THE COMPARISON BETWEEN MAXIMUM LIKELIHOOD ESTIMATION AND BAYESIAN METHOD: FITTING TO FINITE MIXTURE MODEL

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SULTAN IDRIS EDUCATION UNIVERSITY

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THE COMPARISON BETWEEN MAXIMUM LIKELIHOOD ESTIMATION AND BAYESIAN METHOD: FITTING TO FINITE MIXTURE MODEL

ABSTRACT

In the era of Big Data, statistical modelling plays important role in handling a prodigious flow of datasets. The existing literatures regarding the performance of maximum likelihood estimation and Bayesian method that fit with finite mixture model in time series modelling is still lacking. The main objective of this study was to compare the maximum likelihood estimation and Bayesian method in fitting with finite mixture model and determine the plausible method in analysing time series data. Also, this study aimed to identify the number of components and the representation existed in time series data. Additionally, this study also evaluated and modelled the exchange rate, inflation rate, electrical and electronic export values in Malaysia, Thailand and the Philippines using both methods that fit to finite mixture model. The finite mixture model is an unsupervised learning model that can fit with all types of distributions and hence modelling a variety of data. In this study, maximum likelihood estimation and Bayesian method were adapted with finite mixture model to investigate the relationship between sampled variables as both methods are well-known parameter estimation method used in large sample study. As a result, the two components mixture model obtained in sampled variables. Both approaches revealed that a negative relationship presented between exchange rate with electrical and electronic export prices. Besides that, a positive relationship exhibited between inflation rate with electrical and electronic export prices. For exchange rate and inflation rate, negative relationship occurred in the normal situation while no relationship existed in crisis period. In conclusion, both methods provided almost similar results but maximum likelihood estimation performed better than the Bayesian method. As an implication, the efficiency of statistical method, importance of components' representations and statistical modelling highlighted in this study can be a guideline to statisticians who are interested in the similar field.

PERBANDINGAN ANTARA ANGGARAN KEMUNGKINAN MAKSIMUM DAN KAEDAH BAYESIAN: PENYESUAIAN DENGAN MODEL CAMPURAN TERHINGGA

ABSTRAK

Dalam era Data Raya, pemodelan statistik memainkan peranan penting dalam mengendalikan sejumlah data. Literatur yang fokus kepada prestasi anggaran kemungkinan maksimum dan kaedah Bayesian dalam model campuran terhingga adalah terhad. Tujuan utama kajian ini adalah untuk membandingkan kecekapan anggaran kemungkinan maksimum dan kaedah Bayesian dalam menyesuaikan model campuran terhingga serta mengenal pasti kaedah yang paling sesuai dalam mengendalikan data siri masa. Kajian ini juga bertujuan untuk mengenal pasti bilangan komponen dan perwakilan yang terdapat dalam data siri masa. Selain itu, kajian ini juga menganggar dan membuat permodelan terhadap kadar pertukaran wang, kadar inflasi, nilai eksport elektrik dan elektronik di Malaysia, Thailand dan Filipina dengan menggunakan kedua-dua kaedah yang berpadanan dengan model campuran terhingga. Model campuran terhingga merupakan model pembelajaran tanpa pengawasan yang sesuai dengan semua jenis taburan dan memodelkan pelbagai jenis data. Dalam kajian ini, anggaran kemungkinan maksimum dan kaedah Bayesian telah diadaptasi dengan model campuran terhingga untuk mengkaji hubungan antara pemboleh ubah sampel. Hasilnya, model campuran dua komponen telah diperoleh dalam pemboleh ubah sampel. Kedua-dua kaedah menunjukkan bahawa hubungan negatif wujud di antara nilai penukaran wang dengan harga eksport elektrik dan elektronik. Selain itu, hubungan positif wujud di antara kadar inflasi dengan harga eksport elektrik dan elektronik. Untuk kadar pertukaran wang dan kadar inflasi, hubungan negatif terjadi dalam situasi normal manakala tiada hubungan ditunjukkan dalam keadaan krisis. Kesimpulannya, kedua-dua kaedah memberikan hasil yang hampir serupa, tetapi anggaran kemungkinan maksimum menunjukkan keberkesanan yang lebih baik daripada kaedah Bayesian. Sebagai implikasi, kecekapan kaedah statistik, kepentingan perwakilan komponen dan pemodelan statistik yang ditekankan dalam kajian ini dapat menjadi panduan kepada ahli statistik yang berminat dalam penyelidikan yang seperti ini.

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LIST OF ABBREVIATIONS

1MDB	One Malaysia Development Bank
ADF	Augmented Dicky-Fuller
AIC	Akaike's Information Criterion
ARCH	Autoregressive Conditional Heteroskedasticity
BIC	Bayesian Information Criterion
Covid-19	Coronavirus Diseases 2019
DMS	Duan, Moreau and Sealey
DSGE	Dynamic Stochastic General Equilibrium
E&E	Electrical and Electronic
EM	Expectation Maximisation
E-step	Expectation step
FMM	Finite Mixture Model
FOREX	Foreign Exchange
GDP	Gross Domestic Product
GST	Goods and Service Tax
ISIS	Islamic State of Iraq and Syria
KPSS	Kwiatkowski-Phillips-Schmidt-Shin
MATRADE	Malaysia External Trade Development Corporation
MC	Monte Carlo

MCMC	Markov Chain Monte Carlo
MCO	Movement Control Order
MENA	Middle East and African Nations
MPC	Monetary Policy Committee
MRI	Magnetic Resonance Images
M-step	Maximisation step
MYR	Malaysian Ringgit
NEER	Nominal Effective Exchange Rate
OPR	Overnight Policy Rate
PHP	Philippines Peso
PP	Phillips-Perron
PROC FMM	Finite Mixture Model Procedures
R&D	Research and Development
REER	Real Effective Exchange Rate
SAS	Statistical Analysis System
THB	Thai Baht
USD	United States Dollar

CHAPTER 1

INTRODUCTION

1.1 Introduction

In the 21st century, all countries applied the technique of open economy in which a nation undergoes transactions freely with other nations around the world. It indicates that a country is free to exchange services and goods among countries by crossing the countries' borders. With this, all countries can share the services and goods around the world by carrying out business through importing and exporting process as there is none of the nations is self-sufficiency, especially in this era of globalisation (Vijayasri, 2013).

Trading always involves the activity of purchasing, selling or even exchanging goods or services between countries. However, to increase Gross Domestic Product (GDP), export is incredibly important to the current, modern economy as export could bring positive impacts on a country's financial status (Chetthamrongchai, Somjai, & Chankoson, 2020). Meanwhile, the process of increasing the export rate is the easiest

way to improve the GDP of a country (Berg, & Lewer, 2015; Uddin, & Khanam, 2017). Hence, there is arise of researches regarding commodities export. There are few examples of commodities export's researches were conducted by Ismail, Talib, and Mokhtar (2019); Rahim, Suriadi, and Milia (2016); Saggu and Anukoonwattaka (2015).

In recent years, the top three of the world's export products are monopolised by the Electrical and Electronic (E&E) sector. It indicates that the E&E industry plays a crucial role in the world's economic development, especially in the era of technology. At present, E&E product is the main category of export in the world. According to Errighi and Bodwell (2017), most of the E&E products including 62% of televisions, 70% of semiconductors, 76% of car navigation systems, 86% of smartphones and 100% of digital cameras are manufactured by Asian countries. In the other words, it can be concluded that Asia is the largest E&E producer. With this, any changes in macroeconomic variables which are exchange rate and inflation rate will definitely affect the E&E export performance (Bogdan, Cota, & Erjavec, 2017; Kiganda, Obange, & Adhiambo, 2017).

The exchange rate is a representation of a country's economic development. This is because a country's economic growth can alter the exchange rate easily. For instance, the Asian Financial Crisis 1997 caused the depreciation of the exchange rate among Asian countries. As a result, most of the currencies in Asian countries were pegged to United States Dollar (USD) until Jun of the year 2005 to stabilise the economy and thus overcome the crisis.

The inflation rate is the rate change of commodities' and services' prices over a period of time (Wardhono, Nasir, Qori'ah, & Indrawati, 2021). There are two categories of inflation which are cost-push and demand-pull. The main difference between these two types of inflation is the origin of major impact as cost-push comes from the side of supply while demand-pull originates from the demand side. However, expensive goods and services are always caused by the extremely high rate of inflation.

To determine a country's economic flow, statisticians play a vital role in the process of analysing data and collecting information for economic purposes by applying various statistical methods. There are lots of statistical methods that can be utilised in analysing economic data, however, one of the common, famous statistical methods is the Finite Mixture Model (FMM), which is also well-known as the latent class model. Over the years, FMM has gained great attention in the statistical field as it has proven to be beneficial and usable in the aspect of modelling.

With the arise of computer technology, statisticians are favoured to apply maximum likelihood estimation and the Bayesian method in fitting FMM to analyse time series datasets. Maximum likelihood estimation always shows asymptotically normal and consistency in obtaining results when the sample sizes go to infinity (Psutka & Psutka, 2015). It indicates that maximum likelihood estimation is a consistent, unbiased estimator. Moreover, the Bayesian method has become one of the popular parameter estimation methods used in analysing large sample data due to its unique properties. Its asymptotic and consistency can provide reliable findings (Phoong & Ismail, 2014).

This chapter emphasises the ideas of the present study including research background, problem statements, research questions, research objectives, significance of the study, novelty of the study, operational definition, scope and limitations.

1.2 Research Background

The finite mixture model provides a natural representation of heterogeneity in a finite number of latent classes. With its flexibility and wide usage in the field of statistics, there is an increasing rate of FMM's articles regarding theoretical and practical in the literature of statistical and general scientific (McLachlan & Peel, 2001) over the past decades. In statistics, FMM is introduced to model different types of data (heterogeneous data) with a finite amount of unobserved subpopulations. Meanwhile, FMM is a mixture of several distributions that used to model a statistical distribution. With this, FMM has been widely implemented in different fields of biological, physical and social sciences sectors such as agriculture, economics, medicine, marketing, biology and psychiatry.

Additionally, there are plenty of statistical methods that can be utilised to fit in FMM such as the method of moments, minimum distance method, maximum likelihood estimation and Bayesian method. However, the method of moments and minimum distance method will not be implemented in this study due to the inadequate properties. The results of the method of moments will be reliable and valid if the sample size used

is small while the minimum distance method is usually applied in the study of distance measurements. With this, maximum likelihood estimation and the Bayesian method were introduced to fit with FMM in analysing the time series data of this study.

In the econometric study, a large sample of data is required to ensure the findings are always reliable and valid. With this, maximum likelihood estimation and the Bayesian method are popular, famous statistical approaches used by statisticians in analysing a huge sample of time series data. Since both methods provide outstanding properties, hence, it is believed that these methods can provide convincing results for the research. Therefore, maximum likelihood estimation and the Bayesian method are applied widely in the field of economic and finance.

In this study, maximum likelihood estimation and the Bayesian method were implemented to determine the relationship between E&E export value, exchange rate and inflation rate among Malaysia, Thailand and the Philippines. According to Chen and Intal (2017), Malaysia, Thailand and the Philippines are export-oriented nations that are competitive in skilled and labour-intensive manufactures of E&E, thus, these two countries are selected because they are the largest E&E competitors of Malaysia among Asian developing countries.

In the era of technology, the E&E industry is getting attention among countries around the world. Generally, there is a total of four sub-sectors in the E&E industry, including consumer electronics, electronic components, industrial electronics and

electrical products. Goods such as smartphones, cables and computers are under the category of E&E. With this, it can be easily found that E&E products have covered almost all essential products in our daily life. Geiger (1991) stated that the effects of dynamic growth can be further increased by the expansion of export goods in developing countries. With this, developing countries economic development becomes closer to international standards through export earnings. Hence, developing countries including Malaysia are trying their best to enhance the quality of products and services with the aim of increasing the export rate. For instance, the Malaysia External Trade Development Corporation (MATRADE) intends to put Malaysia as one of the top 20 world's main exporting countries within these few years by organising promotional events and planning few creative, appropriate approaches to boost up Malaysian export rate (The Star, 2016).

Malaysia has experienced economic transformation since independence in August 1957. In the 1960s, Malaysia is a commodity and agriculture-based country due to its natural resources such as tin and petroleum. Nevertheless, to fulfil the needs of international economic growth, Malaysia always transforms its economy with the times. As a result, Malaysia has become one of the export-oriented countries starting from the eighties. As evidence, according to Muhammad and Yaacob (2008), Malaysia was in the top 20 of the world's trading nations in the 1980s as Malaysia has doubled its export within five years, especially the export of E&E products. It showed that the E&E export is the main, powerful key that pushes Malaysia to the international market successfully. Other than that, according to the Ministry of International Trade and Industry (MITI), E&E is undoubtedly a great donor in the Malaysian industrialisation process. Hence, it

can be concluded that the E&E industry is a significant contributor to Malaysian economic growth.

Furthermore, E&E is the golden goose to all countries as it is a golden opportunity to get a huge return of profits in international trade. In Malaysia, the E&E industry is the greatest contributor in the aspect of export earnings (Mamun, Rahman, Taufiq, & Muzzammir, 2015). This statement is then supported by the Department of Statistics Malaysia who mentioned that the E&E products contributed 33.7% of total exports, that is RM 25.1 billion in February 2020. The major destinations of Malaysia export of E&E are United States, China, Singapore, Hong Kong and Japan. However, according to Trading Economics, developing countries such as Thailand and the Philippines are the largest competitors of Malaysia in terms of exporting E&E products to these countries. It is then supported by Chen and Intal (2017) who pointed out that Malaysia, Thailand and the Philippines are competitive in the manufacture of E&E. Concurrently, Mamun et al. (2015) also stated that Malaysia faced obstacles in exporting E&E products as competitors always offer strong competition edges such as providing cheap labour and raw materials which is then brought pressure to Malaysia.

Apart from that, the exchange rate plays a vital role in the aspect of international trade (Chowdhury & Hossian, 2014). This statement is supported by Hada, Avram, and Barbuta-Misu (2018) who stated that the exchange rate is potential in determining a country's trade performance. The exchange rate refers to the amount of the change of currency rate. Alternation of the exchange rate would affect the country's development. For instance, a low currency rate brings to a high export rate as the goods' value

becomes cheaper and vice versa. Thus, the stable the exchange rate denotes better economic development of a country.

Moreover, Maurya (2017) commented that macroeconomic factors including the inflation rate also bring huge impacts on the growth of the economy. With this, all countries are trying to sustain high economic growth with a low and stable inflation rate to maximise trade's profits. This is because a high rate of inflation may bring negative impacts on the country as it will cause its export value to become extremely expensive and hence reducing its competitiveness in the international market. As an example, the Global Financial Crisis 2008 hit countries including Malaysia. As a result, the inflation rate of Malaysia is extremely high during the year 2008, that is 5.8%. As one of the victims of the Global Financial Crisis, the Malaysian government introduced a stimulus package with 7 billion MYR in November 2008 in overcoming the global crisis (Bank Negara Malaysia, 2009). This scenario reveals that Malaysia tried to curb the inflation rate by building up the Malaysian economy. In the other words, it can be found that the rate of inflation would affect the economic growth of a country.

In Malaysia, E&E are the main contributor of export over the past four decades. Therefore, it is necessary to identify the relationship between the export value of E&E products, exchange rate, inflation rate among Malaysia and its competitors to ensure Malaysia can always gain and maximise the profits from the E&E industry through international trade. With this, the relationship between E&E export values, exchange rate and the inflation rate are examined throughout this study. At the same time, new

equations for estimating E&E export values, exchange rate and inflation rate nexus in sampled countries are generated from this research.

In conclusion, maximum likelihood estimation and the Bayesian approach were applied to fit with FMM in examining and hence modelling the variables of E&E export values, exchange rate and inflation rate throughout this study. Concurrently, by exploring the interaction between selected variables, the most appropriate method was determined among maximum likelihood estimation and the Bayesian method.

1.3 Problem Statement

In Coronavirus Diseases 2019 (Covid-19) era, the world economy has been greatly influenced by the outbreak of the global pandemic crisis. The Covid-19 pandemic was initiated in Wuhan, China since December 2019. However, the Covid-19 is then spread out to all countries around the world due to underestimated its effects. With this, many countries including Malaysia have announced to lockdown in order to prevent the continuous outbreak of Covid-19. The lockdown's rules including movement restriction, temporary closure of companies and international flight interrupted economic activities across the region. Malaysia, one of the E&E oriented exporters has implemented Movement Control Order (MCO) on 18 March 2020, hence, all factories and companies are temporarily closed as all citizens are allowed to work from home only. This scenario has greatly impact Malaysian economic growth especially in Malaysia's largest export

contributor, E&E. Thus, it can be known that Asia, as the world's E&E suppliers have been affected by this pandemic as export among countries is highly restricted due to lockdown measures. Therefore, it is required to carry out this research in modelling the relationship between E&E export value, exchange rate and inflation rate among sampled Asian countries.

Nowadays, all countries are competing to grab a piece of cake from the E&E market including our country, Malaysia. With this, many studies regarding the E&E sector have been conducted by researchers as a guideline for policymakers to sustain high economic growth. In Malaysia, researches regarding the relationship between E&E and macroeconomic variables such as inflation rate and exchange rate are still lacking. Most of the E&E researches emphasised on competitiveness and performance of Malaysia's E&E export only. There are few examples of researches were done by Mamun et al. (2015); Chavosh, Halimi, Soheilirad, Ghajarzadeh, and Nourizadeh (2011); Arshad and Radam (1997). As an example, the findings of Chavosh et al. (2011) mentioned that customers were satisfied with the performance of export E&E. However, these existing researches are insufficient in providing useful information and idea for the government in making an accurate decision to sustain economic growth.

Additionally, there is a lack of studies that are related to the comparison of E&E studies and macroeconomic variables among different countries due to its difficulties in the data collection process. According to MITI (2018), the E&E industry consists of four sub-sectors (components, consumers, industrial and electrical) where each of the sub-sectors contains various E&E products. Moreover, all data is collected and recorded

by the country's relevant department, hence, it is not surprising that different country has different way in collecting E&E monthly data. In Malaysia, the E&E data is collected and recorded generally as shown in the report of the Department of Statistics Malaysia. In Thailand and the Philippines, E&E data is recorded according to E&E components as highlighted in the report of the Thai Customs Department and Philippine Statistics Authority respectively. These scenarios made researchers are facing obstacles and troubles in conducting E&E researches as researchers have to total up the E&E data themselves.

The inconsistent change of exchange rate might influence the economic development of a country, especially in developing countries. A developing country's exchange rate plays an important role in attracting or repelling importers and exporters. Malaysia got into trouble in the year 2016 when the Malaysian Ringgit (MYR) depreciates to 4.45MYR/USD due to several incidents including the gloomy global economy. It was the highest depreciation faced by Malaysia within these 10 years. This scenario is then brought negative impacts on citizens, investors, importers and exporters. For instance, in 2016, the Malaysian economy faced a headwind from the high living cost (Bank Negara Malaysia, 2017). Concurrently, the imported goods will become extremely expensive due to the devaluation of MYR. This statement is supported by Conway (2012) who mentioned that the exchange rate is known as a nominal anchor which plays a crucial role in determining the prices of imported goods in local markets. However, the exchange rate can be affected and altered by a country's monetary policy (Dilmaghani & Tehranchian, 2015). With this, this study is conducted to modelling the

relationship between export and exchange rate among selected developing countries as a reference for policymakers.

Subsequently, there is a lack of researches that emphasises on the modelling between variables specifically according to different situations. The majority of the researches focus on the relationship between variables only. There are few examples of studies were conducted by Imimole and Enoma (2011); Khodeir (2012). As an example, Imimole and Enoma (2011) mentioned that there was a negative effect between exchange rate and inflation rate in Nigeria throughout the study but Imimole and Enoma (2011) did not specify the situation. However, the fluctuation in economic variables often occurs due to external events such as the oil price crisis and financial crisis. With this, the existing researches which usually focus and discuss on the variables nexus generally is insufficient to provide a general view about the relationship during certain period caused by external factors.

In statistical view, there is a lack of economic time series studies regarding the comparison between maximum likelihood and Bayesian method by fitting to FMM although FMM is getting famous in recent years. Researches of time series data analyses are getting popular with the rapid growth of economic development. However, most of the researchers favour comparing maximum likelihood estimation and the Bayesian method by fitting to other models such as Autoregressive Conditional Heteroskedasticity (ARCH) model (Andrade & Oliveira, 2011) and latent growth model (Kim, Huh, Zhou, & Mun, 2020). However, it provides insufficient evidence about the performance of maximum likelihood estimation and the Bayesian method in fitting to

FMM to analyse time series data because different models might yield different findings as every model has dissimilar properties. Therefore, a comparison between statistical methods which fit FMM can be carried out to determine the best, effective method in analysing financial time series data. The contribution of this finding is useful for practitioners and academic research use.

In conclusion, the fluctuation of E&E export value, exchange rate and inflation rate may bring troubles to the country. To manage these troubles, research containing these variables is significant to be investigated. Therefore, in the present study, the E&E export values, exchange rate and inflation rate nexus for selected countries were further discussed.

1.4 Conceptual Framework

The conceptual framework is applied as a guideline in this study. Maximum likelihood estimation and the Bayesian method were proposed in this study to examine and hence model the relationship between sampled variables. In addition, the most appropriate statistical method in analyse the time series dataset was determined throughout this study. Figure 1.1 presented the conceptual framework applied in this study to give a clear first impression about the main purpose of conducting this research.

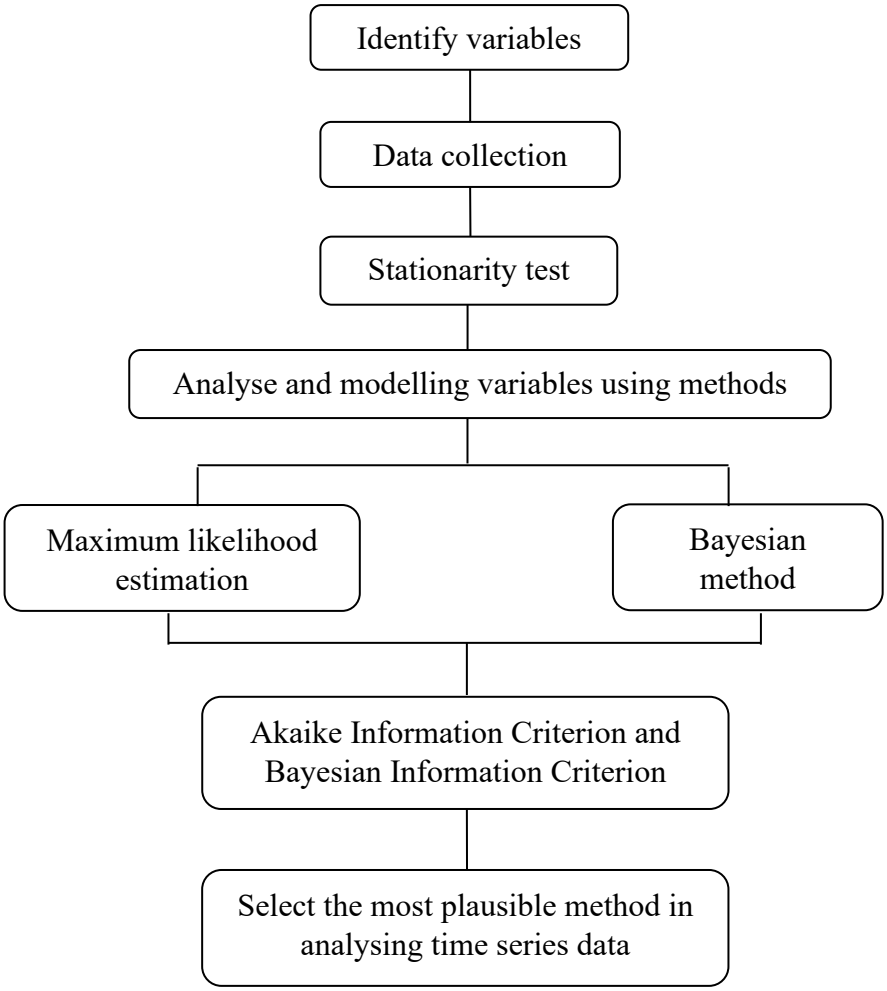

Figure 1.1. *Conceptual framework*

1.5 Purpose of Study

Nowadays, every country is competing to export E&E products to other countries such as United States, China, Singapore, Japan and Hong Kong, hence, it could bring some impacts on a country's development. Therefore, E&E products with the inflation rate and exchange rate among Malaysia, Thailand and the Philippines were involved in this study. With the assistance of maximum likelihood estimation and the Bayesian method,

the researcher evaluated the relationship between E&E export price with its inflation and exchange rate among these countries. Meanwhile, the brand-new modelling equations were generated and developed for sampled variables among Malaysia, Thailand and the Philippines with the implementation of maximum likelihood estimation and the Bayesian method. Lastly, a comparison between these two parameter estimation methods was carried out throughout this study

1.6 Research Objectives

There are few objectives stated in this study to achieve the purpose of the study:

i. To identify the component exists in the time series data.
ii. To evaluate the relationship between the E&E export value and exchange rate, exchange rate and inflation rate, the E&E export value and inflation rate among Malaysia, Thailand and the Philippines using maximum likelihood estimation and the Bayesian method.
iii. To model the E&E export value and exchange rate, exchange rate and inflation rate, the E&E export value and inflation rate among Malaysia, Thailand and the Philippines using finite mixture model fitted with maximum likelihood estimation and the Bayesian method.
iv. To determine the most plausible method in analysing time series data among maximum likelihood estimation and the Bayesian method.

1.7 Research Questions

In order to accomplish the research objective, there are few research questions stated in this study which are:

i. What are the components that exist in time series data?

ii. Is there any relationship between the E&E export value and exchange rate, exchange rate and inflation rate, the E&E export value and inflation rate among Malaysia, Thailand and the Philippines using maximum likelihood estimation and the Bayesian method?

iii. How is the modelling for the E&E export value and exchange rate, exchange rate and inflation rate, the E&E export value and inflation rate among Malaysia, Thailand and the Philippines using finite mixture model fitted with maximum likelihood estimation and Bayesian method?

iv. Which statistical method is the most plausible in analysing time series data among maximum likelihood estimation and the Bayesian method?

1.8 Significance of Study

This study focuses on the modelling and comparison between the export value of E&E product, exchange rate and inflation rate for sampled countries using maximum likelihood estimation and Bayesian method is potential in providing advantages to statisticians, governments and investors.

Based on this study, a better statistical view for statisticians in estimating the movements of E&E export value, exchange rate and inflation rate among Malaysia, Thailand and the Philippines is then provided in different situations by modelling a new equation for selected variables among sampled nations. For instance, statisticians can apply the brand-new equation to examine the relationship between selected variables during a specific period separately. This scenario indicates that new equations developed can be applied to different periods for selected countries. In short, this research is potential to assist statisticians in predicting the flow of selected variables in various situations through developed modelling equations.

Subsequently, the performance of maximum likelihood estimation and the Bayesian method is always a debatable issue in the statistical field. Both methods are well-known parameter estimation approaches in data analysis, however, the suitability of these methods in data analysis is still unknown due to the conflicts between previous studies such as Li and Hao (2016); Beerli (2005). By comparing maximum likelihood estimation and the Bayesian method through FMM, statisticians can gain new information regarding the performance of both methods in analysing time series data.

Furthermore, the economy is always influenced by macroeconomic factors. The appreciation and depreciation of currency will affect the economic growth of a country. By identifying the relationship between the export value of E&E products, exchange rate and inflation rate, the study provides better visualisation for governments in forecasting the movement of macroeconomic factors on the export value of E&E products. Hence, this research can assist the government in using the country's resources wisely by investing money in the right path.

As policymakers, governments have to always monitor the effectiveness of policies because an effective policy could boost up a country's economic growth indirectly. This statement is supported by Parveen, Khan and Ismail (2012) who mentioned that economic growth can be improved through the implementation of appropriate monetary and fiscal policies. Moreover, the decision in making a policy will be considered and taken right after research is done to determine the suitability of implementation of a policy (Boa, Johnson, & King, 2010). Hence, it can be found that researches play a significant role in policymaking process.

Additionally, investors are those organisations who invested money into financial schemes when the exchange rate is steady and stable (Chowdhury & Hossain, 2014). Concurrently, there is a link between the exchange rate and the inflation rate (Monfared & Akin, 2017). Good investment planning is always bringing those investors a great return. Therefore, by identifying the relationship between the sampled variables among these three countries, investors could make a smart, accurate decision in their investments, and hence reduce investment risk.

1.9 Novelty of Study

Novelty of the study plays an important role to reveal uniqueness and the primary contribution of a research. The main novelty of this study was to compare and determine the most plausible method among the maximum likelihood estimation and Bayesian

approach in fitting with FMM. Both statistical methods are well-known approaches that introduced in various fields such as finance (Avdis & Wachter, 2017) and social science (Han & Coulibaly, 2017) with the excellent strength in modelling data. Since both methods are attractive in term of modelling, hence, the comparison between these approaches is a trend topic in statistical field as shown in the study of Beerli (2005); Ismail and Al-Harbi (2020); Kim et al. (2020). However, the comparison between these methods in fitting with FMM is still lacking. FMM is an unsupervised learning model which has been introduced by McLachlan (2001) and getting popular over the past few years due to its ability in discovering the data patterns, therefore, it would be an interesting topic to compare both excellent methods in fitting with the unsupervised learning model, especially in this era of Big Data where a prodigious flow of data has witnessed in the Digital Age. The efficiency of maximum likelihood estimation and Bayesian method in FMM should be examined to propose an appropriate method in handling different properties of time series data. With this, this study presented a comparison between both approaches in modelling time series data by fitting with FMM.

Besides that, another novelty of this study was to identify the components existed in time series data. The existing literatures only focuses on identifying the number of components as shown in the study of Eagle, Romanczyk, and Lenzenweger (2010); Nord, Valton, Wood, and Roiser (2017); Suesse et al. (2021) but there is no supportive point to the components number obtained on which the component represent to. The representation of components should be identified because it is important to reveal the different conditions existed in time series data such as structural break, trend

and seasonal patterns. With this, this study provided an overview of the components' representation by referring to the timeline obtained and historical events.

1.10 Scope of Study

The relationship between the export value of E&E, exchange rate and the inflation rate of sampled countries were investigated through this study. The countries involved in this research are Malaysia, Thailand and the Philippines. Meanwhile, maximum likelihood estimation and the Bayesian method were applied to carry out the modelling process for sampled data among selected countries. Furthermore, the best, appropriate statistical method was selected using AIC and BIC values. With the intention of conducting this research, all data were obtained from Census and Economic Information Center (CEIC), Trading Economics and DataStream.

1.11 Limitation of Study

In this study, there were three limitations including the constraints of time, countries and variables. The data collected from July 2005 to August 2020 were used in this study. The main reason for choosing this time range is the Asian Financial Crisis. In 1997, there was an Asian Financial Crisis that caused economic disruption to Asian countries

in term of currencies. Hence, most of the Asian countries have pegged their currencies to USD for economic stabilisation purposes. For instance, the exchange rate against the USD for Asian countries such as Malaysia are constant in those years. However, time is needed for economic recovery. Therefore, the data were collected and obtained starting from July of the year 2005 to ensure the accuracy of the results.

Furthermore, a total of three countries were involved in this study which are Malaysia, Thailand and the Philippines. Malaysia is E&E export-oriented country since the 1980s. Meanwhile, Thailand and the Philippines are the world leaders in the production of electrical and electronics especially hard drives and semiconductors (ASEAN, n.d.). Hence, the main reason for selecting Thailand and the Philippines as a comparative measure for Malaysia's E&E export price due to these countries are the largest competitors or suppliers in sector E&E for exporting E&E products as these countries have great strength in manufacturing and exporting E&E products to world markets.

Additionally, this study identified the relationship between two variables only, which are the E&E export price and exchange rate, inflation rate and exchange rate, the E&E export price and inflation rate. The primary reason of investigating two variables is due to the presence of the E&E export value. The existing literatures which focused on the relation between exchange rate and inflation rate have contributed in research field, but there is still lack of the study of the E&E export price. Since the E&E is not macroeconomic variable, therefore, the E&E export price is unnecessary to have relationship with both exchange rate and inflation rate. As an example, the war between

China and United States (U. S.) caused the decline in Malaysian E&E export (Carvalho, Azevedo and Massuquetti, 2019). With this, researcher conducted the study between two variables to avoid any confusion in the results.

1.12 Operational Definition

The terms used in this study are defined as follows:

1.12.1 Exchange Rate

According to Batten and Thornton (1985), the exchange rate is the rate price of one currency in terms of another currency. There are two statuses of the exchange rate which are floating and fixed. For fixed exchange rate, it is decided by a country's central bank while the floating exchange rate is determined by the market supply and its demand. In this study, the domestic exchange rate against USD was used to model its relationship with E&E export value and inflation rate among Malaysia, Thailand and the Philippines.

1.12.2 Inflation Rate

According to Islam, Ghani, Mahyudin, and Manickam (2017), inflation denotes an increase in the price of goods and services over time. In the other words, the inflation rate is the percentage of a country's currency that is undervalued during a period. The alternation of the inflation rate may affect the living costs of the citizen. The inflation rate can be collected annually or monthly. In this study, monthly data of the inflation rate was used for analysation and modelling purposes.

1.12.3 Electrical and Electronic

Electrical refers to an appliance that is used to connect and supply electricity whereas electronic denotes a device which deals with electrical. According to MITI (2015), there are three subsectors under the category of electronic which are components, consumers and industrial whereas the electrical category has an electrical subsector only. Hence, it can be found that electrical and electronic are strongly dependent on each other. In the present study, both electrical and electronic export prices were utilised to explore their relationship with the exchange rate and inflation rate among Malaysia, Thailand and the Philippines through modelling.

1.13 Summary

FMM has become one of the popular models in the statistical modelling field due to its flexibility and versatility. Therefore, the researcher implemented FMM in the present study with the aim of modelling and hence comparing the relationship between the export price of E&E products, inflation rate and exchange rate among Malaysia, Thailand and the Philippines using maximum likelihood estimation and the Bayesian method.