DETERMINANTS OF ECONOMIC GROWTH IN SOUTHEAST ASIAN COUNTRIES: BAYESIAN MODEL AVERAGING APPROACH

Master's Degree Thesis

Supattra MARAYA

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Supattra MARAYA

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Department of Economics

Supervisor: Prof. Dr. Mustafa ÖZER

Eskişehir

Anadolu University,

Graduate School of Social Sciences

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This thesis titled "**Determinants of Economic Growth in Southeast Asian Countries Bayesian Model Averaging Approach**" has been prepared and submitted by **Supattra MARAYA** in partial fullfillment of the requirements in "**Anadolu University Directive on Graduate Education and Examination**" for the Master of Arts in **Department of Economics Program in Economic (English)** has been examined and approved on **09/05/2019.**

Committee Members		**Signature**
Member (Supervisor)	: Prof.Dr.Mustafa ÖZER	
Member	: Assoch.Prof.Dr.Erkan ÖZATA	
Member	: Assoch.Prof.Dr.Necati ÇIFTÇİ	

09/05/2019
Date

Prof.Dr.Hasan TUTAR
Director
Graduate School of Social Sciences

ÖZET

GÜNEYDOĞU ASYA ÜLKELERİNDE EKONOMİK BÜYÜMENİN BELİRLEYİCİLERİ: BAYESCİ ORTALAMA MODEL YAKLAŞIMI

Supattra MARAYA

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Danışman: Prof. Dr. Mustafa ÖZER

Güneydoğu Asya, olağanüstü büyümesiyle dikkat çeken bir bölgedir. Dünyadaki altıncı büyük ekonomik işbirliği olan Güneydoğu Asya Ülkeleri Birliği (ASEAN,) önemli bir başarıdır. Bölgenin hızlı büyümesi, araştırmacıları bu büyümenin arkasındaki nedenleri araştırmaya motive etmektedir. Bu çalışmada, Güneydoğu Asya ülkelerindeki ekonomik büyümenin itici güçleri ve temel belirleyicileri, Bayesci Ortalama Model yaklaşımı ve Bayesci Çoklu Doğrusal Regresyon yöntemleri ile tahmin edilmektedir. Tahminde 1975-2014 döneminde on ülkeye ait panel veriler kullanılmıştır. Veriler, büyümenin artan ve azalan trendlere sahip olduğunu göstermektedir. Bu nedenle, tahminler, büyümede artan (CLMV) ve azalan (ASEAN kurucu) trendlere sahip ülkeler ve tüm ülkeler için yapılmıştır. Tahmin sonuçları, doğrudan yabancı sermaye girişlerinin, tüm bölge ülkelerinin büyümesi için; temel itici güçleri olduğunu göstermektedir. Bunun temel nedeni, bölgenin oldukça vasıflı işgücü yapısına sahip olması ve toplam faktör verimliliğinin sürekli artmasıdır. Bu etkenler sayesinde, bölgeye yatırım yapan yabancı yatırımcılar ikna edilmektedir. Daha az gelişmekte olan ülkeler ile ve artan büyüme trendine sahip olan ülkelerde büyümenin temel belirleyicileri beşeri sermaye artışları ile artan tasarruf oranları iken, azalan büyüme trendine sahip ülkelerde toplam faktör verimliliğidir.

Anahtar Sözcükler: İktisadi büyüme, Güneydoğu Asya, Büyümenin belirleyicileri, Bayesci yaklaşımı

ABSTRACT

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Southeast Asia is a region with the recognized outstanding growth. The Association of Southeast Asian Nations (ASEAN) which ranks the sixth largest economy of the world is a key success. The rapid economic growth motivates researchers to study the reason behind that growth. This study is done to determine the robust determinants and investigate the driving forces of the economic growth in Southeast Asian countries. Determinants are estimated by applying Bayesian Model Averaging approach through Bayesian Multiple Linear Regression. We used panel data of ten countries during 1975-2014 for the regression. The data illustrates the insight of growth trend for every country into increasing and declining trends. We, then, do the estimation and get the results for different three groups, the whole region, upward (CLMV), and downward (ASEAN founder) growth trends. The results suggest that foreign direct investment inflows are the main economic drivers of the whole region. This is because of the rich labor characteristics and the continuous improvement of total factor productivity. These, therefore, seem to convince the international investors investing in this region especially in production side. The growth determinants of the less developing countries or increasing growth trend group are increase in human capital and increase the rate of saving, while the declining growth trend group is total factor productivity.

Keywords: Economic growth, Southeast Asia, Determinants of growth, Bayesian approach

PREFACE

Economic growth is a main objective for macroeconomics since growth makes you happy. Historically, growth seems not long-lasting due to business cycle and other external change and shock. Economists have been tried to focus on the sustainable growth rather than transitory growth and what determines the growth types is important.

The aim of this study was to take a closer look at determinants of long-term economic growth in Southeast Asian region which representative by 10 countries of ASEAN members. By looking at the factors that determine the growth in these countries, this study has tried to recommend how those determinants directly and consequently affect to the economic growth. Whether they are sustainable or just lead to the growth in short-run only.

I would like to declare the highest gratitude toward my supervisor, Prof. Dr. Mustafa Özer, for his kind support, patience and guidance throughout my thesis and for facilitating me in successful completion of my work. I would also like to express my gratitude to my family and friends for their prayers, support and encouragement throughout my work.

Last but not the least, I would like to humbly thank Turkish government for providing me an opportunity to study in one of their prestigious universities. It has been a learning experience along multiple dimensions and has added to my personal growth and development.

22/04/2019

STATEMENT OF COMPLIANCE WITH ETHICAL PRINCIPLES AND RULES

I hereby truthfully declare that this thesis is an original work prepared by me; that I have behaved in accordance with the scientific ethical principles and rules throughout the stages of preparation, data collection, analysis and presentation of my work; that I have cited the sources of all the data and information that could be obtained within the scope of this study, and included these sources in the references section; and that this study has been scanned for plagiarism with "scientific plagiarism detection program" used by Anadolu University, and that "it does not have any plagiarism" whatsoever. I also declare that, if a case contrary to my declaration is detected in my work at any time, I hereby express my consent to all the ethical and legal consequences that are involved.

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LIST OF ABBREVIATIONS

AEC	: ASEAN Economic Community
AFTA	: ASEAN Free Trade Area
ASEAN	: Association of Southeast Asian Nations
ASEAN-6	: Brunei, Indonesia, Malaysia, the Philippines, Singapore, and Thailand
BIC	: Bayesian Information Criterion
BMA	: Bayesian Model Averaging
BMLR	: Bayesian Multiple Linear Regression
CLMV	: Cambodia, Lao PDR, Myanmar, and Vietnam
COE	: Centre of Excellence
FDI	: Foreign Direct Investment
GDP	: Gross Domestic Product
GERD	: Gross Expenditure on R&D
H	: Labor
JAGS	: Software Program Name “Just Another Gibbs Sampler”
K	: Capital
LRT	: Likelihood Ratio Test
NHST	: Null Hypothesis Significance Testing
MCMC	: Markov Chain Monte Carlo
MDG	: Millennium Development Goal
PPP	: Purchasing Power Parity
PWT9.0	: Penn World Table 9.0
rjags	: R package to create an interface between R and JAGS
R&D	: Research and Development
SD	: Standard Deviation
TFP	: Total Factor Productivity
TFR	: Total Fertility Rate
UNPD	: United Nations Population Division
USA	: United States of America
USD	: United States Dollar
WDI	: World Development Indicators
WGI	: Worldwide Governance Indicators

1. INTRODUCTION

1.1. Background of Economic Growth in Southeast Asian Countries

Southeast Asia is one regional part of Asia. It is located between the east of the Indian subcontinent and the south of China. It consists of two geographic lands - a continental projection, commonly called mainland Southeast Asia, and a cluster of archipelagoes to the south and east of the mainland, called insular Southeast Asia. Mainland Southeast Asia consists of Cambodia, Vietnam, Laos, Myanmar, Thailand, Malaysia and Singapore. Insular Southeast Asia consists of the archipelagic nations of Brunei, Indonesia, Timor-Leste, and the Philippines. Sometime Cambodia, Laos, and Vietnam often are collectively called the Indochina. The tip of the mainland from the south of Thailand to Singapore is previously called Malaya. Malaysia is both mainland and insular with the western part on Malaya and the eastern part on the island of Borneo, the same island with Brunei and some parts of Indonesia.

The whole part of Southeast Asia falls within the tropical climate zones. Hence it receives lots of annual precipitation. The landscape combines three physical elements - mountain ranges, plains, and plateaus. The rivers probably reflect the greatest historical and cultural significance as it contributes to agriculture, the border of political and economic patterns and cultural diversity. In addition, Southeast Asia is perhaps the most diverse region with multi-ethnic, multi-religious, multicultural and multilinguistic patterns.

From the past, Southeast Asia has been knowing as an important trade area due to its location which is easily accessible to the sea. Many western nations came to intervene in the region during the colonization and World War II because they yearned for its abundance of natural resources. The integration of Southeast Asia into the world economy had essential contributed to the regional economic development and this led to the significant improvements among their population growth and economic activity.

The Association of Southeast Asian Nations, or ASEAN, was established on August 8, 1967, in Bangkok, Thailand with the signing of the ASEAN Declaration (Bangkok Declaration) of six countries, Brunei, Indonesia, Malaysia, the Philippines, Singapore, and Thailand, henceforth ASEAN-6 (ASEAN Secretariat, 2017). Later, new members, who most were once considered adversaries during the Cold War era, joined

the organization, Vietnam in 1995, Lao PDR and Myanmar in 1997, and Cambodia in 1999 (Samphantharak, 2017), hereafter called CLMV.

In 2017 which is the occasion of 50 years of ASEAN, we could clearly see the growth progress in Table 1.1. It implies that the robust economic growth resulted ASEAN collectively stood as the sixth largest economy in the world with a combined GDP of USD2.55 trillion in 2016. This reflected the positive real GDP growth and improved almost 2 times for the share of the world GDP from 3.3% in 1967 to 6.2% in 2016.

Table 1.1. *ASEAN Growth Progress in 50 Years (ASEAN Secretariat, 2017)*

50 years of ASEAN in figures	**1967**	**2017**
Population (in million)	185	634
GDP per capita (in USD)	122	4,021
Trade (in billion USD)	10	2,219
Life expectancy (in years)	56	71

In addition, there has been rapid economic growth in CLMV groups rather than ASEAN-6. The evolution of CLMV real GDP growth caused a rise in the standard of living in those countries. As a result, there is a poverty reduction in ASEAN which ASEAN population living below USD1.25 PPP per day declined from 47% in 1990 to 14% in 2015. This achievement has been perceived and we are seeking the reason behind.

Southeast Asian region, especially CLMV group, is only one from emerging Asia market which is projected remaining strong on growth to 2022 although its growth might be a bit lower than the average of the 2011-2015 period (OECD, 2018). The considerable growth performance has driven them up from the poverty country group into the lower middle-income group. However, the rest of the countries in the region are still in the upper middle-income group classification except Singapore and Brunei (World Bank, 2018) which are in the high-income group.

The potential determinants of economic growth are the main thing that has been concerning on the economic growth research area. The facts behind the outstanding growth can be cited in various aspects but to find the appropriate variable that could describe those reasons has been continuously argued. This study is focusing on the determinants of economic growth in Southeast Asia.

1.2. Problem Statement

Various empirical researches have attempted to solve the problem of model uncertainty in order to get the most '*true model*' of economic growth according to their theoretical assumptions. Then, it is applied to the many economic groups of countries or organizations in the world starting from the west to the east. Southeast Asian region is one of the interesting groups that has been studied over time. However, there are only a few studies that directly focus on Southeast Asian economic drivers.

The current study of Southeast Asian growth is from Brueckner and Kraipornsak (2016). They used the traditional approach creating a linear growth model that developed from Loayza, Fajnzylber, and Calderon (2005) and Araujo, Brueckner, Clavijo, Vostroknutova, and Wacker (2014). They found that the most important driver of economic growth in Southeast Asian countries was transitional convergence which contributed one half of the region's growth. Transitional convergence is defined by Loayza et al. (2005) according to neoclassical growth theory that the growth rate mostly depends on its initial position of the economy. According to the convergence theory, low-income countries like Southeast Asian economy would definitely have a high rate of growth.

In addition, Fogel (2009) stated that Southeast Asian countries convergence tended to go forward conditionally. However, there is a study on the income convergence and hypothesis of technological catching up in Southeast Asia. It is found neither evidence of income convergence except Singapore nor technological catching up. This is because ASEAN countries have grown rapidly by copying the technology from the leader country instead of innovating their own one (Lim & McAleer, 2000). So, without having to bear the associated costs of research and development (R&D), they can save the cost of production inputs. This kind of process could contribute to the growth in the short run only as productivity is not improved. A country who invest more in R&D will gain sustainable growth. Hence, the forward growth convergence might be on the condition of regional productivity.

Leon-Gonzalez and Vinayagathasan (2015) used the Bayesian Model Averaging (BMA) approach to find the determinants of growth in Asian developing economies. They found that investment and trade openness are the most robust growth determinants for their sample countries. In addition, many researchers also agreed that government

expenditure plays the important role in East Asian countries (Petri, 1993; Lim & McAleer, 2000). We can see that, with a different approach, the result is diverse significantly.

To study on growth determinants, there are plenty of factors and the long period of data involved in the growth consideration. With the traditional or frequentist approach, dealing with many variables wastes the time for regression and we might not get any factor that is significant to the null hypothesis (Sala-i-Martin, 1997). Therefore, the Bayesian approach is the appropriate method to find the relation between one predicted value and lots of predictors. Because Bayesian way does not go through the null hypothesis that researcher must assume to test the given data whether it is going to be accepted or ignored. With the prior belief of Bayesian rule, it makes the researchers can get the result directly from observed data not from the postulated statement.

The study for identifying the facts and sources of growth of ASEAN will be useful to understand the economic process of growth driving that have been done in Southeast Asia. Moreover, it will help policymaker be able to focus and develop effectively on the essential factors that relative to sustainable growth rather than transitory increase. Therefore, this study aims to determine the robust determinants and investigate the driving forces of economic growth in Southeast Asian countries. We are going to apply the Bayesian framework in model regression using panel data across countries in Southeast Asia.

1.3. Significance of the Study

Southeast Asia mostly refers to the region of developing countries with potential economic growth performance over 50 years since ASEAN was established. Identifying the facts and sources of growth will be useful for both other developing countries in other regions and even the developed countries in term of structural and policy managements for sustainable growth. Moreover, the main reason of this growth study is for the development of Southeast Asia itself. Since many pieces of research claimed that, without the growth of total factor productivity, their growth is just only transitory and not going to be last especially during the digitalization. If this statement is correct whether they need to reform again and move forward to grow sustainably. This study could suggest them the way forward from their own background.

1.4. Research Objectives

The study aims to diagnose the factors that impact significantly on the outstanding economic growth of Southeast Asian countries. This must be done by achieving the following research objectives:

- To identify the prominent determinants of economic growth in Southeast Asian countries by the Bayesian approach
- To measure the impact of the identified determinants and analyze their causes
- To forecast the future growth trend and provide the suggestion on policy implementation for sustained economic growth in Southeast Asia.

1.5. Assumptions

The basic assumption surrounding this research is based on endogenous growth model which economic growth rate is strongly influenced by human capital investments and technological changes. According to Barro (1996), the higher rates of the involved human capital factors—the initial schooling rate, the life expectancy rate, the government policies, the political freedom and the term of trade—are assumed to impact the rate of economic growth positively. While other involved factors such as the fertility rate, the government spending and the initial level of real per capita GDP relate the economic growth rate negatively. The inflation rate is one of the facts that have an impact on economic growth.

1.6. Scope and Limitation

Among Southeast Asian countries, Timor-Leste is excluded from our method due to a few reasons. Firstly, Timor-Leste is a new country whose current status and characteristics are somewhat different from the main group. Second, the unavailable of data before independence. This study is focusing on 10 countries which have joined in ASEAN because trade openness and government policies within the region are estimated as relevant factors of regional growth. These 10 countries are divided into 2 groups which are CLMV group and ASEAN-6. Another limitation is that a threshold level of any assumed impacts on economic growth that Leon-Gonzalez and Vinayagathasan (2015) have done is not applied. In other words, inflation level across-country is ignored and assumed to be constant over the period.

1.7. Organization of the Study

This study is organized as follows; the second part reviews the literature available on the facts behind Southeast Asian growth. It explains how social and economic factors impact regional economic growth. The public and international relations within the region are also included. This part will help to figure out which predictor values are going to be applied in the Bayesian growth regression.

The third part provides the background of Bayesian inference and the hypotheses testing in this study along with a brief explanation of their development. The fourth part discusses the research methodology, the variables, and their collection in detail and provides the methodology of data analysis. After testing the dataset through the Bayesian approach and providing descriptive statistics, the findings of the data analysis are discussed in the fifth part. The findings are discussed in three dimensions according to the growth trend found by an author.

The final part of the study provides the conclusion in which the research objectives are revisited and linked with the findings of the study, the extent to which they are fulfilled and suggests policy measures in order to have sustainable long-term economic growth in the sample countries.

2. LITERATURE REVIEW

This part contains the facts, the theoretical evidence, and the empirical studies in all economic conditions of economic growth in Southeast Asia. Undoubtedly, given regional diversity, there is no a single comprehensive model of socioeconomic development that could explain their outstanding growth performance in the past six decades (Hill, 2014; Leinbach & Frederick, 2018; Petri, 1993; Samphantharak, 2018; Tilak, 2002; World Bank, 1993). However, some common factors have occurred in several Southeast Asian economies. Below illustrates those contexts and explanations derived from available macroeconomic literature works and theories.

2.1. Stylized Facts of Southeast Asian Growth

This section collects the factors associated with the realistic conditions of economic growth in all economies of Southeast Asia. One objective is to examine how each factor influenced their economic growth. Another is to know whether the factor is a common and significant with the regional rapid growth. In other words, we attempt to specify how different or similar Southeast Asian countries are compared to other developing countries in the world. Do those facts cause outstanding performance in economic growth? The facts presented below are primarily qualitative and used to derive the possible involving indicators for economic growth determinants in Southeast Asia.

2.1.1. Diverse region

This region is fundamentally diverse in various aspects. Geographically, it consists of the mainland, also previously known as Indochina, and maritime which is called Malaya. Being a popular maritime economics and trade routes in history brought people and cultures from other parts of the world into the region. Indigenous ethnics have been living with migrants of Arabs, Indians, and Chinese until now. Consequently, the region becomes a tremendous diversity in religion, culture, and languages (Samphantharak, 2017). In addition, political regimes are settled differently among them due to French, Dutch and British colonization. Both geographical and demographical diversities have led to disparities in socioeconomic outcomes. Regional and individual socioeconomic indicators are dispersed in every level span – low, middle and high – for every country member. Evidently, GDP classification illustrates that Singapore and Brunei are in the

high-income group while Cambodia, Lao, Myanmar, and Vietnam just jumped out from the low income to the lower-middle income class. Besides, their gap is filled up by upper-middle countries such as Thailand and Malaysia (World Bank, 2018).

2.1.2. Outward orientation

Although the socioeconomic development in Southeast Asia is diverse, the development strategies adopted by these countries are somewhat identical over decades. In other words, every country in this region has opened up its economy. Historically, after intervention by both colonialism and the Second World War, they did try to implement the protectionist policies focusing on self-sufficiency. However, this strategy led to several economic problems and the practice was limited by the size of the domestic economy. Therefore, government control has been decreased and the free market has implemented (Samphantharak, 2017). The reform has been reduced the importance given to import substitution strategy and replaced by export orientation.

Petri (1993) mentioned that international trade did play an important role remarkably in Southeast Asia as shown in Table 1.1 above. With ASEAN, their trade has been expanded considerably more than 200 times in 2016 compared to 1967, year of establishment. The reformation of the international policies in favor of multinational firms willing to invest and use their countries as the production base for exports was begun from Singapore in the 1960s following by Malaysia in the 1970s, Thailand and Indonesia in the mid-1980s, respectively (Samphantharak, 2017). The rest, later, did allow access after the collapse of the Soviet Union. As a result, the openness and outward orientation facilitate economic integration of the region.

In 1992, The ASEAN Free Trade Area (AFTA) reflected their need to promote exports and attract foreign direct investment (FDI) in response to competitive emerging economies worldwide. Furthermore, the ASEAN Economic Community (AEC) with the goal of a single market for intra-regional trade is established in 2003 to strengthen the regional economic integration. The agreement is gone through free flows of goods, services, investment, and skilled labor country-to-country.

The concept of economic cooperation does not currently happen but has been continuing for 50 years already. Hence, it is able to say that outward orientation toward the global economy like a case of Southeast Asian countries benefits to an economy in term of trades and investments. Besides, the Southeast Asian region had been recorded

for the highest rank of outward orientation during 1960s – 1990s compared to other regional groups (World Bank, 1993). This caused them to become a new emerging market in the world then.

2.1.3. Export-based countries

Another remarkable success of Southeast Asian outward orientation is that its contribution toward export performance. Given the implementation of trade openness, most of the Southeast Asian income relies heavily on the export of goods and services as its percentage share of GDP shown in Table 2.1 is extremely high especially Singapore, Malaysia, and Brunei.

Table 2.1. *Export of Goods and Services (% of GDP), 1960-2010 (Samphantharak, 2018)*

	1960	**1970**	**1980**	**1990**	**2000**	**2010**
Brunei			93.4	61.8	67.4	81.4
Cambodia	13.9	5.8			49.8	54.1
Indonesia	15.0	13.5	34.2	25.3	41.0	24.6
Lao PDR				11.3	30.1	35.5
Malaysia	50.6	41.4	56.7	74.5	119.8	93.3
Myanmar	19.7	5.2	9.1	1.9	0.5	
Philippines	11.9	21.6	23.6	27.5	51.4	34.8
Singapore	162.9	126.1	202.1	177.2	189.2	199.3
Thailand	15.7	15.0	24.1	34.1	66.8	71.3
Vietnam				36.0	50.0	72.0

In the earlier of export-oriented strategy, commodity export of Southeast Asia was agricultural products because of abundant natural resources. The main commodities are rice for Indonesia and Thailand and metals and oil crops in Malaysia (Petri, 1993). Meanwhile, Singapore is the absence of natural resource but able to export mainly electronics and chemical production from multinational firms. During the 1980s oil price collapse, the region was affected by the commodity price drop and later reformed export strategy by moving from primary good export to manufacturing good export instead. Currently, the top export commodity is electrical machinery and equipment. But

nowadays, good export has been replaced proportionally by service export especially Singapore who dominates in technological and financial services.

The top three export destinations of Southeast Asian countries are intra-ASEAN, China, and the United State. Definitely, ASEAN Secretariat (2017) reported the growth success in the occasion of 50 years anniversary that intra-ASEAN export highly contributed to the economy of the region accounted for 282,274 million US dollar in 2016. Exports seem to be as the engine of growth in the economy of Southeast Asia depending on which sector they are focusing on.

2.1.4. Foreign direct investment

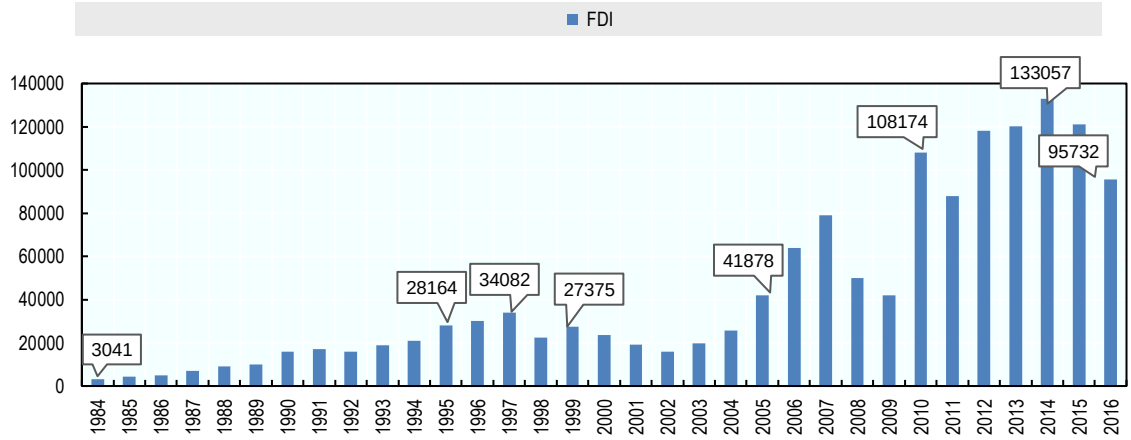

Figure 2.1. *FDI Net Inflows to ASEAN in Million USD (ASEAN Secretariat, 2017)*

However, the flourish of the industrialization and export in Southeast Asia come from the source of FDI. The feature of labor rich and low wage has been attractive FDI into the region since the 1960s. Singapore and the Philippines are competitive in high skilled labor while the rest of ASEAN-6, Thailand, Malaysia, and Indonesia, is a target of low wage foreign investors. Hence, education seems insignificant for the contribution of the East Asian Miracle which is the impressive growth described by World Bank (1993). ASEAN Secretariat (2017) reported FDI inflow to ASEAN tripled higher in 2016 compared to 1999. Figure 2.1 demonstrates an increasing trend of FDI level in ASEAN since 1984. There are some fluctuations - Asian financial crisis during the late 1990s to the early 2000s and global financial crisis in the late of 2000s. After 2015, FDI inflows a bit decline as the world economy slows down both China and Europe. However, OECD (2018) notices the upswing trend in the recent year due to trade recovery, the big infrastructure projects from China like One Belt One Road, the resilience of domestic

demand and the aggressive policy implementation of some governments to develop industries related to information technology and e-commerce. The attempt of keeping the standard level of FDI undoubtedly implies FDI is aware as the true economic driver in Southeast Asia.

2.1.5. High rate of saving and investment

One prominent feature of outstanding Southeast Asian growth is its high saving rates. It leads to a high investment rate because of the high volume in funding resource availability. World Bank (1993) reported on '*The East Asian Miracle*' that Singapore, Thailand, Malaysia, and Indonesia are the new economy of faster growth between 1960 and 1990. Their investment levels during those periods were higher than other developing countries in other regions. The remarkable thing, which made them did better than other middle-income countries, is a 7 percent increase in private investment. In the same way, public investment was processed through domestic infrastructures such as transportation, communication network, and industrial estate.

Moreover, they were only one group of developing economies which saving had excess investment. As a result, it makes them exporters of capital. Besides, when it was compared in term of quantity versus quality, the productivity is found as using less quantity for the same quality. This reflects the development not only in physical capital but also human capital since the school enrollment in the region has increased over time.

2.1.6. Total factor productivity

Total factor productivity (TFP) is discussed during the East Asian Miracle especially the growth from the Southeast Asian region. According to the above mention on saving, investment, and labor, these intensive-input accumulations without the improvement in productivity, such as technological progress or skilled labor, contributes the short-term growth only. It is not long lasting due to the diminishing return to scale once it is closed the steady state. Hence it is debated whether there is real sustainable growth in Southeast Asia during the past half-century.

Krugman (1994) is a strong opponent to this point. He showed the evidence that during that time there was a higher unemployment rate and low school enrollment rate in Singapore. This reflects that Singapore had grown without any improvement in social welfare or human capital investment then this might lead to the slower growth in the

future. In addition, Lim and McAleer (2000) found that no TFP through technological catching up. Every country in Southeast Asia seems to be a technological adopter rather than a technological inventor. Another proponent of the East Asian Miracle argued on the large measurement errors in the study of Krugman (1994) which might cause his conclusion becoming incorrect.

2.1.7. Structural transformation

Structural transformation in Southeast Asia is recognized in all aspects as an economy become more developed and its income increases. The goal of becoming frontier level and the previously supported policies cause the change of economic and social structures in two broad dimensions – sectoral change and demographic transition.

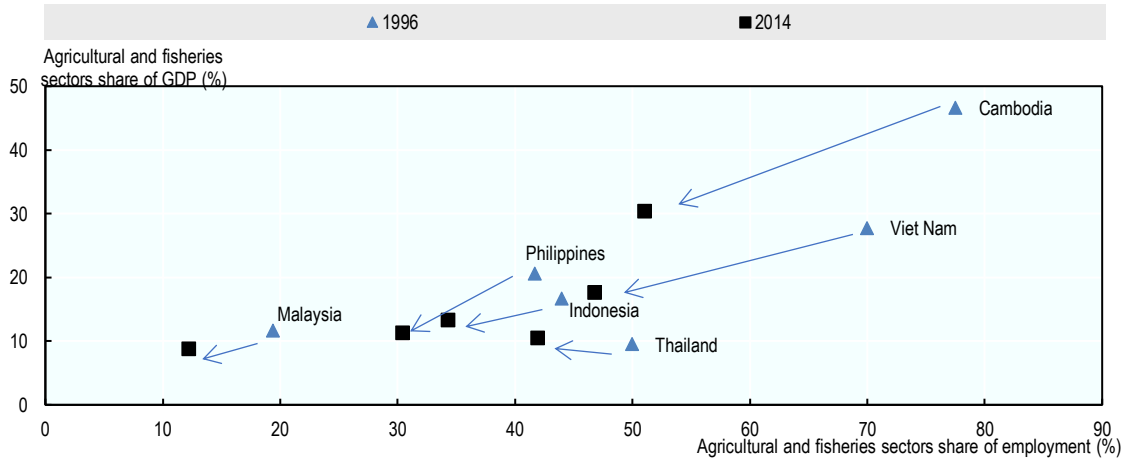

Figure 2.2. *Agricultural and Fisheries Sectors Share of Employment and GDP between 1996 and 2014 (OECD/FAO, 2017, retrieved from http://dx.doi.org/10.1787/888933521579)*

Firstly, sectoral change is an important key to enormous growth performance in Southeast Asia then impacts to other following results of social transition. Basically, there are three sectors in the production side, which are agriculture, industry, and services. Agriculture, which is meant to farming and livestock production, and the fishery are the main source of income for all economies in the region except Brunei and Singapore. Nevertheless, agricultural employment and value have been declining throughout the decades. As the previous mention, Figure 2.2 shows those significant structural changes in the agricultural sector of Southeast Asian countries between 1996 and 2014.

Figure 2.3. *Sectoral Value Added (% of GDP), 1960-2010 (Samphantharak, 2018)*[1]

In addition, the decline in agriculture is associated with a rise in manufacturing. Figure 2.3. illustrates the value added of each sector as the share of GDP from 1960 to 2010. It can be seen clearly that most of all economies faced an increase in manufacturing share over the time of a falling in the share of the agricultural sector. Southeast Asian pattern is quite similar to the structural transformation in other frontier economies of the world, such as the United Kingdom and the United State, that moved from agriculture based to industry based economy since the 1830s (Jones, 2016).

[1] The notation above is arranged from bottom to top: Agriculture (Blue), Non-manufacture Industry (Green), Manufacture (Yellow), Services (Red)

Industrialization is a relatively recent phenomenon as Southeast Asia is about to start the structural transformation from natural-capital intensive primary sector, agriculture, to produced-capital intensive manufacturing, industrialization, in the early 1960s (Hill, 2014; Leinbach & Frederick, 2018; Samphantharak, 2018). However, Singapore recently stands on service sector by providing efficient financial facilities to attract FDI rather than manufacturing hub. As shown in Figure 2.3. , other countries in ASEAN-6, especially Malaysia, Thailand, and Indonesia, are following on the same path unless their financial institutes are not enough potential yet.

Secondly, demographic transition is the impact of sectoral change. Since sectoral change definitely creates an enormous income growth in Southeast Asia then spreads to living standard and health development. As a result, they impact consistently the decline in fertility and mortality rates. Total Fertility Rate (TFR) is defined as the average number of children that a woman will have during her reproductive period (15 to 49 years old) and it is an element of population growth. The improvement in health care is the main cause of lowering mortality at birth then leads to the falling in fertility rate (Samphantharak, 2018). Furthermore, fertility rate relates to population growth which is one of the elements for economic and social developments.

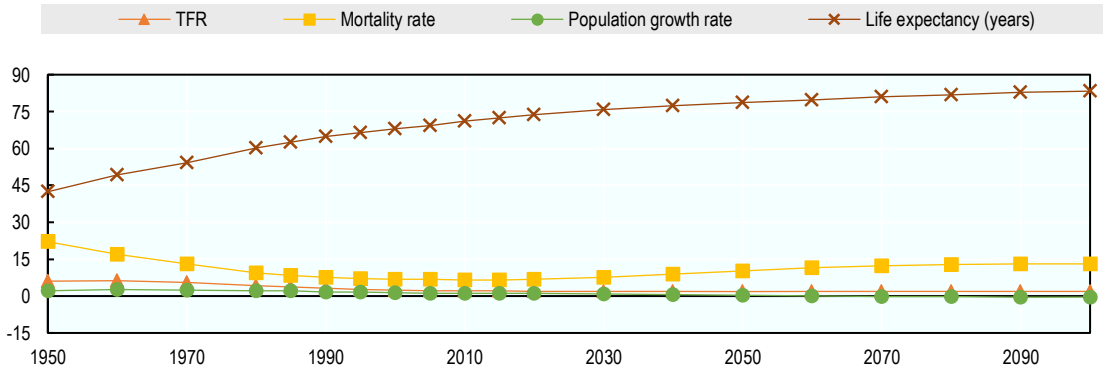

Figure 2.4. *Total Fertility Rate (TFR), Mortality Rate, Population Growth Rate and Life Expectancy (Years) in Southeast Asia, 1950-2100 (UNPD, 2011)*

Figure 2.4 demonstrates the evolution of TFR, mortality rate, population growth rate and life expectancy in Southeast Asia. Besides, there is a projection in the 2100 population prospect that there is no more population growth in this region. Also, population structure might go to an aging society as life expectancy is high, nearly a century life (UNPD, 2011). Life expectancy is defined as '*the average number of years*

that a person could expect to live if he or she experienced the age-specific mortality rates prevalent in a given country in a particular year' (OECD, 2011).

In summary, the change from pre-industrialized to post-industrialized economy significantly impacts both economic and social contexts in Southeast Asia. Moreover, sectoral change from agriculture to industry leads consequently to urbanization in which people leave their rural area moving to urban cities for getting the better-paid job in the manufacturing sector. Household production is replaced by formal market transaction form and the life-being becomes more formalization. Structural transformation implicitly reflects the better wellbeing of Southeast Asian citizen as the poverty rate has been reduced significantly. Economic development contributes to poverty reduction since, in 2015, 14 percent of the poverty rate was less than a third of the 1990's rate, as reported in Figure 2.5 ASEAN accomplished the Millennium Development Goal (MDG) earlier that its target which aimed to reduce the poverty rate to 23.5 percent in 2015.

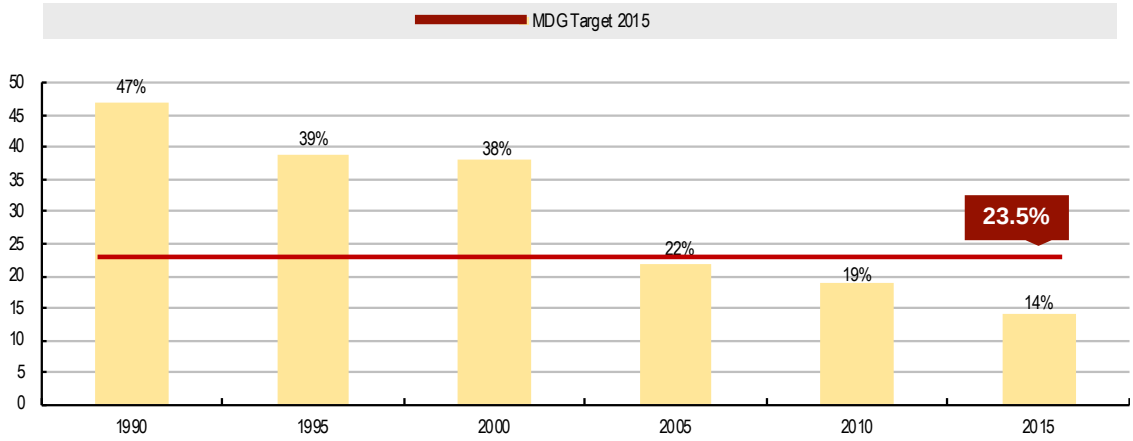

Figure 2.5. *Poverty Rate in ASEAN (% of People Living with less than $1.25 PPP per Day), 1990-2015 (ASEAN Secretariat, 2017)*

2.2. Growth Theories

Theoretical economic growth is defined as the study of the evolutionary behavior of potential output in the economy. Since the industrial revolution period, economic growth is about to produce and trade more goods and services. The classical model emphasized on the input productivity to earn more output by less or equal input. Hence the growth model is chiefly represented through the lens of the supply side. So, the key part of economic growth model is Cobb-Douglas production function which focuses on

capital, labor, and productivity which implies idea and all knowledge to help capital and labor producing more output or is called as technology.

2.2.1. Neoclassical growth theory

Neoclassical growth theory is an economic theory that outlines how a steady-state economic growth rate can be achieved with the proper economic driving inputs which are labor, capital, and technology. It is first introduced in the late 1950s-1960s but the most contribution to the theory was done by Solow (1956). Solow model considers two-factor production function which is capital and labor as determinants of output. Besides, it added exogenously technology to the production function. The neoclassical growth theory assumes that technological change is an exogenous effect. In a constant technological change, an increase of capital and labor causes output growth with increasing rate onward to the economy attains the maximum economic welfare. Then the economy is closer to its steady state. After this point, any increase of input results in the growth rate with the diminishing return to scale and the growth rate is slower until becoming zero since the economy will grow in the constant amount.

The model was raised by criticizing to the Harrod-Domar models that emphasized on the rate of saving and investment. Since Solow developed the model based on the assumption of diminishing marginal product of capital, his model is attempted to prove that the saving rate does not affect the long-run growth rate. The saving rate helps to boot the economy in the short run only. In the neoclassical framework, the high saving rate is an effective variable between financial sector policies and high rates of investment. In the structuralist framework, it is on a general government effort to provide the way of capital accesses and to promote investment either directly through public investment or indirectly through private investors (Petri, 1993).

However, in Southeast Asia, high rates of savings and investment are cited as the important tool for its outstanding growth in the past decades (Barro & Sala-i-Martin, 2004; Petri, 1993; World Bank, 1993). Moreover, there are lots of other common factors that have been discussed above in the section of stylized facts in Southeast Asia. We estimated that because of the diverse characteristics and different policies applied, the key of Southeast Asia success might be the outward orientation which other countries in other regions could apply to its own unique. The consistency adaptation is the way to survive for future growth.

Samphantharak (2018) emphasized three important economic implications of Southeast Asia growth by neoclassical growth model – physical capital accumulation, the growth of population and labor and the growth of TFP. First, physical capital accumulation is not a key to long-run growth sustainability as it affects the growth in transitory regarding the diminishing return to scale. Secondly, the population size and labor input growth will not make a sustainable increase in living standard. Although population growth leads to an increase of labor input which results in a rise of aggregate output, like physical capital, it is subject to diminishing return as well. Finally, the third implication of the neoclassical growth model is TFP which refers to more efficient productivity by using the same or lesser amount of inputs to earn more or equal outputs such as technological progress. Consequently, the per capita output growth rate, in the long run, is equal to the rate of TFP growth.

There are two sources to increase TFP which are technical growth in micro level and efficiency improvement at the macro base. The first one is the example of the improvement in the production process in which the firm is able to produce more outputs by using the same amount of inputs. The second source means to the development of financial institutes in which provide more efficient allocation of capital or an increase in competition between individual firms in order to get higher productivity. Institutions must reduce market distortions which allows more efficient resource allocation in the economy.

The first source of TFP's increase, technical growth by production improvement, refers to the development of technology. The catching up of the lagging country, which refers to the low initial income and productivity level economy like Southeast Asian countries, has the tendency to grow more rapidly by copying frontier countries' technology without bearing R&D costs. In other words, Lim and McAleer (2000) found that no technological catching up in Southeast Asia countries. Hence, it can be assumed that there is no sustainable growth in Southeast Asia due to no TFP growth in technical progress.

However, Samphantharak (2018) mentioned the finding of Jeong and Townsend (2007)'s study about the efficient resource reallocation that it could result in higher TFP at the aggregate level. They found that 73 percent of Thailand's TFP growth between 1976 and 1996, which is the period of rapid growth and structural change, was explained

by occupational shifts and financial development without any exogenous technical progress.

2.2.2. Endogenous growth theory

For the Solow model, the impact on economic growth is only caused by the impact on saving which is not for sustainable growth. Wickens (2008) stated that there are three main causes of the growth in productivity output. First, an increase in the capital stock is called physical capital. The second portion is the growth in labor inputs due to population growth, immigration, changes in participation rates and human capital. Third, the technological progress embodied in new capital equipment. The technological change simply reflects advances in human knowledge acquired from R&D and education. This implies that the growth of human capital leads to technological innovation. Therefore, the capital investment in people causes the increasing or constant returns to scale rather than diminishing returns as physical capital does. It reflects that technological improvement is endogenously done through intensive human capital which costs the physical capital as well. Hence it is no longer an exogenous effect on the growth. This inspired economists on endogenous theories of economic growth which focus more on the impact of government policies on the growth.

Dewan and Hussein (2001) agreed with Hall and Jones (1999) who believe that differences in levels of economic success across countries are driven mainly by the institutions and government policies that frame the economic environment. Moreover, they emphasized that countries with strong macroeconomic fundamentals tend to grow faster than those without them. There are many cases suggest that only some of these conditions do not result in faster growth.

The effectiveness of research and innovation management at policy and institutional levels in four ASEAN member countries - Cambodia, Malaysia, Thailand, and Vietnam is recognized by policymakers as important in all four economies but there has been less significant progress in the implementation (OECD, 2013). While ASEAN has been enjoyed with its outstanding growth, its research and innovation have not moved forward together. This observation definitely applies to all other countries in the region except Singapore. Table 2.2 shows the Gross Expenditure on R&D (GERD), R&D Intensity and per capita GERD among ASEAN members by the latest available data.

Table 2.2. *GERD, R&D Intensity and Per Capita GERD among ASEAN Members by Latest Available Data (ABAPAST, 2011)*

Country (Year available)	GERD (in current USD)	R&D Intensity (GERD as % of GDP)	Per capita GERD (in thousand PPP USD)
Brunei (2004)	3,125,406	0.04	17.30
Cambodia (2002)	2,078,858	0.05	0.50
Indonesia (2009)	320,237,706	0.04	3.50
Lao PDR (2002)	769,050	0.04	0.50
Malaysia (2006)	874,697,462	0.63	80.10
Myanmar (2002)	5,751,400	0.16	0.16
Philippines (2007)	142,869,371	0.11	3.9
Singapore (2009)	5,188,042,112	2.26	1,431.40
Thailand (2009)	555,766,514	0.21	16.70
Vietnam (2002)	44,229,746	0.19	3.10

The recommendations from the study of OECD (2013) on current gaps in research and innovation management that could apply to bridge the gaps in all ASEAN members. First, governments should subsidize more to create the capacity and the expansion of research in their universities. Second, involving institutions in the country should be up to date on global research trends and providing sources for research and innovations. Third, policymakers must know the training needs of researchers in universities and research institutes regarding the commercial processes of their outputs. Fourth, public policymakers should give priority authorization to universities or research institutes if they are expected to contribute to research and innovation. Fifth, ASEAN must promote and cooperate more in regional collaboration of research and innovation. A possible model for this collaboration is the new Centre of Excellence (COE) in Malaysia established by the Chartered Institute of Management Accountants in order to support innovative research in the region. The COE will work with many participants from universities, public sector and key industry players in Southeast Asia to ensure the plausibility and efficiency of research and innovation. Science research is able to boost the regional spread economic growth. Hence, governments must contribute more afford to business, research institutions and industry.

2.3. Growth Accounting

Growth accounting measures empirically the relative importance of input growth to output growth based on production function. The objective of growth accounting is to split the economic growth rate of a country into contributions from different factors – capital (K), labor (H), and productivity. While real GDP growth rates are easy to obtain, measuring the growth rates of K and H is more difficult (Ghosh & Kraay, 2000). Therefore, estimates of TFP growth has been always discussed and it is a very sensitive point of percentage distribution among these three factors. Hence, growth accounting of Southeast Asian economy always depends on the issue of TFP calculation. Growth accounting might give the different results and conclusion alike Young (1992) and Krugman (1994) criticized the East Asian Miracle of World Bank (1993) which the debate is mostly about the perception of how growth is considered. However, the growth accounting that is used for this study received from multiple sources. The details will be discussed later in part 4 of methodology.

3. BAYESIAN FRAMEWORK

In this part, the theoretical approach in measuring determinants of economic growth in Southeast Asia countries are presented. For the general growth regression, the issue that has been crucially concerned is model uncertainty. The model uncertainty is occurred by the assumption that the true single model is unknown. Hence, all probabilities of being a true model are considered in order to get the best one. Moral-Benito (2012) stated that model averaging method is a suitable alternative for the growth regression. Its weighted average results from all possible models are considered for model selection.

It is recommended by many researchers about the application of Bayesian inference in social science as it could be more useful rather than the frequentist or traditional approach when the model uncertainty is involving. This study, therefore, applies Bayesian inference method in order to find the plausibility of the robust determinants of economic growth.

In addition, estimated data are expressed in the details together with their sources of collection. Moreover, the importance and reasons for the data as predictors are clarified.

3.1. Bayesian Inference

Bayesian approach is the application of Bayes' rule into the probability estimation. It is actually used on the same objective with the traditional statistics inference, also known as null hypothesis significance testing (NHST), that relied on the probability to accept or reject the null hypothesis, H_0. To go on the methodology, firstly, we need to understand how the probability is affected by our beliefs on data via Bayes' rule and why it is used to interpret the posterior probability in the research area.

3.1.1. Bayes' rule

Kruschke (2011) emphasized on the three goals of Bayesian inference which are the estimation of parameter values, prediction of data values and model comparison. Bayesian analysis is named after Thomas Bayes, who discovered a simple mathematical relation among conditional probabilities that is now known as Bayes' rule.

$$p(\beta|y) = \frac{p(y|\beta)p(\beta)}{p(y)} \tag{3.1}$$

The conditional probability is simply the posterior probability $p(\beta|y)$ which is defined as the probability of y data attributes causing the parameter β. While $p(y|\beta)$ is the likelihood. The likelihood means the probability of having y data attributes given that the parameter β exists. $p(\beta)$ is the prior probability and means the probability of being the parameter β. $p(y)$ is the total probability of observing all data or evidence. Sometimes, $p(y)$ is called as the marginal likelihood and in many applications of Bayes' Rule, this is ignored, as it mainly serves as normalization. Therefore, Bayes' rule is also shown as;

$$p(\beta|y)\ \alpha\ p(\beta)p(y|\beta) \tag{3.2}$$

Above equation implies that the main result of Bayesian statistic inference may depend on the simple device: posterior α prior × likelihood (Kumam, Saipara, & Kumam, 2017).

3.1.2. Parameters

Estimation of the parameter value is the first thing that researchers consider to accomplish among three goals of Bayesian inference by Kruschke (2011). This is because it shows the relationship between the predictors, or explanatory variables, and the predicted value, which is called the dependent variable, in the mathematical model.

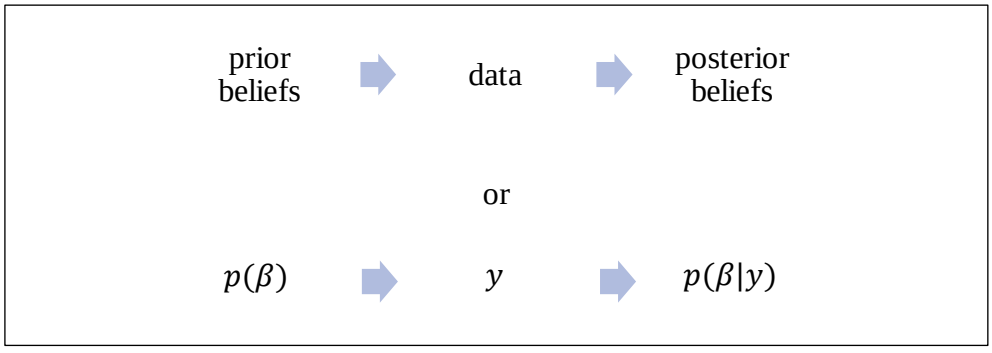

Figure 3.1. *Diagram of Parameter Estimation in Bayesian Approach*

In the frequentist or traditional approach, we call the parameter value, denoted by β, as the coefficient which means the probability that the value of the dependent variable is impacted by an explanatory variable value change equals to β. For Bayesian inference,

however, Bayes Theorem tells us how to set our prior beliefs, $p(\beta)$, about the parameter, β, in the light of data y, in order to have posterior beliefs, $p(\beta|y)$, (Jackman, 2009).

3.1.3. Probability

Statistics provides the way to compute precisely the uncertainty which is measured in terms of probability (Kruschke, 2011). When we think about how likely an event will occur, we always have a set of possible events in mind. Then all possible events are called the sample space.

Probability in Bayesian analysis is a way to show the degree of belief in a statement while in frequentist analysis means to the limit of an event frequency for a large number of experiments and only in the sense of random experiments which are well defined (Kumam et al., 2017). In addition, Bayesian probability refers to subjective probability in which the probability means the degree of belief (Jackman, 2009).

The use of subjective probability also means that the Bayesian approach does report probabilities in unlimited dimensions. All types of data such as mean, mode or sequence can be used to reflect the degree of belief. In contrast, frequentists report only in the dimension of frequency. Otherwise, they would assume those data as zero probability. In this study, the probability that we use to set the hypothesis is that the probability of parameter of economic growth rate in the sample of Southeast Asia countries.

3.2. Bayesian Model Averaging

Generally, the empirical study of economic growth has been provoked by model uncertainty problems because the growth regressions are involving with the plenty numbers of variables. When the goal is the prediction of data for interesting values of the predictors, we then consider all models to get the most reliable model based on as much information as possible. This approach is called Bayesian model averaging (BMA). In other words, BMA is an application of the Bayesian inference to the problems of model selection under uncertainty of the true model. For example, when a researcher wants to find the best single model that the maximum variables of all possible model candidates are K explanatory variables, it is required to run 2^K regressions while BMA is able to produce a straightforward model choice criteria with less risky predictions. As a result, it does not waste the time for doing so many regressions in order to find only one true model. However, the application of BMA is not always straightforward, it might lead to

diverse assumptions and the difficulty of the integral computation (Hoeting, Madigan, Raftery, & Volinsky, 1999; Kruschke, 2011; Steel, 2011).

3.2.1. BMA and panel data growth regression

The general growth model of panel regression is

$$\hat{y}_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \cdots + \beta_k X_{kit} + \varepsilon_{it} \tag{3.3}$$

where y_{it} and ε_{it} represent growth rates and the error terms respectively. The subscript i denotes the sequence of the ith country and the subscript t denotes the time. X_{nit} represents growth determinants of the ith country at time t according to theories and the facts that are able to be included in all possible models. β_K is the parameter which is set to $\beta_K = (\beta_1, \beta_2, \dots, \beta_k)$ when there are k explanatory variables in the model.

Using the Bayesian approach, a model is defined by a likelihood function and a prior density. As mentioned above, there are 2^k candidate models to be estimated and those are represented by M_j for $j = 1, \dots, 2^k$ which all attempt to explain the sample data. So model M_j depends on parameters β^j.

As mentioned above, BMA methods take a weighted average across the models with the assumption that the true model is unknown. Therefore, the prior belief is set as every predictor weights being the posterior probabilities of the models instead of conditionalizing on the winning model only (Kruschke, 2011).

3.2.2. BMA: prior, posterior model probabilities and computation

According to the Bayesian logic, the posterior probability for the parameters β^j of M_j is written as

$$g(\beta^j | y, M_j) = \frac{f(y|\beta^j, M_j)\, g(\beta^j | M_j)}{f(y|M_j)} \tag{3.4}$$

now we have a posterior, $g(\beta^j | y, M_j)$, a likelihood, $f(y|\beta^j, M_j)$, and a prior, $g(\beta^j | M_j)$, for each model.

Since the inference of Bayes' Theorem suggests us to derive the probability of being the true model of growth regression for ASEAN which we do not know based on the

conditional probability from the data that we have, the posterior model probability can be used to estimate the degree of support for M_j. Hence the posterior model probability will be used as '*model weights*' in BMA.

From the assumption that M_j contains 2^k different models for $j = 1, \dots, 2^k$, now we know the probability of M_j without conditional to the data which means how we believe that M_j is a true model before looking into the data. Therefore, it does not involve with the data and it is called the prior model probability, $P(M_j)$. We can calculate the posterior model probability of M_j conditional on the data (y) by using a prior density, $P(M_j)$, and a likelihood function following Bayes' Rule as

$$P(M_j|y) = \frac{f(y|M_j)\, P(M_j)}{f(y)} \tag{3.5}$$

As can be seen from (3.4) and (3.5), it is shown that BMA requires two different prior aspects which are on the parameter of each model space, $g(\beta^j|M_j)$, and the model probability itself, $P(M_j)$.

In order to calculate the posterior model probability, $P(M_j|y)$, in (3.5) we also need to get the likelihood function, $f(y|M_j)$, which can be derived from (3.4). The derived likelihood function is often called the marginal (or integrated) likelihood. We integrate both sides of (3.4) with respect to β^j which is equal to 1 which is the fact of probability density functions.

$$\int g(\beta^j|y, M_j)\, d\beta^j = 1$$

$$g(\beta^j|y, M_j) = \frac{1}{\int d\beta^j} \tag{3.6}$$

Then the posterior probability of parameter which equals to $1/\int d\beta^j$ in (3.6) is substituted in (3.4) to get the marginal (or integrated) likelihood.

$$f(y|M_j) = \frac{f(y|\beta^j, M_j)\, g(\beta^j|M_j)}{1/\int d\beta^j}$$

$$f(y|M_j) = \int f(y|\beta^j, M_j)\, g(\beta^j|M_j)\, d\beta^j \tag{3.7}$$

The result of the integrated likelihood in (3.7) is the marginal probability of data and it is used to calculate Bayes Factor which the derivation is explained in the next section. We use the Bayes Factor to find the probability of being a true model between two competing models and parameters.

3.3. Bayesian Hypothesis Testing

This section explains how the Bayesian approach to compare and select a best model.

3.3.1. Bay factor

Raftery (1995) and Moral-Benito (2010 & 2012) gave a justification for BMA that, in a large sample, its posterior mode is very close to maximum likelihood statistic which parameters are eliminated by maximization. While BMA is done by the integration. This causes BMA being most useful for the regressive model with many parameters. As mentioned above that we can use Bayes Factor justifying the hypothesis of being a true model between models M_1 and M_2 in which parameter vectors are β_1 and β_2 respectively.

According to Bayes' theorem, the posterior probability that M_1 is the correct model given M_k which $k = 1, 2$ is;

$$P(M_1|y) = \frac{P(y|M_1)\,P(M_1)}{P(y)}$$

$$P(M_1|y) = \frac{P(y|M_1)\,P(M_1)}{P(y|M_1)\,P(M_1) + P(y|M_2)\,P(M_2)} \tag{3.8}$$

where $P(y|M_k)$ is the marginal probability of the data given M_k or we know as the likelihood of model M_k and $P(M_k)$ is the prior probability of M_k. This is applied to the hypothesis that M_2 is the true model, $P(M_2|y)$, as well because of $P(M_1|y) + P(M_2|y) = 1$.

The marginal probability of data, $P(y|M_1)$, in equation (3.8) can be obtained by integrating over β_1.

$$P(y|M_1) = \int P(y|\beta_1, M_1)\,P(\beta_1|M_1)\,d\beta_1$$

$$P(y|M_1) = \int (likelihood\ of\ parameter\ x\ prior)\ d\beta_1 \tag{3.9}$$

This is why it could be called the integrated likelihood for model M_1.

Now we can measure the ratio of M_2 posterior probability against M_1 or the posterior odds by using equation (3.8).

$$\frac{P(M_2|y)}{P(M_1|y)} = \left[\frac{P(y|M_2)}{P(y|M_1)}\right]\left[\frac{P(M_2)}{P(M_1)}\right] \tag{3.10}$$

The ratio of the posterior probability of two models is equal to the ratio of the integrated likelihoods for M_2 against M_1 or Bayes Factor, B_{21}, multiplies with the ratio of their prior probabilities or prior odds. Without a prior preference among two models, the prior odds is always equal to 1. Therefore, the posterior odds equals to the Bayes Factor.

Raftery (1995) gave the interpreting of B_{21} that the data favor M_2 over M_1 when $B_{21} > 1$ and favor M_1 when $B_{21} < 1$. This implies that the higher posterior probability is better evidence for being a favorite.

3.3.2. The BIC approximation

Once we decide to use Bayes Factor for defining a favored model, the Bayesian Information Criterion (BIC) approximation is consistently a simple way to measure the fit of data. The value of BIC for model M_1, denoted by BIC_1, is the approximation to

$$2\log B_{21} \approx \chi^2_{21} - df_{21}\log n \tag{3.11}$$

where B_{21} is the Bayes Factor for model M_2 against M_1 and χ^2_{21} is the standard likelihood ratio test (LRT) for model M_2 against M_1. In addition, the LRT is often called the deviance of model M_1. Hence the smaller deviance is preferred because it shows the better fit of data in that model. While df_{21} is the number of degrees of freedom.

Since the null model is the model with no independent variable, the BIC_0 value is zero. If we compare two models, M_1 and M_2, with the baseline null model M_0, the model with negative BIC_k will be preferred.

We can see that the two models can be compared by taking their BIC difference in equation (3.12). Raftery (1995) proposed the interpretation of the Bayes Factor value for M_2 against M_1, the BIC difference, and the posterior probability of M_2 in which can be used for model selection. The study recommended the strong evidence of M_2 favor over M_1 when Bayes Factor value is between 20 and 150, the BIC difference is between 6 and

10, and the posterior probability of M_2 is between 95 and 99. If all measurements are higher, it could be concluded that the model is very strong to be the true model.

$$\begin{aligned} B_{21} &= P(y|M_2)/P(y|M_1) \\ &= \left[\frac{P(y|M_0)}{P(y|M_2)}\right] / \left[\frac{P(y|M_0)}{P(y|M_1)}\right] \\ &= B_{02}/B_{01} \\ 2\log B_{21} &= 2\log B_{02} - 2\log B_{01} \\ &= \mathrm{BIC}_2 - \mathrm{BIC}_1 \end{aligned} \tag{3.12}$$

3.4. Simulation-Based Bayesian Analysis

This part illustrates how we apply Bayesian inference from the above explanation into the multiple linear regression of economic growth. The common criticisms of BMA implementation are the difficult computation of likelihood function, improper prior setting and the complication of descriptive model results (Hoeting et al., 1999). However, in the present, there are various algorithms and software in advance for BMA implementation. The one popular method is the Markov chain Monte Carlo (MCMC) method.

To run the regression of BMA, we must proceed through MCMC chain. At every step in the MCMC chain, the parameters are randomly used to simulate data from the model. When the model is linear regression, those procedures are exactly the same as the generating for posterior predictions of Bayesian Multiple Linear Regression (BMLR) application using the prior ignorance uniform.

The only difference between BMA and BMLR is that BMA provides the inclusion coefficients for every single possible model, while BMLR provides the posterior distribution for one overarching model. In reality, parameters in BMLR overarching model are inclusion coefficients. Thus, BMA is really no different than posterior predictions derived from BMLR application (Kruschke, 2011). And the commands used in this research are applied from the working programs for BMLR by Kruschke, Aguinis, & Joo (2012).

3.4.1. Markov chain Monte Carlo implementing

Markov chain Monte Carlo is termed by two processes of approximating posterior distribution which is Monte Carlo and Markov chain. Monte Carlo method is a technique of computer programs used in simulation by using random numbers of all data which are distributed in the uniform distribution. This method will approximate the model to be closest to the real data in order to get the most efficient parameter values. The results are called the posterior probability. Any step in the Monte Carlo method that is stochastic or no memory for the step before the current step is called the Markov chain.

MCMC method makes Bayesian approach possible by generating the random sample without the integral computation of evidence, $p(y)$ of Bays' rule in equation (3.1), which is quite difficult. Now researchers can use MCMC methods to analyze realistically complex models by just specifying the type of the likelihood function and the prior distribution in order to get the posterior distribution results (Kruschke, 2011). This is because there are recently some developments in MCMC algorithms, software, and hardware that runs incredibly quickly.

3.4.2. Establishing the prior distribution

The mathematic forms of the prior can be calculated by the method of MCMC in the computational program. The idea is to accurately approximate the posterior distribution by a very large representative random sample of parameter values. From this very large sample of representative parameter values, we can determine the mean or modal parameter value, the quantiles of the parameter distribution, its detailed shape, and the forms of trade-offs between values of different parameters.

Bayesian analysis is used for deriving statistical predicted values. Refer to (3.2), the main result of Bayesian statistic inference, the posterior distribution, depends on the prior distribution. Thus, the prior distribution of plausibility on the parameter values must be established without the untruthfulness. Crucially, the prior distribution cannot be set arbitrarily to any individual favor. According to Kruschke et al. (2012),

> When there is little publicly agreed prior knowledge about the parameters, then the prior distribution can be very broad so that no parameter value is given much more credence than any other parameter value (p. 726).

The prior distribution is clearly and fairly stated about the suspiciousness that when the appropriateness of the prior distribution is doubted, then a researcher must use a

noncommittal broad prior distribution. Another useful step is the analysis can be done by using more than one prior distribution in order to show that the posterior distribution remains stable under the reasonable changes in the prior. Although the prior distribution was often chosen to be noncommittal, it does not mean that the prior distribution is difficult to apply in the research.

In this study, multiple linear regression is applied to find the posterior distribution. Our goal is to generate the prediction without specific prior commitments. Hence, we use a noncommittal and vague prior to all parameters. The prior distribution is a normal distribution with a mean of zero and a large standard deviation relative to the scale of the data. The prior ignorance on the standard deviation of the predicted value has been expressed via '*uniform prior*' extending from zero to an extremely large value beyond the data scale.

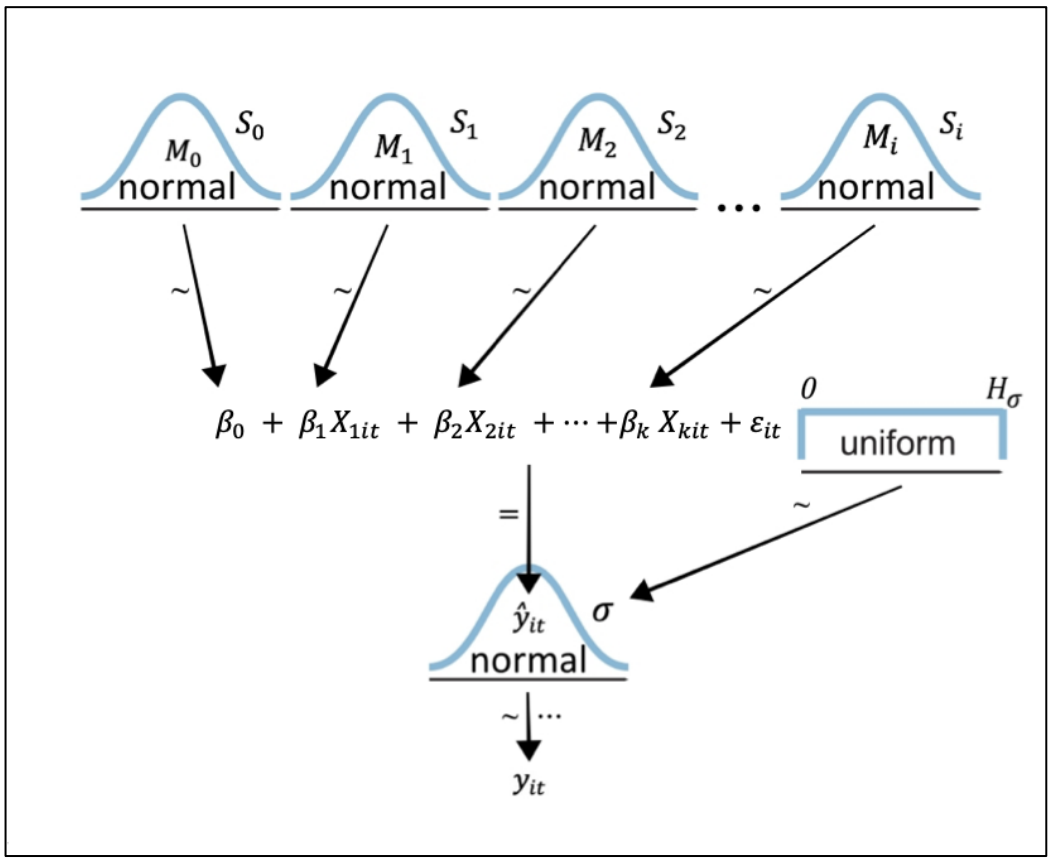

Figure 3.2. *Hierarchical Diagram for Multiple Linear Regression with Uniform Prior*

For the standardized data, we replicated the BMLR regression setting from the study of Kruschke et al. (2012). The priors on the intercept and regression coefficients are a normal distribution with mean at zero and standard deviation of 100. This normal

distribution is relatively flat over the range of possible intercepts and regression coefficients for standardized data. The prior on the standard deviation parameter is a uniform distribution from 0 to 10, which also far exceeds any suitable value for σ in standardized data. Therefore, the prior sets essentially no bias on the posterior distribution.

To visualize the Bayesian analysis, the hierarchy model is illustrated in Figure 3.2. The lower normal distribution curve illustrates the likelihood function of equation (3.1). The arrow to y_{it} indicates that the data are normally distributed with mean, $\hat{y}_{it}$, and standard deviation, σ. The arrow pointing to $\hat{y}_{it}$ indicates that the predicted value equals a linear function of the predictors. The upper normal distribution curves represent the prior distribution.

In summary, Bayesian inference involves reallocating reliability in the space of parameter values. The allocation will depend on the actual observable data, not the imaginary data that may be obtained from the null hypothesis. The reallocation starts from a prior distribution. As noted earlier, the prior distribution cannot be use arbitrary and must be explicitly reasonable according to the scientific method.

3.4.3. Software for Bayesian multiple linear regression

Bayes' rule in the equation (3.1) shows that the likelihood function and prior distribution have mathematical forms which are multiplied together as the numerator. While the denominator of Bayes' rule, $p(y)$, which is termed as '*evidence*' or known as '*the marginal likelihood*' is difficult to compute because it is actually an integral over the parameter space same like explained for the integrated likelihood of model M_1 in equation (3.9). However, new computer-based methods such as MCMC have turned up Bayesian analysis to be able for complex models.

The hierarchical diagram in Figure 3.2 contains all the information that must be communicated to the computer program in order to be able to perform MCMC sampling. All arrows in the hierarchical diagram have a corresponding display to the software. The program has been created packages to allow all users for doing the Bayesian analysis through three simple processes - loading the data, creating the MCMC chain and generating a graph of the posterior distribution.

R program is used as a tool to run the regression for Bayesian analysis. R program is a programming language and free software environment for statistical computing and

graphics supported by the R Foundation for statistical computing. To get the software, we can easily go to download the latest available version of the R program from *https://www.r-project.org* then install into our computer. For multiple linear regression for the economic growth, JAGS, rjags, and RStudio need to be installed for generating MCMC, interacting commands between R and JAGS and editing R commands respectively. The working commands for Bayesian multiple linear regression of this study can be found in the appendix. These commands are derived and developed from the example of Bayesian multiple linear regression in the organizational sciences (Kruschke et al., 2012).

4. METHODOLOGY

This part describes the study framework, the data sources, and descriptions. The estimated model and methodology employed in the study are also mentioned. In addition, the tool of data analysis is determined.

4.1. Study Framework

This is quantitative research that has put secondary data into the empirical Bayesian analysis. The data structure is panel data since the study has made use of data from 10 countries over a specific time period.

The study period is from 1975 to 2014. This time frame is concerned in order to provide the most up to date results. Another implication for choosing this particular period is the fact that Southeast Asia during this period, the economic growth performance is outstanding and has made them become new emerging economies in the East. Therefore, to realize the causes of this situation is the main goal of this study.

Among 11 countries in the Southeast Asian region, the sample counties are Brunei, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam. Timor-Leste, a new separated country in 2002, is excluded from the sample. Since a country statistics of Timor-Leste is missing up to 70 percent of time frame, the study needs to ignore it due to the unavailability of data. In addition, the country sample is classified into two groups, CLMV and ASEAN-6, according to the growth trend.

4.2. Data

Our data set contains 17 explanatory variables and 1 dependent variable of per capita GDP growth rate. All independent variables are derived from stylized facts of Southeast Asian economies in part two section 2.1. Although the fundamental demography of each economy is diverse, there are the things in common that have been inferred as the economic drivers of the region. We look into those characteristics to derive the variables that help us obtaining the suitable economic growth model for Southeast Asia.

The first characteristic is outward orientation by structure reformation. In order to complete the goal, the government must play important roles such as taxation, law

regulations, infrastructure services, financial market supports, and other aspects of the economy both domestic and international level. The government, therefore, could impact good or ill through the projection of the long-term growth rate. The variables that we choose to follow up on the government actions are the percentile rank on control of corruption and government effectiveness with 0 is the lowest and 100 is the highest rank. Another one is the percentage of government final consumption expenditure which can imply government purchases of goods and services for public services. The trade openness and supportive regulation are measured by the indicators of trade volume and tax revenue on international trade.

Second, Southeast Asia is aware as export based place to the global market which is the consequence of FDI. Therefore, the share of good and service exports and FDI inflows to GDP are used to present this fact. Fourth, high saving rate raises predominantly to the growth according to neoclassical theory. It reflects the capacity between government policies and the financial sector in funding for investments. Thus the investment increases accordingly. We use gross fixed capital formation and gross domestic saving to follow up on this.

According to endogenous technological change theory, it emphasized on the unexplainable and exogenous effect of technological change in neoclassical theory. Romer (1990) stated that using ideas and innovating through R&D are able to escape from the diminishing return to the scale of the neoclassical theory. Hence patent application is applied in the regression too.

Total factor productivity is one of the factors developed by the endogenous growth theory. So far, many researchers have either agreed (World Bank, 1993) or disagreed (Young, 1992; Krugman, 1994; Lim & McAleer, 2000) that total factor productivity significantly impacts to Southeast Asian growth. Since there are various opinions about regional total factor productivity growth, we decide to include total factor productivity, high skill labor proportion, and total labor force as the predictors into the model regression. We do so in order to see whether there will be any effect on this regional economic growth via these arguments.

Finally, another key exogenous parameter of the neoclassical growth model is the population growth rate. The higher population growth tends to lower the per capita growth rate. In Southeast Asia, the population growth rate has been reduced significantly. Later, the endogenous growth model incorporates it with fertility rate which might give a

different result between low and high-income countries. Hence we focus on total fertility rate and life expectancy rather than population growth rate.

4.2.1. Data description

Variable names and descriptions are shown in Table 4.1. The variable 1 is the dependent variable. The variable 2 – 18 are the explanatory variables.

Table 4.1. *Variables and Their Descriptions*

No	Variable	Description
1	y	GDP per capita growth (annual %)
2	lnGDP75	Log of initial GDP per capita (at current prices in USD)
3	TFR	Total fertility rate (births per woman)
4	LE	Life expectancy at birth (years)
5	ENROLL	Secondary school enrollment (% net)
6	PAT	Patent applications
7	TFP	Total factor productivity
8	CORR	Control of corruption: percentile rank
9	GOVEF	Government effectiveness: percentile rank
10	GOVEX	General government final consumption expenditure (% of GDP)
11	L	Labor force participation rate (% of total population ages 15-64) (modeled ILO estimate)
12	H	Labor force with advanced education (% of total working-age population with advanced education)
13	GFCF	Gross fixed capital formation (% of GDP)
14	SAV	Gross domestic savings (% of GDP)
15	FDI	Foreign direct investment inflows (% of GDP)
16	TRD	Trade (% of GDP)
17	TXINTRD	Taxes on international trade (% of revenue)
18	EXP	Exports of goods and services (% of GDP)

Many studies have indicated the determinants of economic growth using the average basis such as two-year period, four-year period and ten-year period (Leon-Gonzalez & Vinayagathasan, 2015; León-González & Montolio, 2015; Moral-Benito, 2012). However, this study is not using data on an average basis. In other words, the study is conducted in the context of 40 annual time periods for 10-country observation of 18 variables. So the number of observations in a set of data is 7,200 observations.

4.2.2. Data collection and sources

Data on 1975 GDP and TFP is obtained from the United Nations Statistics Division and the Penn World Table 9.0 (PWT9.0), respectively. While the data source of the remaining predictors is the World Bank. Two indicator groups of World Bank is used for compiling data. The data on control of corruption and government effectiveness is gathered from Worldwide Governance Indicators (WGI) and the rest is collected from World Development Indicators (WDI). These data sources are chosen because of their creditability with the fact that they are the most used data sources in the literature relevant to the study perspective. Also, they provide availability for all time frames being used in this study.

The previous part has mentioned about TFP calculation which is inconsistent among empirical researchers. It depends on the factors and the allocative proportion that have been used in the calculation. The TFP level from PWT9.0 represents annual productivity level across countries with TFP equal to one for the USA. Empirically, TFP is computed with real GDP of the output side, the capital stock of structures and equipment, labor input data and share of labor income in GDP in which price levels are constant across countries and labor refers to both employees and self-employed workers.

4.3. Estimated Model

$$\begin{aligned} y_{it} = {} & \beta_0 + \beta_1 lnGDP75_{it} + \beta_2 TFR_{it} + \beta_3 LE_{it} + \beta_4 ENROLL_{it} \\ & + \beta_5 PAT_{it} + \beta_6 TFP_{it} + \beta_7 CORR_{it} + \beta_8 GOVEF_{it} \\ & + \beta_9 GOVEX_{it} + \beta_{10} L_{it} + \beta_{11} H_{it} + \beta_{12} GFCF_{it} + \beta_{13} SAV_{it} \\ & + \beta_{14} FDI_{it} + \beta_{15} TRD_{it} + \beta_{16} TXINTRD_{it} + \beta_{17} EXP_{it} + \varepsilon_{it} \end{aligned} \tag{4.1}$$

The posterior probability of Southeast Asian countries is obtained from the above model. The estimated model (4.1) is in the panel structure of data in which i denotes the sequence of the ith country and t denotes the time.

4.4. Data Analysis

Model estimation is executed through the Bayesian approach by applying BMLR package in R program. The data is arranged to the standardized mode in order to compare the effectiveness among each predictor. The prior distribution for this study is a joint distribution across the nineteen-dimensional parameter space, according to Figure 3.2. Nineteen parameters are the intercept, 17 predictors, and the standard deviation of the model.

We are trying to estimate the mentioned nineteen parameters. The calculation progress can be expressed as the multiplying of the probability of the hypothesis, in which each parameter is significant and not equal to zero, without any additional prior information and the probability of observing the new evidence, all predictor values, given our initial hypothesis. The process and commands are explained in the appendix.

5. FINDINGS

This part illustrates and analyzes the results obtained by model estimation through the mentioned methodology from the previous section. As can be seen, the trend of economic growth in Southeast Asian countries during 1975-2014 in Figure 5.1 reflects a linear trend. Hence, Bayesian multiple linear regression is applied in the estimation of parameters.

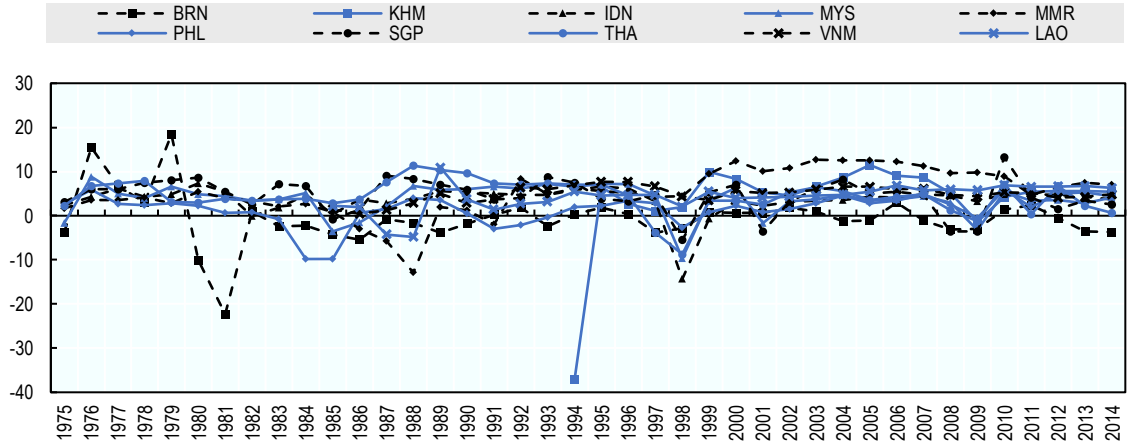

Figure 5.1. *Economic Growth Trend of Southeast Asian Countries during 1975-2014*

Looking in the details, we are able to differentiate the slope of the growth into two groups – upward and downward sloping. For CLMV, the later economic openness to the international investment and the lower initial point help them grow faster after the 1990s. Meanwhile, ASEAN-6 except for the Philippines, who achieved higher growth before, becomes slower at the growth rate due to the diminishing return of both capital and labor accumulation. Surprisingly, the economic growth of the Philippines, which is a member of ASEAN-6 and is expected to have a similar growth trend with other countries in the ASEAN-6 group, reveals the increasing trend.

With our research objective of identifying the prominent determinant of economic growth in Southeast Asian region, the finding here is designed to present the economic growth in three groups of the sample which are the whole Southeast Asian region, ASEAN-6 except the Philippines and CLMV plus the Philippines. In addition, the separation could provide us the different results for the country-specific objective. The supportive evidences of the economic growth trend for these three economic groups are provided below.

Figure 5.2 illustrates the downward sloping growth trend of ASEAN-6 except for the Philippines. While Figure 5.3 represents the growing trend of CLMV and the Philippines which is upward sloping.

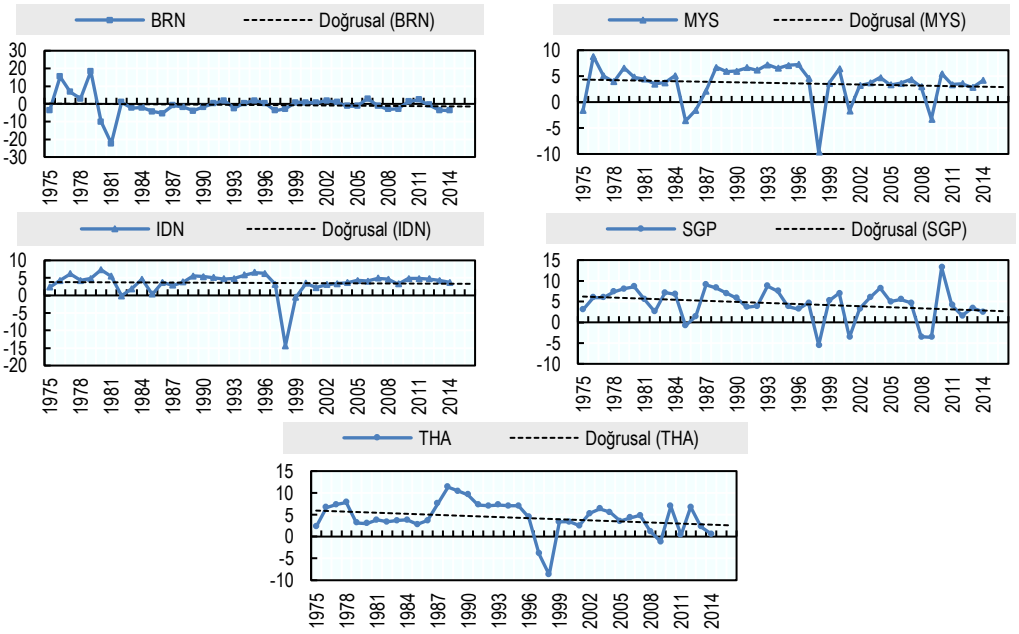

Figure 5.2. *Economic Growth Trend of ASEAN-6 except for the Philippines during 1975-2014*

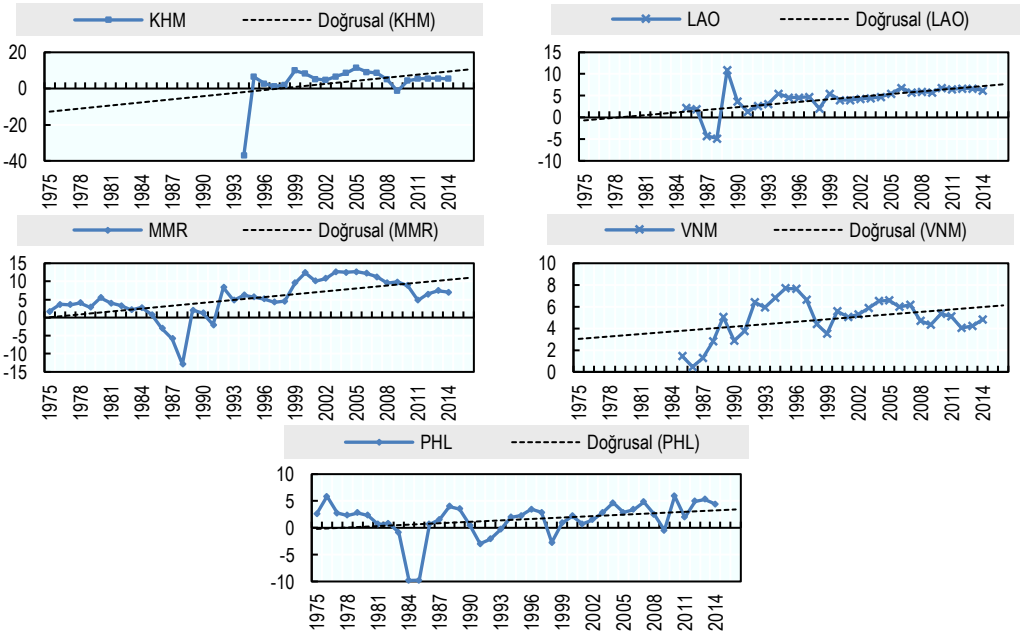

Figure 5.3. *Economic Growth Trend of CLMV and the Philippines during 1975-2014*

The different growth trend is coincident with facts that countries who appear to an increasing trend are a new emerging market and did trade openness lately among ASEAN.

Also, most of them are classified into the lower-middle income group (World Bank, 2018). While the declining trend is a group of ASEAN founder countries whose performance appeared to be outstanding earlier and they are in higher income level.

5.1. The Whole Region

The program and its command are shown in the appendix. The MCMC chain provides a large sample of credible combinations of parameter values in the nineteen-dimensional parameter space – the posterior of 17 regression coefficients, the intercept and the standard deviation (SD) of the data around the linear prediction. As a result, the posterior provides an explicit distribution of the credibility or probability of each possible value for the regression coefficient.

Table 5.1. *Descriptive Statistics for 10 Southeast Asian Countries*

Variable	Obs	Mean	Std. Dev.	Min	Max
year	400	1994.5	11.55785	1975	2014
country	400	5.5	2.875878	1	10
y	400	3.109175	4.709186	-37.0023	18.3831
lnGDP75	400	5.911579	1.510239	4.248495	9.113389
TFR	400	3.352505	1.391454	1.15	6.369
LE	400	66.02223	9.499756	18.907	82.4951
ENROLL	400	14.32464	25.37804	0	92.97257
PAT	400	147.8475	284.5499	0	1572
TFP	400	.3165181	.2987354	0	1.206885
CORR	400	15.81052	26.6211	0	98.9899
GOVEF	400	20.30151	30.94624	0	100
GOVEX	400	8.680077	6.396792	0	29.86726
L	400	46.17946	36.29959	0	87.205
H	400	6.963861	22.09536	0	91.1836
GFCF	400	20.21975	12.12712	0	46.2467
SAV	400	24.11463	19.52139	-5.6306	86.2865
FDI	400	3.210536	4.471785	-2.7574	26.5212
TRD	400	99.76216	99.41806	0	441.6038
TXINTRD	400	6.280493	8.036497	0	29.96738
EXP	400	6.387215	10.10644	-31.80498	73.76177

Table 5.1 shows the descriptive statistics for 10-Southeast Asian country sample. In general, their data on the logarithm of initial GDP per capita which refers to the year 1975 ($lnGDP75$), total fertility rate (TFR), life expectancy (LE), total factor productivity (TFP), taxes on international trade ($TXINTRD$) and foreign direct investment (FDI) are grouped well. These data are not considerably different. These insights reflect the

economic and social development in Southeast Asian countries. However, we found that the data of patent applications have the highest gap among them. It implies that some countries have gone considerably beyond some others in term of innovations.

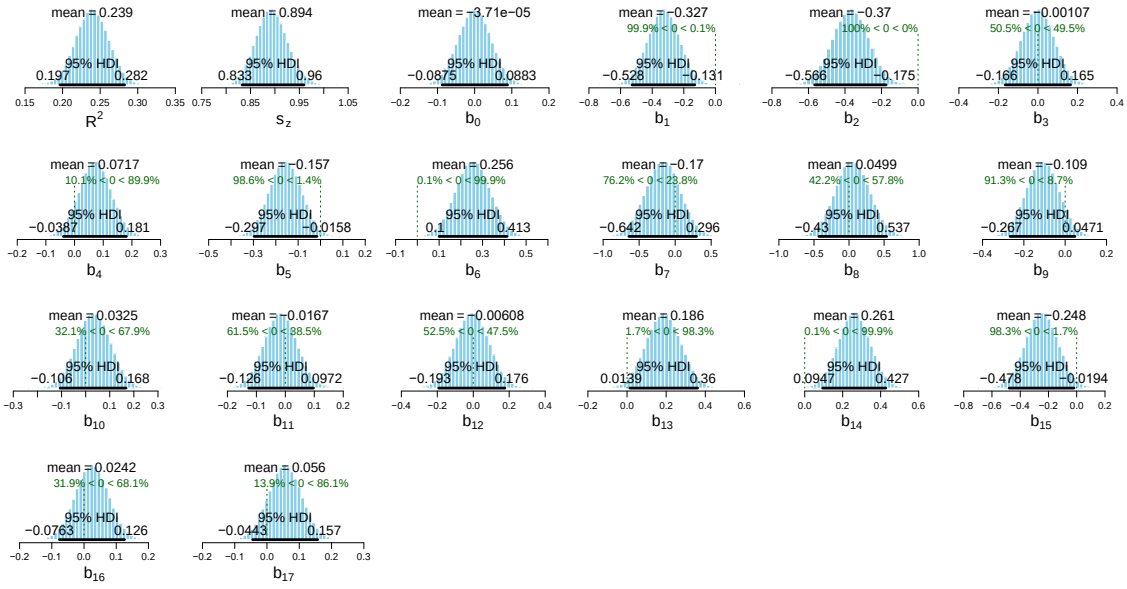

Figure 5.4. *Posterior Distribution for the Multiple Linear Regression Showing Parameters for Standardized Data in the Whole Southeast Asian Region*

Figure 5.4 shows the posterior distribution for data that have been standardized for the sample of 10 Southeast Asian countries. Panels of $\beta_1 - \beta_{17}$ represent the coefficient of predictors which refer to variable no. 2 to variable no. 18 according to Table 4.1. While β_0 and σ_z are presenting the intercept and the standard deviation value respectively.

The panels in Figure 5.4 show an interval marked as the highest density interval (HDI). Points inside an HDI have higher probability density (credibility) than points outside the HDI and the points inside the 95% HDI include 95% of the distribution. Therefore, the 95% HDI includes the most credible values of the parameter and it is useful for both as a summary of the distribution and as a decision tool.

Definitely, the 95% HDI helps to decide which parameter values should be deemed not credible or, in other words, it should be rejected. This process goes beyond probabilistic Bayesian inference intrinsically. It generates the complete posterior distribution, not a discrete decision regarding which values can be accepted or rejected. One simple decision rule is that any value outside the 95% HDI is rejected (Kruschke et al., 2012).

In particular, if we want to decide whether the regression coefficients are nonzero, we consider whether zero is included in the 95% HDI. For example, Figure 5.4 shows that zero is excluded from the 95% HDI for predictor 1, 2, 5, 6, 13, 14 and 15. It implies that the coefficients of these predictors are definitely not equal to zero. In other words, these factors have the probability to impact the growth rate at the significance level of 0.05 and the posterior distribution values are statistically significant. As a result, the determinants of economic growth for the sample of Southeast Asian region are initial GDP per capita, total fertility rate, patent applications, TFP, gross domestic savings, FDI inflows, and international trade.

In addition, the most influential determinant derived by the comparison of the standardized coefficient is FDI which its standardized coefficient is equal to 0.261. This indicates that if 1 unit standard deviation of FDI changes, the probability of an increase in the economic growth rate also rises for 0.261 standard deviation units. The following is TFP. While initial GDP and population growth impact the growth rate negatively.

The result is consistent with the fact that the Southeast Asia is grown heavily by FDI. Thus, the presence of slowdowns in the global economy has reflected the decline of FDI in Southeast Asia since 2015. Hence, it might have the probability to impact regional growth so on. In the same time, the improvement of human capital is necessary for this region as well.

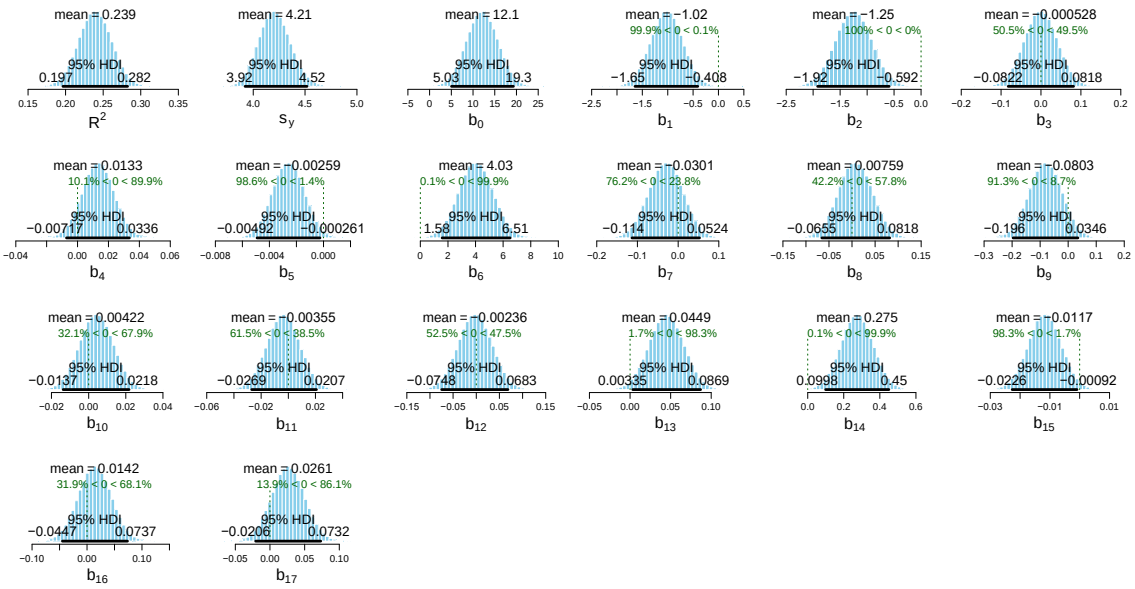

Figure 5.5. *Posterior Distribution for the Multiple Linear Regression Example, Showing Original-Scale Parameters in the Whole Southeast Asian Region*

Figure 5.5 shows the posterior distribution of economic growth determinants for the whole Southeast Asian countries sample on the original data scale. Panels of σ_y, b_0, and $b_1 - b_{17}$ refer to the posterior distribution for the intercept, the standard deviation, and coefficients of explanatory variable no.2 – 18 in Table 4.1 on the original data scale, respectively.

The original scale shows that an increase in 1 percent of FDI impacts to the probability of an increase in the GDP per capita growth rate by 0.275 percent. While an increase in 1 unit of TFP ratio and 1 percent increase of domestic savings affect the probability of an increase in the growth rate by 4.03 and 0.449 percent respectively.

5.2. ASEAN-6 except for the Philippines

The same method is applied to the declining trend group, ASEAN-6 except for the Philippines. The study is conducted in the context of 40 annual time periods for 5-country observation of 18 variables. So the number of observations in a set of data is 3,600 observations. Table 5.2 shows the descriptive statistics for 5 ASEAN-6 countries except for the Philippines.

Table 5.2. *Descriptive Statistics for ASEAN-6 except for the Philippines*

Variable	Obs	Mean	Std. Dev.	Min	Max
year	200	1994.5	11.57236	1975	2014
country	200	4.6	2.583286	1	8
y	200	3.100157	4.589056	-22.2854	18.3831
lnGDP75	200	7.021834	1.304816	5.602119	9.113389
TFR	200	2.615715	.9991375	1.15	5.043
LE	200	71.04613	5.226514	57.24	82.4951
ENROLL	200	16.41039	29.78395	0	92.97257
PAT	200	246.845	367.1565	0	1572
TFP	200	.4797986	.2888913	0	1.206885
CORR	200	24.00941	33.55953	0	98.9899
GOVEF	200	29.06745	37.75304	0	100
GOVEX	200	12.51963	5.387034	0	29.86726
L	200	43.86558	34.26875	0	79.059
H	200	9.43965	25.21115	0	86.57
GFCF	200	26.01933	9.980064	0	46.2467
SAV	200	38.41835	15.2807	0	86.2865
FDI	200	4.072386	5.431339	-2.7574	26.5212
TRD	200	148.1429	112.7039	0	441.6038
TXINTRD	200	4.89361	6.606131	0	26.84382
EXP	200	6.814931	8.822307	-31.80498	29.83393

In general, their data on logarithm of initial GDP per capita which refers to year 1975 ($lnGDP75$), total fertility rate (TFR), life expectancy (LE), total factor productivity (TFP), general government final consumption expenditure ($GOVEX$), gross fixed capital formation ($GFCF$), foreign direct investment (FDI), taxes on international trade ($TXINTRD$) and exports of goods and services (EXP) are in the same range which these data are not considerably different. These insights, also, reflect the economic and social development in Southeast Asian countries. However, it is the same as the sample of the whole region. The data of patent applications (PAT) has the highest gap among them. The second highest variance is the percentage of trade amount (TRD). While the data on human development and government effectiveness have a moderate gap among them. It might be because of the population number. Singapore, Malaysia, and Brunei are small countries in which their population are smaller than Indonesia and Thailand.

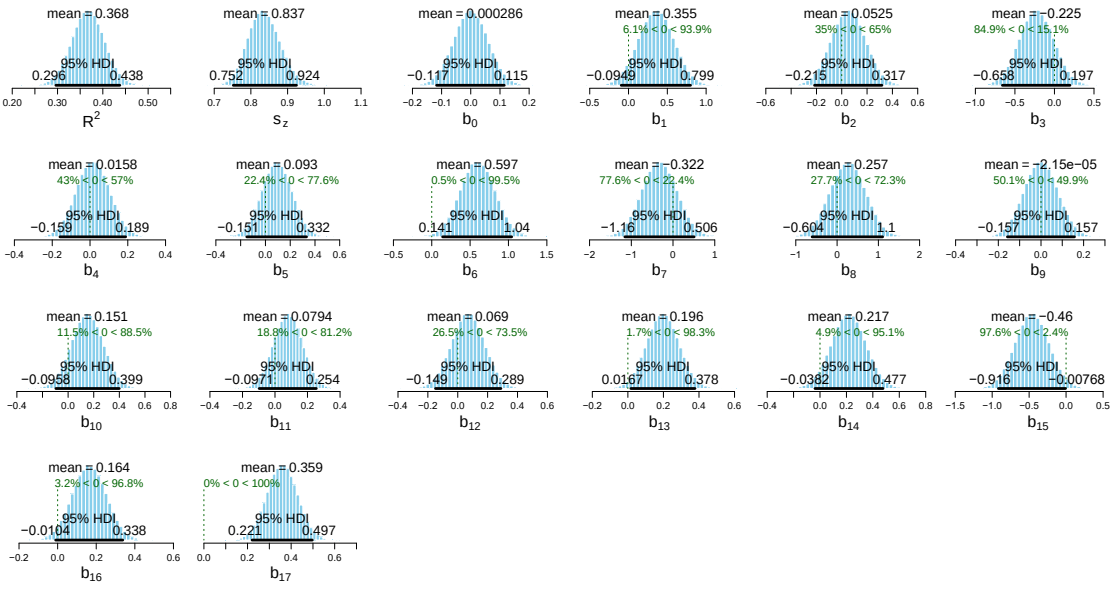

Figure 5.6. *Posterior Distribution for the Multiple Linear Regression Showing Parameters for Standardized Data in ASEAN-6 except for the Philippines*

Figure 5.6 shows the posterior distribution for data that have been standardized for 5 countries of ASEAN founder except the Philippines. Similarly with the whole region sample, panels of $\beta_1 - \beta_{17}$ represent the coefficient of predictors which refer to variable no. 2 to variable no. 18 according to Table 4.1. While β_0 and σ_z are presenting the intercept and the standard deviation value respectively.

The result in Figure 5.6 illustrates that total factor productivity, the rate of saving, foreign direct investment, trade volume, taxes on trade and export volume are significant predictors impact to the economic growth rate at 0.05 significance level. All factors' directional impact is causality except trade. Trade volume should impact the economic growth rate positively. However, trade, in this case, represents the openness rather than account balance and its value contains both import and export. As the direction of export is causal, it is possible that in this market experiences import higher than export. The prominent determinant is TFP which can be interpreted that 1 unit of standard deviation increase in TFP impacts to an increase in economic growth rate by 0.597 units of its standard deviation. While one unit of standard deviation increase in export, FDI, the rate of saving and taxes in trade impacts to an increase in economic growth rate by 0.359, 0.217, 0.196 and 0.164 units of their standard deviation respectively.

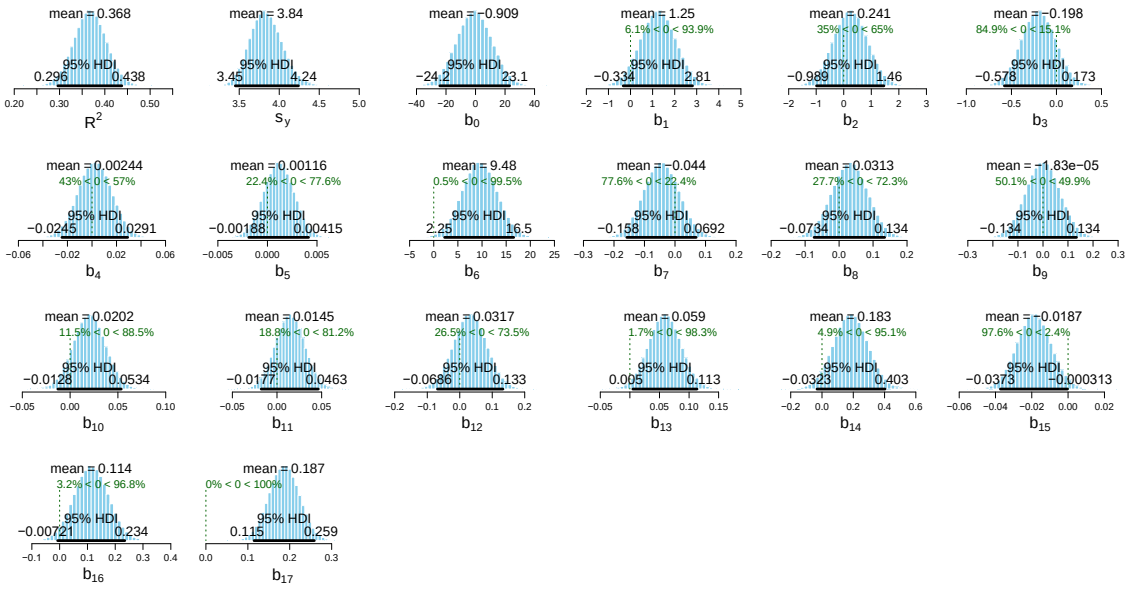

Figure 5.7. *Posterior Distribution for the Multiple Linear Regression Example, Showing Original-Scale Parameters in ASEAN-6 except for the Philippines*

Figure 5.7 shows the posterior distribution of economic growth determinants for the sample of ASEAN-6 except for the Philippines on the original data scale. Panels of σ_y, b_0, and $b_1 - b_{17}$ refer to the posterior distribution for the intercept, the standard deviation, and coefficients of explanatory variable no.2 – 18 in Table 4.1 on the original data scale, respectively.

The original scale shows that an increase in 1 unit increase in TFP ratio impacts the probability of an increase in the GDP per capita growth rate by 9.48 percent. Besides, 1 percent increase of exports, domestic savings, tax revenue for international trade, and FDI affects the probability of an increase in the growth rate by 0.187, 0.059, 0.114, and 0.183 percent respectively.

5.3. CLMV and the Philippines

The same method is applied to the increasing trend group - CLMV and the Philippines – as well.

Table 5.3. *Descriptive Statistics for CLMV and the Philippines*

Variable	Obs	Mean	Std. Dev.	Min	Max
year	200	1994.5	11.57236	1975	2014
country	200	6.4	2.877743	2	10
y	200	3.118194	4.837841	-37.0023	12.6854
lnGDP75	200	4.801323	.6267699	4.248495	5.991465
TFR	200	4.089295	1.338868	1.894	6.369
LE	200	60.99833	10.14372	18.907	75.855
ENROLL	200	12.23889	19.88715	0	66.83912
PAT	200	48.85	88.54779	0	487
TFP	200	.1532376	.2046631	0	.6002461
CORR	200	7.611623	12.63194	0	45.8763
GOVEF	200	11.53557	18.45004	0	61.0577
GOVEX	200	4.840527	4.836417	0	21.38435
L	200	48.49335	38.16847	0	87.205
H	200	4.488073	18.19176	0	91.1836
GFCF	200	14.42017	11.29881	0	35.21704
SAV	200	9.810921	10.92411	-5.6306	36.9628
FDI	200	2.348687	3.016909	-.3267	13.058
TRD	200	51.3814	49.09657	0	169.5345
TXINTRD	200	7.667375	9.054718	0	29.96738
EXP	200	5.959499	11.25135	-21.03382	73.76177

The study is conducted in the context of 40 annual time periods for 5-country observation of 18 variables. So the number of observations in a set of data is 3,600 observations. Table 5.3 shows the descriptive statistics for CLMV and the Philippines. In general, their data are quite dispersed. The logarithm of initial GDP per capita which refers to year 1975 ($lnGDP75$), total fertility rate (TFR), total factor productivity (TFP), general government final consumption expenditure ($GOVEX$), foreign direct investment (FDI), and taxes on international trade ($TXINTRD$) are in the same range which these

data are not considerably disperse. Even though the data is dispersed but their gap is lesser than the highest gap in the ASEAN-6 group except for the Philippines. The data of patent applications (PAT) has the highest gap among them as well while the second highest variance is the percentage of trade amount (TRD). These are the same as the declining growth trend group too.

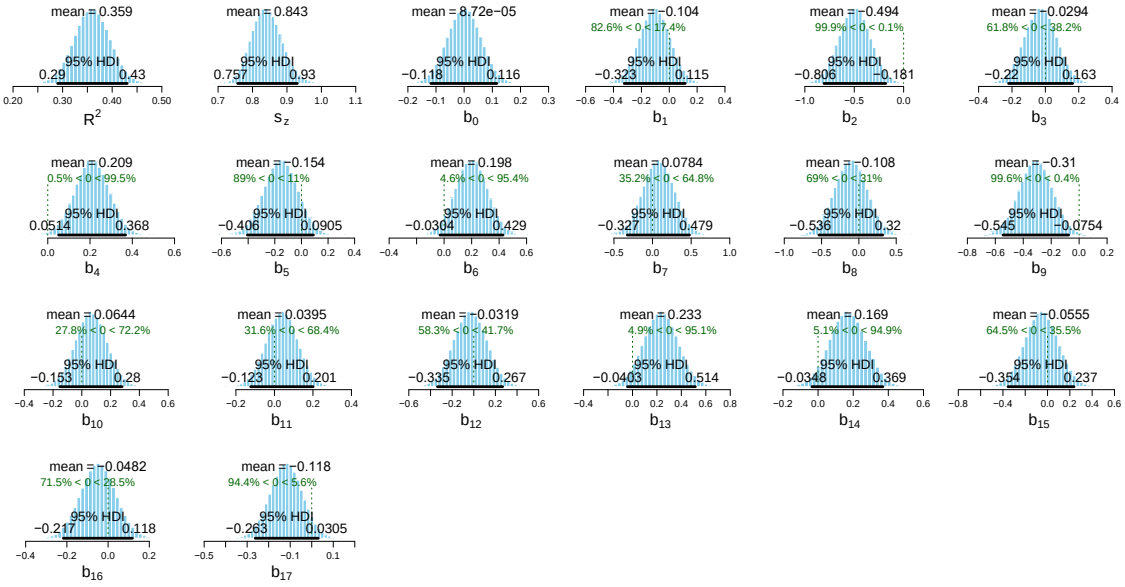

Figure 5.8. *Posterior Distribution for the Multiple Linear Regression Showing Parameters for Standardized Data in CLMV and the Philippines*

Figure 5.8 shows the posterior distribution for data that have been standardized for 5 countries which are Cambodia, Laos, Myanmar, Vietnam, and the Philippines. Similarly with the whole region sample, panels of $\beta_1 - \beta_{17}$ represent the coefficient of predictors which refer to variable no. 2 to variable no. 18 according to Table 4.1. While β_0 and σ_z are presenting the intercept and the standard deviation value respectively.

The posterior distribution for determinants of economic growth for CLMV and the Philippines in Figure 5.8 results in contrast with the regional downward growth trend group, ASEAN-6 except for the Philippines. We found that 1 unit of standard deviation increase of TFP impacts to an increase in economic growth rate by 0.198 units of its standard deviation only. TFP contribution is lesser than the rate of saving and secondary enrollment which their 1 unit of standard deviation increase impacts to an increase in economic growth rate by 0.233 and 0.209 units of their standard deviation.

On the other hand, 1 unit of standard deviation decline in TFR and general government final consumption expenditure impact to an increase in economic growth rate by 0.494 and 0.310 units of their standard deviation, respectively. And all directional impact is causality

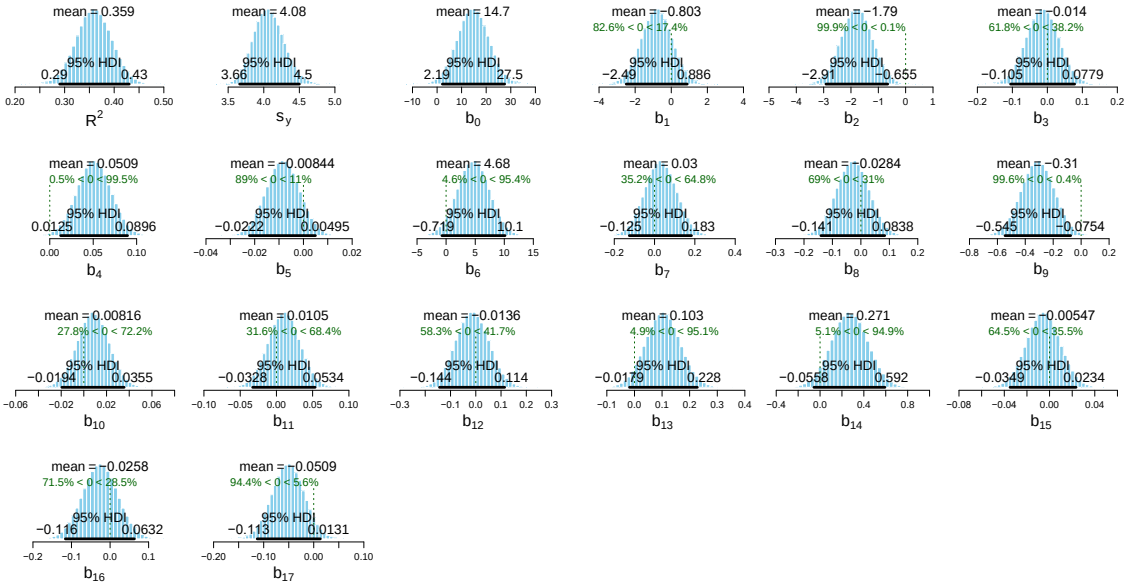

Figure 5.9. *Posterior Distribution for the Multiple Linear Regression Example, Showing Original-Scale Parameters in CLMV and the Philippines*

Figure 5.9 shows the posterior distribution of economic growth determinants for the sample of CLMV and the Philippines on the original data scale. Panels of σ_y, b_0, and $b_1 - b_{17}$ refer to the posterior distribution for the intercept, the standard deviation, and coefficients of explanatory variable no.2 – 18 in Table 4.1 on the original data scale, respectively.

The original scale shows that an increase in 1 percent increase in domestic savings and school enrollment rate impacts the probability of an increase in the GDP per capita growth rate by 0.103 and 0.0509 percent respectively. While, 1 percent decrease in total fertility rate affects the probability of an increase in the growth rate by 1.79 percent.

5.4. R^2 of Bayesian Multiple Linear Regression

Finally, the first panels of Figure 5.4, 5.6, and 5.8 illustrate an entire distribution of credible values that the proportion of variance accounted for, R^2. At each step in the

MCMC chain, a credible value of R^2 is computed as simply an indication of the credible regression coefficients at that step.

$$R^2 = \sum_{j=1}^{n} \beta_j r_{y.x_j} \tag{5.1}$$

β_j is the standardized regression coefficient for the j^{th} predictor at that step in the MCMC chain and $r_{y.x_j}$ is the sample correlation of the criterion values, y, with the j^{th} predictor values, x_j. The equation for expressing R^2 in terms of the regression coefficients is used by analogy to least squares regression in which the equation is exactly true. The mean value in the distribution of R^2 is essentially the maximum likelihood estimate when using vague priors and the least squares estimate when using a normal likelihood function. The posterior distribution reveals the entire distribution of credible R^2 values. The posterior distribution of R^2 can exceed 1.0 or fall below 0.0 because R^2 here is a linear combination of credible regression coefficients, not the singular value that minimizes the squared deviations between predictions and data.

6. CONCLUSION AND RECOMMENDATIONS

The potential determinants of economic growth are the main thing that has been concerning on economic growth research area. This study is done to determine the robust determinants and investigate the driving forces of economic growth in the Southeast Asian region. Determinants are estimated by applying the Bayesian approach with panel data of ten countries during 1975-2014.

The first objectives of this research were to identify the prominent determinants of economic growth in Southeast Asia by applying the Bayesian approach. It can be concluded from the finding of this research in Figure 5.4 that the prominent determinants of the whole region are the foreign direct investment and total factor productivity. This finding agrees with the statistics provided by ASEAN Secretariat showing ongoing inflows of FDI to the region. Therefore, we are able to say that the Southeast Asian region is perceived and concerned as one of the attractive markets to investors.

The outstanding economic performance came from international capital inflows especially the big powerful investors from China and the United State. In other words, the regional economy depends on the world economy significantly. Hence, FDI inflows to the ASEAN market have been found decreasing since 2015 due to the slowdown economic growth in the global market.

However, the economic growth of CLMV and the Philippines does not go down as the world trend. When the whole region is separated into two groups according to the downward and upward growth trend, their prominent determinants also differ. For ASEAN-6, the founder of ASEAN except for the Philippines, the findings suggest that prominent determinant of their economic growth is total factor productivity. Because ASEAN founder is a group of countries who began the outward orientation earlier, the economy of ASEAN founder is mostly cited as the old emerging market already. They have improved their basic capacity such as infrastructure and physical capital for a half century. Thus, TFP could a main driver of their economic growth. While population control, domestic saving volume, and education are prominent determinants for the latter following members, CLMV. This group, now, becomes the new emerging market of the region and the world.

The finding results support the fact that economic growth contributes the economic development. And the attractive characteristic of Southeast Asian market toward the

investors is the cheap labors. With their development in the ASEAN founder countries, it helps their total factor productivity and capitals, which means both physical and human capital, become higher without any costs of technological change or innovational improvement. At the same time, the investors who are looking for the cheap labor market has been moving to CLMV instead and it contributes to an increase of their economic growth trend significantly. Furthermore, countries in the upward growth trend, such as Vietnam and Laos have the considerable improvement in human capital and technology. This makes them become the new emerging market and attractive production place for foreign investors especially the Chinese.

Each country in Southeast Asia become the emerging market sequentially by the same process. The old market did control on fertility rate, government expenditure and human capital improvement before the new market. Hence, these factors are not significant for them anymore. In order to have sustainable growth in the long run, the endogenous growth theory encourages to develop human resource by funding in technological research and development. The result of this study is totally convinced that ideas and innovations can lead to a higher steady-state economic growth rate (Barro & Sala-i-Martin, 2004; Jones, 2016; Romer, 1990). The case study of Southeast Asia could explain clearly the situation between the growth of less and more developing markets.

In light of the second and third objectives of this study, the impact of the identified determinants for the sample countries has been measured and the future growth trend has been indicated. The results for the whole region, upward, and downward growth trend countries have been analyzed and discussed along absolute and comparative dimensions in the previous part.

This section aims to achieve the final objective of this study, the policy recommendations that can lead to sustainable economic growth in Southeast Asia. With the evidence of this research, the determinants of long-run economic growth help to understand the insightful comments of this regional economy. Therefore, we have the right perception in order to move forward the sustainable growth in the future. So the policy-makers in lower-middle income countries like CLMV groups should focus on human capital improvement. They also could implement the public policy and social welfare to help their citizens easier access to the existing knowledge rather than promoting more saving. In the present time of the digital era, using technologies and

digital platform for the process of education and training is encouraged and helps them to save their budgets.

For the upper-middle income and high income countries like the group of ASEAN-6, the ongoing policies about tax subsidies for research and development in both private and public business sectors are recommended in order to move forward to become government-led technology state. Hence, they are able to survive by their own technology and innovations instead of depending heavily on foreign direct investment and other technological processes (Romer, 1994).

However, this study does not go in the detail of the country-specific effect which might result differently apart from our results. The further study should be considered this aspect in the estimation in order to ensure more properly prominent determinants of economic in Southeast Asia.

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APPENDIX

The main software used in this study is R program. To run BMLR, R program, JAGS, rjags, and RStudio need to be installed. The latest general programming language R can be downloaded and installed from the website *https://www.r-project.org*. Its editor, RStudio, can be downloaded from the website *https://www.rstudio.com*. RStudio helps for interacting with R but it is not compulsory to have it. The MCMC generator works through the program names as JAGS *http://mcmc-jags.sourceforge.net*. In order to let R work with JAGS, the package rjags is needed to install in R by typing command `install.packages("rjags")`at the command line in R console. The working commands of R programs for running BMLR are below.

```
graphics.off()          # Clears all graphical displays.
rm(list=ls(all=TRUE))   # Removes all variables from memory!

# Get the Bayesian functions into R's working memory:
source("BMLR.R")

# Important:
# The matrix dataMat must have the criterion y in its first column,
# and the predictors in the subsequent columns!

# Run BMLR analysis and put the results in variable named mcmcChain:
mcmcChain = BMLRmcmc( dataMat )

# Plot the posterior distribution & put summary in variable named
postInfo:
postInfo = BMLRplot( mcmcChain )

# Display the summary on the console:
show(postInfo)
```

`BMLR.R` file is a command file for generating MCMC chain. This file must be in working directory folder. In RStudio, working directory can be set by clicking menu items Tools -> Set Working Directory -> To Source File Location. The working commands for `BMLR.R` file are following.

```
# Load auxiliary functions for plotting the MCMC chain:
source("plotPost.R")
source("plotPost1.R")
source("openGraphSaveGraph.R")

# This part is for panel data, otherwise it can be ignored:
library(Formula)
library(plm)

# Load the data into R:
dataMat = read.csv( file="CLMVP.csv" )

# Make data a panel dataset for country and year:
dataMat<-pdata.frame(dataMat, index=c("Country", "Year"))

# Delete string column:
dataMat<-dataMat[,-c(1:2)]
```

We use broad prior for each regression coefficient and intercept in normal distribution form at mean = 0 and standard deviation = 100. For the parameter of variance, the uniform distribution prior is used due to prior ignorance at mean = 0 and standard deviation = 10.

```
BMLRmcmc = function( dataMat , numSavedSteps=250000 ,
checkConvergence=FALSE ) {
  # Program written in the style of:
  require(rjags)
  #------------------------------------------------------------------
  # THE MODEL.
  modelstring = "
  # JAGS model specification begins here...
  model {
  # Likelihood:
     for( i in 1:N ) {
     y[i] ~ dnorm( y.hat[i] , tau )
     y.hat[i] <- b0 +  inprod( b[1:nPred] , x[i,1:nPred] )
     }
  # Prior (assumes standardized data):
     tau <- 1/pow(sigma,2)
     sigma ~ dunif( 0 , 10 )
     b0 ~ dnorm( 0 , 1.0E-2 )
     for ( j in 1:nPred ) {
     b[j] ~ dnorm( 0 , 1.0E-2 )
     }
  }
  # ... end JAGS model specification
  " # close quote for modelstring
       writeLines(modelstring,con="model.txt
```

This part shows data adjustment for file `dataMat` which is supplied as an argument to this function. The program assumes that the first column is y, and the remaining columns are x_k (predictors).

```
43    #------------------------------------------------------------------
44    # THE DATA
45
46    # Now re-name variables from dataMat:
47    N = NROW(dataMat)
48    y = cbind(as.vector(dataMat[,1]))
49    predictedName = colnames(dataMat)[1]
50    x = as.matrix(dataMat[,-1])
51    predictorNames = colnames(dataMat)[-1]
52    nPred = NCOL(x)
53
54    # Prepare data for JAGS:
55    # Re-center data at mean, to reduce autocorrelation in MCMC
56  sampling.
57    # Divide by SD to make prior specification generic.
58    standardizeCols = function( dataMat ) {
59      zDataMat = dataMat
60      for ( colIdx in 1:NCOL( dataMat ) ) {
61        mCol = mean( dataMat[,colIdx] )
62        sdCol = sd( dataMat[,colIdx] )
63        zDataMat[,colIdx] = ( dataMat[,colIdx] - mCol ) / sdCol
64      }
65      return( zDataMat )
66    }
67    zx = standardizeCols( x )
68    zy = standardizeCols( y )
69
70    # Get the data into JAGS:
71    dataList = list(
72      x = zx ,
73      y = as.vector( zy ) , # JAGS does not treat 1-column mat as
74  vector
75      N = N ,
76      nPred = nPred
77    )
```

This part is the setting of MCMC chains, the command of execution, and the result examination. We need MCMC chain for plotting the result of Bayesian linear model regression.

```
78    #------------------------------------------------------------------
79    # INTIALIZE THE CHAINS.
80
81    # Start the chains at the least-squares fit:
82    lmInfo = lm( dataList$y ~ dataList$x )
```

```
  initsList = list(
    b0 = lmInfo$coef[1] ,
    b = lmInfo$coef[-1] ,
    sigma = sqrt(mean(lmInfo$resid^2))
  )

  #------------------------------------------------------------------
  # RUN THE CHAINS

  parameters = c("b0" , "b" , "sigma" )
  adaptSteps = 1000   # Number of steps to "tune" the samplers.
  burnInSteps = 1000  # Number of steps to "burn-in" the samplers.
  nChains = 10        # Number of chains to run.
  numSavedSteps=250000 # Total number of steps in chains to save.
  thinSteps=1     # Number of steps to "thin" (1=keep every step).
  nPerChain = ceiling( ( numSavedSteps * thinSteps ) / nChains )
# Steps per chain.

  # Create, initialize, and adapt the model:
  jagsModel = jags.model( "model.txt" , data=dataList ,
                          inits=initsList , n.chains=nChains ,
                          n.adapt=adaptSteps )

# Burn-in:
  cat( "Burning in the MCMC chain...\n" )
  update( jagsModel , n.iter=burnInSteps )

  # The saved MCMC chain:
  cat( "Sampling final MCMC chain...\n" )
  codaSamples = coda.samples( jagsModel ,
                              variable.names=parameters ,
                              n.iter=nPerChain , thin=thinSteps )

  # resulting codaSamples object has these indices:
  #   codaSamples[[ chainIdx ]][ stepIdx , paramIdx ]

  #------------------------------------------------------------------
  # EXAMINE THE RESULTS

  if ( checkConvergence ) {
    openGraph(width=3,height=3)
    autocorr.plot( codaSamples[[1]] , ask=FALSE )
    show( gelman.diag( codaSamples ) )
    effectiveChainLength = effectiveSize( codaSamples )
    show( effectiveChainLength )
  }

  # Convert coda-object codaSamples to matrix object for easier
handling.
  # But note that this concatenates the different chains into one
long chain.
  # Result is mcmcChain[ stepIdx , paramIdx ]
```

```
135     mcmcChain = as.matrix( codaSamples )
136     chainLength = NROW(mcmcChain)
137
138     # Rename results, for convenience:
139     zsigma = mcmcChain[,"sigma" ]
140     zb0 = mcmcChain[,"b0"]
141     zb = matrix( 0 , nrow=chainLength , ncol=nPred )
142     for ( j in 1:nPred ) {
143       zb[,j] = mcmcChain[,paste("b[",j,"]",sep="")]
144     }
145     colnames(zb) = paste("zb",1:nPred,sep="")
146
147     # Convert to original scale
148     sigma = zsigma * sd(as.vector(y))
149     # for b0:
150     subtractTerm = rep(0,chainLength)
151     for ( j in 1:nPred ) {
152       subtractTerm = subtractTerm + zb[,j] * sd(as.vector(y)) *
153   mean(x[,j])/sd(x[,j])
154     }
155     b0 = zb0 * sd(as.vector(y)) + mean(y) - subtractTerm
156     # for b:
157     b = 0*zb
158     for ( j in 1:nPred ) {
159       b[,j] = zb[,j] * sd(as.vector(y)) / sd(x[,j])
160     }
161     colnames(b) = paste("b",1:nPred,sep="")
```

This part is how to compute R^2 for credible parameters and combine them with all standardized and original data, as well as their intercepts and standard deviations in MCMC chain.

```
162     Rsq = rep(0,chainLength)
163     YcorX = cor( y , x ) # correlation of y with each x predictor
164     for ( stepIdx in 1:chainLength ) {
165       Rsq[stepIdx] = sum( zb[stepIdx,] * YcorX )
166     }
167     ## Old version, perhaps useless:
168     #Rsq = rep(0,chainLength)
169     #for ( stepIdx in 1:chainLength ) {
170     #  predY = dataList$x %*% cbind(zb[stepIdx,]) + zb0[stepIdx]
171     #  Rsq[stepIdx] = cor(dataList$y,predY)^2
172     #}
173
174     # Combine results into one big matrix:
175     mcmcChain = cbind( zsigma,zb0,zb, sigma,b0,b, Rsq )
176     return( mcmcChain )
177   }
178
179   BMLRplot = function( mcmcChain , ROPEbeta=NULL , ROPEbetaDiff=NULL
180   ) {
```

```
181
182     summaryMatrix = matrix( NA , nrow=0 , ncol=11 ,
183
184   dimnames=list(ParameterName=NULL,PosteriorInfo=NULL) )
185
186     # Compute number of predictors from NCOL of mcmcChain matrix.
187     # Assumes mcmcChain has columns zsigma,zb0,zb,sigma,b0,b,Rsq
188     nPred = (NCOL(mcmcChain)-1)/2 - 2
```

Below are the code for displaying scatter plots of parameter values which is pairwise comparison for each variables.

```
189     openGraph(width=15,height=15)
190     chainLength = NROW(mcmcChain)
191     nToPlot = 400
192     plotIdx = seq(1,chainLength,by=ceiling(chainLength/nToPlot))
193     pairs(
194   mcmcChain[plotIdx,c("Rsq","zsigma","zb0",paste("zb",1:nPred,sep=""
195   ))] ,
196             col="skyblue" )
197     openGraph(width=15,height=15)
198     pairs(
199   mcmcChain[plotIdx,c("Rsq","sigma","b0",paste("b",1:nPred,sep=""))]
200   ,
201             col="skyblue" )
202
203     #   # Show correlation matrix on console:
204     #   cat("\nCorrlations of posterior sigma, b0, and b's:\n")
205     #   show( round( cor( mcmcChain ) , 3) )
206     #   cat("\nCovariances of posterior sigma, b0, and b's:\n")
207     #   show( round( cov( mcmcChain ) , 5) )
```

This part is the code for displaying the marginals of posterior distribution for standardized regression coefficients, the intercept and standard deviation.

```
208     nPostCol = 6 # arbitrary number of columns for display
209     nPostRow = ceiling((3+nPred)/nPostCol)
210     openGraph(width=nPostCol*2.5,height=nPostRow*2.0)
211     layout(matrix(1:(nPostCol*nPostRow),nrow=nPostRow,byrow=TRUE))
212     par( mar=c(4,1,2,1) , mgp=c(2.5,0.7,0) )
213     histInfo = plotPost( mcmcChain[,"Rsq"] , xlab=bquote(R^2) ,
214   main="" ,
215                          cex.main=1.67 , cex.lab=1.67 ,
216   col="skyblue" )
217     summaryMatrix = rbind( summaryMatrix , histInfo )
218     histInfo = plotPost( mcmcChain[,"zsigma"] ,
219   xlab=bquote(sigma[z]) , main="" ,
220                          cex.main=1.67 , cex.lab=1.67 ,
221   col="skyblue" )
222     summaryMatrix = rbind( summaryMatrix , histInfo )
```

```
  histInfo = plotPost( mcmcChain[,"zb0"] , xlab=bquote(beta[0]) ,
main="" ,
                       cex.main=1.67 , cex.lab=1.67 ,
col="skyblue" )
  summaryMatrix = rbind( summaryMatrix , histInfo )
  for ( j in 1:nPred ) {
    histInfo = plotPost( mcmcChain[,paste("zb",j,sep="")] ,
                         xlab=bquote(beta[.(j)]) , main="" ,
                         compVal = 0.0 , ROPE=ROPEbeta ,
                         cex.main=1.67 , cex.lab=1.67 ,
col="skyblue" )
    summaryMatrix = rbind( summaryMatrix , histInfo )
  }
```

This part is the code for displaying the marginals of posterior distribution for regression coefficients, the intercept and standard deviation in original scale.

```
  nPostCol = 6 # arbitrary number of columns for display
  nPostRow = ceiling((3+nPred)/nPostCol)
  openGraph(width=nPostCol*2.5,height=nPostRow*2.0)
  layout(matrix(1:(nPostCol*nPostRow),nrow=nPostRow,byrow=TRUE))
  par( mar=c(4,1,2,1) , mgp=c(2.5,0.7,0) )
  histInfo = plotPost( mcmcChain[,"Rsq"] , xlab=bquote(R^2) ,
main="" ,
                       cex.main=1.67 , cex.lab=1.67 ,
col="skyblue" )
  #summaryMatrix = rbind( summaryMatrix , histInfo )
  histInfo = plotPost( mcmcChain[,"sigma"] , xlab=bquote(sigma[y])
, main="" ,
                       cex.main=1.67 , cex.lab=1.67 ,
col="skyblue" )
  summaryMatrix = rbind( summaryMatrix , histInfo )
  histInfo = plotPost( mcmcChain[,"b0"] , xlab=bquote(b[0]) ,
main="" ,
                       cex.main=1.67 , cex.lab=1.67 ,
col="skyblue" )
  summaryMatrix = rbind( summaryMatrix , histInfo )
  for ( j in 1:nPred ) {
    histInfo = plotPost( mcmcChain[,paste("b",j,sep="")] ,
                         xlab=bquote(b[.(j)]) , main="" ,
                         compVal = 0.0 ,
                         cex.main=1.67 , cex.lab=1.67 ,
col="skyblue" )
    summaryMatrix = rbind( summaryMatrix , histInfo )
  }
```

Below are the code for displaying differences of standardized regression coefficients. This benefits for comparing each predictor in order to find effective one.

```
  nPostCol = 18
```

```
    nPostCell = nPred*(nPred-1)/2
    nPostRow = ceiling(nPostCell/nPostCol)
    openGraph(width=nPostCol*2.0,height=nPostRow*1.5)
    layout(matrix(1:(nPostCol*nPostRow),nrow=nPostRow,byrow=TRUE))
    par( mar=c(3,1,1,1) , mgp=c(2,0.5,0) )
    for ( j in 1:(nPred-1) ) {
      for ( k in (j+1):nPred ) {
        histInfo = plotPost1( mcmcChain[,paste("zb",j,sep="")]
                             -
mcmcChain[,paste("zb",k,sep="")],HDItextPlace=0.75,
                             xlab=bquote(beta[.(j)] - beta[.(k)]) ,
main="" ,
                             compVal = 0.0 , ROPE=ROPEbetaDiff ,
cex=0.75,
                             cex.main=0.75 , cex.lab=0.75 ,
col="skyblue" )
        summaryMatrix = rbind( summaryMatrix , histInfo )
      }
    }

    return( summaryMatrix )

}
```

This is the end of function `BMLRplot`