	29.40306	7.718959	3.951898	6.818547	3.714575
Jarque-Bera	24.41444	24.30444	594.7953	6732.546	381.6919	7.994128	146.0812	70.56553
Probability	0.000005	0.000005	0.000000	0.000000	0.000000	0.018369	0.000000	0.000000
Sum	495343.4	312.0826	8183439.	949.6297	1.66E+14	587.3393	-1.46E+12	1.35E+14
Sum Sq. Dev.	9.51E+08	209.3848	1.06E+12	7255.149	3.19E+26	2864.361	1.16E+24	1.04E+26
Observations	210	210	210	210	210	210	210	210

From the result above, the mean of Gross Domestic Production (GDP) growth that developed from the EViews is 2.7969 and the median value is 2.3678. The maximum value of the GDP is 14.2309 and the minimum is -10.1493. While the standard deviation of GDP is 3.702. For the independent variables, first of all the mean Research and Development Expenditure (RNDE) developed from the Eviews is 1.4861 and medium value is 1.1180. The maximum value of the RNDE is 3.3679 and the minimum is 0.2008. While the standard deviation of RNDE is 1.0009. For the variable Researchers in Research and Development (RRND), the results show that the mean is 2358.778 and median value is 1211.121. Meanwhile, the maximum value is 7846.658 and the median value is 134.9126. The standard deviation of RRND is 2133.66. The mean and medium value of variable Patent Application (PA) is 38968.76 and 10939.50 respectively. While the maximum value and minimum value of PA is 336340 and 16 respectively. From the data, it shows that the skewness of RNDE, RRND, and PA are positively skewness which means the left skewness and the right tail of the distribution graph are longer while the GDP have negative skewness which means right skewness and left tail of the distribution is longer. The control variables also included in the analysis as well.

4.2 Correlation

Table 4.2: Results of Correlation

Covariance Analysis: Ordinary
Date: 04/11/23 Time: 20:48
Sample: 2005 2019
Included observations: 210

Correlation Probability	RRND	RNDE	PA	INF	GFCF	GDP
RRND	1.000000 -----					
RNDE	0.867173 0.0000	1.000000 -----				
PA	0.189852 0.0058	0.460419 0.0000	1.000000 -----			
INF	-0.378889 0.0000	-0.419546 0.0000	-0.185323 0.0071	1.000000 -----		
GFCF	0.144804 0.0360	0.479614 0.0000	0.862101 0.0000	-0.208838 0.0024	1.000000 -----	
GDP	-0.340438 0.0000	-0.171294 0.0129	0.099234 0.1519	0.008851 0.8985	0.202695 0.0032	1.000000 -----
FDI	0.307447 0.0000	0.274688 0.0001	-0.106592 0.1236	-0.090278 0.1925	-0.184411 0.0074	-0.298763 0.0000
EXP01	0.302342 0.0000	0.617243 0.0000	0.782703 0.0000	-0.297940 0.0000	0.887666 0.0000	0.142418 0.0392

According to the results developed from EViews, there is a a negative weak correlation of RRND and RNDE between GDP. The PA has a positively very weak correlation with GDP. Other control variables, INF and EXP has positively very weak correlation with GDP while FDI has a negative weak correlation with GDP. Last but not least, GFCF has a positive weak correlation with GDP.

4.3 Unit root test

Table 4.3: Unit Root Test

	Augmented Dickey-Fuller		Philip-Perron	
	Level	1st Difference	Level	1st Difference
EXP	43.6384**	98.8168***	65.0877***	161.801***
FDI	34.0515	106.976***	62.3325***	251.260***
GDP	63.0910***	116.039***	100.511***	268.093***
GFCF	37.0983	82.0712***	32.599	95.2044***
INF	52.4224***	92.6527***	56.4190***	202.569***
PA	38.1071*	72.2049***	40.8320*	84.8876***
RNDE	27.3955**	56.8702***	22.3734*	98.7192***
RRND	15.5967	44.7161**	45.1407**	104.133***

Notes: *, **and*** indicated the significant at the 10%, 5% and 1% levels, respectively.

H_0 (Null hypothesis): The panel data has unit root. (Non-stationary)

H_A (Alternative hypothesis): The panel data has no unit root. (Stationary)

As the p-value of the data is less than α=5%, the null hypothesis will be rejected, and we can conclude apart from that the panel data has no unit root and stationary.

From the table above, in the Augmented Dickey Fuller GDP and INF has the significance at 0.01 level. RNDE and EXP has the significance at 0.05 level while PA has the significance at the 0.10 level. On the other side, in the Philip-Perron EXP, FDI, GDP, INF has the significance at the 0.01 level respectively. PA and RNDE has the significance at the 0.10 level while RRND has the significance at the 0.05 level. After first difference, all variables regardless within Augmented Dickey or Phillip- Perron are at the level of 0.01 except RRND in Augmented Dickey has a significance at the 0.05 level. Since p- value of 8 variables is less than 0.05 and reject null hypothesis. Thus, we can conclude that 8 variables had no unit root and stationary at the first difference and these data will be used at the next section.

4.4 Selection Method of Regression

There are three regression models for panel data including Ordinary Least Square, Fixed Effect Model and Random Effect Model. From the last section, the unit root of the data had been tested and results show that the first difference of the variables is stationary and used to form the model. The Redundant Fixed Effect Test, Hausman Test and Test Lagrange Multiplier are used to select which is the model is the best.

4.4.1 Redundant Fixed Effect Test

The redundant fixed effect test has been run to determine the more efficient model between the ordinary least square and fixed effect test. This test tested whether fixed effects are necessary in the determination of the relationship between digital economy and total factor productivity(Rizka Zulfikar, 2018).

Table 4.4.1: Results of Redundant Fixed Effect Test

Redundant Fixed Effects Tests
Equation: Untitled
Test cross-section fixed effects

Effects Test	Statistic	d.f.	Prob.
Cross-section F	0.142190	(13,175)	0.9998
Cross-section Chi-square	2.059426	13	0.9997

H_0 (Null hypothesis): Select OLS model is better. (p-value>0.05)

H_A (Alternative hypothesis): Select FEM is better. (p-value<0.05)

Based on the results from the table above, the p-value of the statistic is 0.9997 which is greater than 0.05, so we do not reject the null hypothesis. Hence, it can conclude that selecting OLS model is more appropriate.

4.4.2 Hausman Test

To determine whether Random Effect or Fixed Effect are better to use, Hausman Test is the suitable method to make selection. If the p value of the Hausman test is below 0.05, the method better to choose is fixed and in contrary, if the p value is greater than 0.05, the random test will be chosen(Rizka Zulfikar, 2018).

Table 4.4.2: Results of Hausmen Test

Correlated Random Effects - Hausman Test
Equation: Untitled
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	1.670072	7	0.9758

H_0 (Null hypothesis): Select REM is better. (p-value>0.05)

H_A (Alternative hypothesis): Select FEM is better. (p-value<0.05)

Based on the result on the table above, the p value of the cross- section random is 0.9758 which is greater than 0.05 level of significance, therefore we accepted the null hypothesis and can conclude that Random Effect Model is better. Then, to choose between Random effect and Ordinary least square, it needs to proceed to the Lagrange Multiplier test.

4.4.3 Breusch-Pagan Lagrange Multiplier Test

Lagrangian Multiplier Test, also known as the Breusch-Pagan Lagrange Multiplier Test, is an analysis used to decide which panel data regression model the common effect or the effect model superior. Whether or not a random effect is used, the Lagrange Multiplier test contains a function to calculate the best estimate(Rizka Zulfikar, 2018).

Table 4.4.3: Results of Breusch-Pagan Lagrange Multiplier Test

Lagrange Multiplier Tests for Random Effects
Null hypotheses: No effects
Alternative hypotheses: Two-sided (Breusch-Pagan) and one-sided (all others) alternatives

	Test Hypothesis		
	Cross-section	Time	Both
Breusch-Pagan	5.867296 (0.0154)	183.2866 (0.0000)	189.1539 (0.0000)

H_0 (Null hypothesis): Select OLS model is better. (p-value>0.05)

H_A (Alternative hypothesis): Select REM is better. (p-value<0.05)

Based on the result on the table above, the p value of the Breusch-Pagan is 0.0000 which is smaller than 0.05 level of significance, therefore we reject the null hypothesis and can conclude that REM is better.

4.5 Model Selection

After the three tests done to estimate the best method, there are two tests that shown that select REM is better in this study so we can conclude that the REM is used to determine the relationship between the research and development expenditure and economic growth.

<u>Random Effect Model</u>

$$\triangle GDP=-0.211780+0.0000\triangle FDI+0.00000\triangle EXP-0.0000\triangle GFCF-$$

[0.1025] [2.2539**] [-0.1466]

$$0.63543\triangle INF-0.0000\triangle PA-12.89879\triangle RNDE+0.002458\triangle RRND$$

[-0.6170] [-0.4888] [-3.1127***] [1.1691]

R square=0.0940 Adjusted R Square=0.0603 Durbin-Watson stat=2.8716

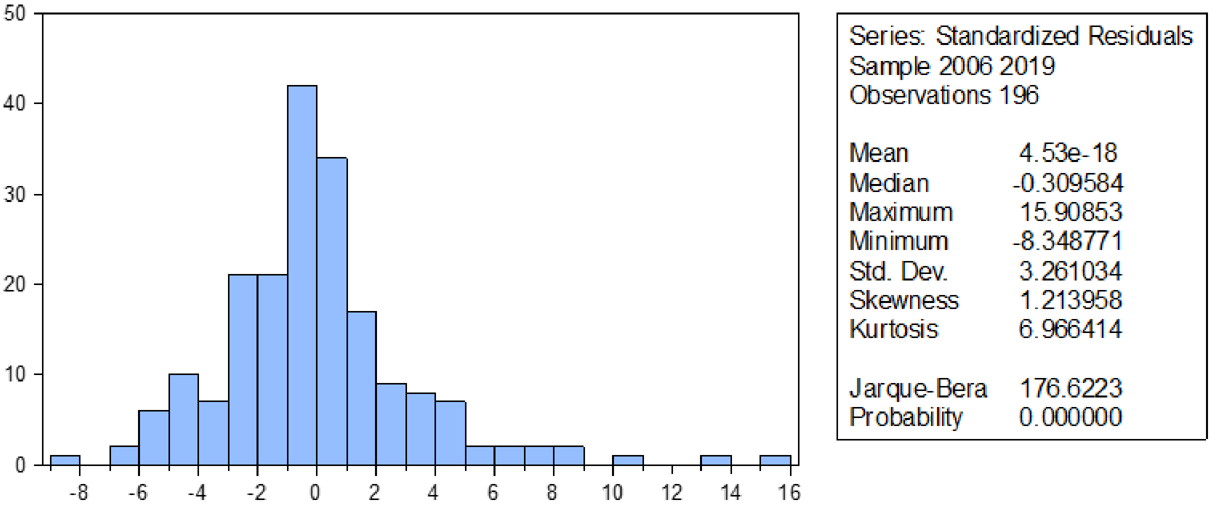
Based on the REM model we selected, the explanatory variables accounted for 9.4% of the variation in the first difference GDP model. Other than that, we can observed that 1 unit increase in △EXP, has positive relationship increasing △GDP by 0.0000 units statistically significance at 0.05 level. Moreover Other than that, we can observed that 1 unit increase in △RNDE, has negative relationship decreasing △GDP by -12.89879 units statistically significance at 0.01 level.

4.6 Residual Diagnosis

In this research, there are a few tests developed in the residual diagnosis section which are Normality Test, Autocorrelation Test, Multicollinearity test, Heteroscedasticity test.

4.6.1 Normality Test

Figure 4.6.1: Graph of Normality Test



H_0 (Null hypothesis): The residuals are statistically normally distributed. (p-value>0.05)

H_A (Alternative hypothesis): The residuals are statistically not normally distributed. (p-value<0.05)

Since the probability value of Jarque-Bera is 0.0000 which is smaller than 0.05; therefore, we reject null hypothesis. We can conclude that the residuals are statistically not normally distributed.

4.6.2 Autocorrelation

Table 4.6.2: Results of Autocorrelation

Autocorrelation
Dependent Variable: RESID01
Method: Panel EGLS (Cross-section random effects)
Date: 04/12/23 Time: 11:12
Sample (adjusted): 2007 2019
Periods included: 13
Cross-sections included: 14
Total panel (balanced) observations: 182
Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.042827	0.238585	-0.179506	0.8577
RESID01(-1)	-0.365395	0.071278	-5.126300	0.0000

H_0 (Null hypothesis): The residuals have no serial correlations. (p-value>0.05)

H_A (Alternative hypothesis): The residuals are serial correlations. (p-value<0.05)

Since the probability value of statistic is 0.0000 which is less than 0.05 at the significance; therefore, we reject null hypothesis and accepted the alternative hypothesis. We can conclude that the residuals are serial correlations.

4.6.3 Multicollinearity Test

Table 4.6.3: Results of Multicollinearity Test

Variance Inflation Factors
Date: 04/13/23 Time: 01:34
Sample: 2005 2019
Included observations: 196

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
D_FDI	1.54E-23	1.054443	1.054298
D_EXP01	1.48E-23	1.934834	1.735480
D_GFCF	1.27E-23	1.859526	1.502289
D_INF	0.012361	1.133858	1.124986
D_PA	9.74E-09	1.444591	1.152484
D_RNDE	18.68522	1.408969	1.207375
D_RRND	5.09E-06	1.557087	1.212508
C	0.107622	1.798928	NA

H_0 (Null hypothesis): The residuals have no multicollinearity. (VIF<5)

H_A (Alternative hypothesis): The residuals are multicollinearity. (VIF>5)

From the table above, the uncentered VIF and centered VIF of the variables of RNDE, RRND, PA, FDI, EXP, GFCF and INF is below 5, therefore we can accept the null hypothesis and conclude that the residuals have no multicollinearity.

4.6.4 Heteroscedasticity Test

Table 4.6.4: Results of Heteroscedasticity Test

Heteroskedasticity test
Dependent Variable: RESID12
Method: Panel EGLS (Cross-section random effects)
Date: 04/12/23 Time: 11:26
Sample (adjusted): 2006 2019
Periods included: 14
Cross-sections included: 14
Total panel (balanced) observations: 196
Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXP01	-5.75E-13	6.91E-13	-0.832367	0.4063
FDI	3.02E-12	2.97E-12	1.017638	0.3102
GDP	0.447021	0.060335	7.408928	0.0000

H_0 (Null hypothesis): The residuals have no heteroscedasticity. (p-value>0.05)

H_A (Alternative hypothesis): The residuals are heteroscedastic. (p-value<0.05)

Hence, the p value of the heteroscedasticity test is 0.0000 which is smaller than 0.05 level of significance, we reject the null hypothesis. It can be concluded that the residuals are heteroscedasticity.

4.7 Conclusion

There are several tests conducted in this chapter, and the results are also discussed with the interpretation. The data had been different one time to make it stationary and no unit root for following tests such as OLS, FEM and REM Finally, there is the best method of regression model which is REM had been chosen to determine the impact of research and development expenditure on economic growth. With the REM model, the residual diagnosis had been done and the finding had discussed as well.

Chapter 5: Discussion, Conclusion and Implications

5.1 Discussion of the major findings

5.1.1 Research and development expenditure

The regression results of this study indicate that the research and development expenditure did influence economic growth as 1 unit increase in RNDE, has negative relationship decreasing △GDP by -12.89879 units statistically significance at 0.01 level. This is supported by (Kadir et al., 2019), as they mentioned the reason why the RNDE will brings negative effects to economy is due to the provisional allegations. Public-sector R&D frequently has distinct objectives and priorities, such as national security or social welfare, in contrast to private-sector R&D, which is largely motivated by commercial interests and market demand. Because of this, the financial advantages of government-funded R&D may not be immediately apparent or quantified, which causes some politicians to doubt the necessity of these expenditures. R&D may take resources away from other productive endeavors that are more immediately advantageous to the economy, which is another rationale that might be put up. For instance, if a government spends a lot of money on research and development but little on infrastructure, healthcare, or education, this might have a detrimental overall effect on economic growth. Similar to this, the net economic impact may be adverse if R&D is focused on areas of the economy that have limited potential for future or growth, such as dwindling manufacturing sectors. The results was also supported by (Zhong et al., 2011), who said that a disproportionate allocation of resources to R&D activities might result in resource waste and slower economic progress. R&D funding may be given to initiatives or sectors that have little bearing on economic growth, which can lead to resource waste and slower economic expansion. Unreasonable resource allocation for R&D activities might result in resource waste and slow down economic progress. This may occur if R&D funds are allocated to initiatives or sectors that have little bearing on economic expansion. For this reason, it's crucial to allocate R&D resources in a strategic manner. Understanding the objectives, priorities, and goals for the country's development is necessary for effective resource allocation. The influence of R&D on economic growth may be increased by properly coordinating these operations with development objectives. Similar results also supported by (Frank R. Lichtenberg, 1992) as they stated the advantages of R&D might not immediately boost economic expansion. Improvements in public health, education, and environmental protection, for instance, might result from R&D operations. These areas are crucial for social welfare and quality of life. But these advantages Furthermore, it's possible that there will be a delay before the advantages of R&D are fully realized. This might make it challenging to assess the short-term effects of R&D operations, but it's crucial to take into account the long-term advantages of R&D in terms of economic growth and social welfare. may not be completely reflected in conventional economic growth indicators like GDP.

5.1.2 Researchers in Research and development

Based on the regression result, increase in the total researchers in R&D did brings positive impacts towards the economic growth. The results is supported by (Gene M. Grossman & Elhanan Helpman, 1991) as they found out increasing in researchers brings spillover effects. It has been shown that one of the main forces promoting innovation and productivity growth is the spread of information and technology through spillover effects. When businesses invest in R&D, they create new technologies and knowledge that can be applied by other businesses and industries in addition to the investing company. Many different channels, including labor mobility, patent licensing, and knowledge spillovers, can lead to these spillovers. The mobility of the labor force is a significant avenue for spillovers. Skilled researchers can bring their knowledge and experience to new projects and technologies when they transfer from one company or sector to another. For instance, a researcher who previously worked for a pharmaceutical company on the development of a new medicine may join a biotech startup and use their expertise to create a new therapy for a different condition. Patent licensing is another method of spillovers. Businesses that possess patents on cutting-edge innovations can license such patents to rival businesses so that other businesses can utilize the technology to advance their own goods or procedures. This enables businesses to benefit from other people's R&D efforts, boosting productivity and efficiency across the economy. Spillovers of knowledge are crucial for fostering innovation and development. Firms may learn from each other's achievements and mistakes when they exchange knowledge, whether formally or informally. This allows them to enhance their own procedures and technology. This kind of information exchange can take place through both official and informal networks, including government-funded research consortiums and trade organizations. Besides, Increasing in researchers also can expedite the research and development progress, as we know R&D process in unprofitable and costly at the same time. As the amount of researchers increased, the whole process can be speed up and the costing can be cut down also the positive effects of R&D can reflected promptly toward the economy(Bayarçelik & Taşel, 2012).

5.1.3 Patent Applications

Refer to the model resulted, the patent application has negative impacts towards countries' economic growth as supported by (Nguyen & Doytch, 2022) especially in the emerging market. They claimed that the advantages of patent regimes might not be dispersed equally, particularly in developing nations where there might be insufficient absorptive capacity and expertise. Competencies are the knowledge and abilities a company needs to successfully find and utilize new information and technologies. Absorptive capacity is the ability to do so. Local businesses in many developing nations could be unable to properly capitalize on patented discoveries due to a lack of necessary skills and capacity for absorption. This might result in a scenario where foreign companies, who could have more resources and expertise, are better equipped to capitalize on patented discoveries than domestic companies. This may result in a situation where developing nations are forced to rely on foreign corporations in order to get cutting-edge technology, which may restrict their capacity to innovate and advance their own technical skills. Furthermore, because patenting comes with high costs, the rise in patent applications may also be detrimental to developing nations. The process of obtaining a patent can be costly and long consuming, involving considerable effort and financial commitments. Local businesses in developing nations may find this particularly difficult because they may have few resources and encounter many obstacles when trying to obtain finance. As a result, local businesses may be discouraged from making R&D investments, which might hinder innovation and technological advancement. Additionally, the increase in patent applications may put local businesses in developing nations at risk of foreign businesses suing them for patent infringement. This might happen when local businesses unintentionally violate a foreign company's patent due to ignorance or a lack of information availability. Local businesses may be required to pay large damages or licensing costs in such circumstances, which might further restrict their capacity to spend money on R&D and advance their technical skills.

5.2 Implication of study

Economic growth, especially its long-run sustainability, has long been a focal point of academic researchers and policy makers. Numerous attempts have been made to provide a long list of factors that may have an impact on economic growth. Any country's growth and development in the economy depend heavily on research and development activities. R&D's effects, however, may differ amongst nations, particularly those with varying degrees of development. R&D might not be the best strategy for developing nations to increase economic growth; alternative factors like foreign direct investment (FDI) might be more suitable. This is because developing nations might not have the infrastructure and capacity for absorption required to fully benefit from R&D expenditures.

Enhancing research quality in terms of effectiveness and efficacy is crucial. This may be done through funding research infrastructure, educating researchers, and forming partnerships with other nations or academic institutions. Furthermore, both in terms of issues and methodologies, the research agenda needs to be precise and well-defined. This can make sure that research efforts are focused on certain objectives and have a bigger influence on economic growth.

It is also vital to make sure that R&D projects have long-term effects that can sustain economic growth over the following 20 to 35 years. This may be achieved by developing a comprehensive R&D plan that takes into account the goals and demands of the country. The strategy should also establish the parameters and components of R&D operations, such as resource allocation, subject selection, and evaluation of research findings. By implementing a planned and all-encompassing R&D strategy, nations may reap the benefits of research and development operations for their economic growth and prosperity.

In order to implement these recommendations into reality, policymakers and decision-makers must collaborate closely with the scientific community to create R&D-focused policies and strategies. This may entail forming collaborations with universities and research organizations, offering money for R&D initiatives, and giving incentives for scientists to do high-caliber research. Additionally, by offering tax breaks or other forms of financial assistance, policymakers can motivate the private sector to invest in R&D activities.

5.3 Limitation

There are several limitation in this study. First of all, the dependent variable (DS) and independent variables are compounded from several components and different indicators. There is no clear understanding of the link between R&D expenditures, patented innovations, and researchers in R&D population in our study. In our study, we are using the aggregate average value of all components and indicators for those three variables. Thus, the results that we found can only show the overall relationship of between research and development (R&D) . Secondly, to ensure the data for all the included variables are available in all the sample period, we have the limitation on small countries sample and periods, which might cause the results are not comprehensively enough.

5.4 Recommendation for Future Research

For future studies, researchers who intend to study the similar topic may include all sub-components and indicators that use to compound the overall research and development environment in one particular country, could be divide into different sector R&D. This may provide a clearer result on which parts of the research and development would have the significant relationship with specific parts of the country economic growth, providing more specific targets for governments to achieve on their policy design. Besides that, researchers may also conduct the study using time series data focus on one country rather than using panel data that conducted on several sample countries. This will provide useful insights for specific country for their policies design.

5.5 Conclusion

Currently, the world is pledged to boost up the research and development sector in order to expecting someday they can be the bellwether in the world. At the same time, current global economic been slowing down due to various factors such as pandemic and shortage of resources lead to they do not have sufficient budget. Therefore, it is important for country to ensure that both R&D and economy can be improved from time to time. Thus, this research aims to study whether increasing research and development expenditure is good or bad for country to achieve higher economic growth. By employing quantile regression analysis on different income-level countries, we able to capture the nexus at different R&D expenditure ratio on different developing status countries.

The results of this research show that importance of research and development for economic growth and development might vary different countries. While enhancing the calibre and efficacy of their R&D initiatives, emerging nations may also need to concentrate on other factors like FDI. This may be accomplished by making investments in research infrastructure, setting up distinct research agendas, and creating thorough R&D plans. Countries may maximise the advantages of research and development activities for their economic development and prosperity by adopting a structured and comprehensive strategy to R&D.

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