MODELLING THE IMPACT OF OIL PRICE AND STOCK MARKET PRICE ON GOLD PRICE USING LONG SHORT-TERM MEMORY (LSTM) AND VECTOR AUTOREGRESSION (VAR) MODEL

UMMI FARIHAH BINTI ABD WAHID

UNIVERSITI TEKNOLOGI MALAYSIA

UTM
UNIVERSITI TEKNOLOGI MALAYSIA

UNIVERSITI TEKNOLOGI MALAYSIA
DECLARATION OF Choose an item.

Author's full name	:	UMMI FARIHAH BINTI ABD WAHID

Student's Matric No.	:	MCS231032	Academic Session	:	2023/2024
Date of Birth	:	13/01/2000	UTM Email	:	ummifarihah@graduate.utm.my

Choose an item. Title	:	MODELLING THE EFFECTS OF OIL PRICE AND STOCK MARKET PRICE ON GOLD PRICE USING LONG SHORT-TERM MEMORY (LSTM) AND VECTOR AUTOREGRESSION (VAR) MODEL

I declare that this thesis is classified as:

☒ **OPEN ACCESS** — I agree that my report to be published as a hard copy or made available through online open access.

☐ **RESTRICTED** — Contains restricted information as specified by the organization/institution where research was done. *(The library will block access for up to three (3) years)*

☐ **CONFIDENTIAL** — Contains confidential information as specified in the Official Secret Act 1972)

(If none of the options are selected, the first option will be chosen by default)

I acknowledged the intellectual property in the Choose an item. belongs to Universiti Teknologi Malaysia, and I agree to allow this to be placed in the library under the following terms :
1. This is the property of Universiti Teknologi Malaysia
2. The Library of Universiti Teknologi Malaysia has the right to make copies for the purpose of only.
3. The Library of Universiti Teknologi Malaysia is allowed to make copies of this Choose an item. for academic exchange.

Signature of Student:

Signature :

Full Name: UMMI FARIHAH BINTI ABD WAHID
Date : 24 JULY 2024

Approved by Supervisor(s)

Signature of Supervisor I: Signature of Supervisor II

Full Name of Supervisor I   Full Name of Supervisor II
PROF. MADYA DR MOHD SHAHIZAN
OTHMAN
Date :   Date :

NOTES : If the thesis is CONFIDENTIAL or RESTRICTED, please attach with the letter from the organization with period and reasons for confidentiality or restriction

This letter should be written by a supervisor and addressed to Perpustakaan UTM. A copy of this letter should be attached to the thesis.

Date:

Librarian

Jabatan Perpustakaan UTM,

Universiti Teknologi Malaysia,

Johor Bahru, Johor

Sir,

CLASSIFICATION OF THESIS AS RESTRICTED/CONFIDENTIAL
TITLE: MODELLING THE EFFECTS OF OIL PRICE AND STOCK MARKET PRICE ON GOLD PRICE USING LONG SHORT-TERM MEMORY (LSTM) AND VECTOR AUTOREGRESSION (VAR) MODEL
AUTHOR'S FULL NAME: UMMI FARIHAH BINTI ABD WAHID

Please be informed that the above-mentioned thesis titled _____ should be classified as RESTRICTED/CONFIDENTIAL for a period of three (3) years from the date of this letter. The reasons for this classification are

(i)

(ii)

(iii)

Thank you.

Yours sincerely,

SIGNATURE:
NAME:
ADDRESS OF SUPERVISOR: PROF. MADYA DR. SHAHIZAN OTHMAN

"I hereby declare that I have read this project report and in my opinion this project report is sufficient in term of scope and quality for the award of the degree of Master of Science (Data Science)"

Signature	:	_____
Name of Supervisor I	:	PROF. MADYA DR. MOHD. SHAHIZAN OTHMAN
Date	:	24 JULY 2024

Signature	:	_____
Name of Supervisor II	:	
Date	:	

Signature	:	_____
Name of Supervisor III	:	
Date	:	

Declaration of Cooperation

This is to confirm that this research has been conducted through a collaboration
<u>Ummi Farihah binti Abd Wahid</u> and <u>University Technologi Malaysia (UTM)</u>

Certified by:

Signature   :
Name   :
Position   :
Official Stamp
Date

* This section is to be filled up for theses with industrial collaboration

Pengesahan Peperiksaan

Tesis ini telah diperiksa dan diakui oleh:

Nama dan Alamat Pemeriksa Luar   **:**

Nama dan Alamat Pemeriksa Dalam   **:**

Nama Penyelia Lain (jika ada)   **:**

Disahkan oleh Timbalan Pendaftar di Fakulti:

Tandatangan   :
Nama   :
Tarikh   :

MODELLING THE EFFECTS OF OIL PRICE AND STOCK MARKET PRICE
ON GOLD PRICE USING LONG SHORT-TERM MEMORY (LSTM) AND
VECTOR AUTOREGRESSION (VAR) MODEL

UMMI FARIHAH BINTI ABD WAHID

A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Science (Data Science)

Faculty of Computing
Universiti Teknologi Malaysia

JULY 2024

DECLARATION

I declare that this project report entitled *"Modelling The Effects of Oil Price and Stock Market Price on Gold Price Using Long Short-Term Memory (LSTM) and Vector Autoregression (VAR) Model"* is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature   : ....

Name   : UMMI FARIHAH BINTI ABD WAHID

Date   : 24 JULY 2024

ACKNOWLEDGEMENT

ABSTRACT

Gold is a valuable metal in the economy because it is said to be the country's main commodity. As a hedge against inflation and other economic downturns, many gold investors keep their assets in the form of bullion coins or bars. As commercialized inflation hedges, gold, Islamic stock, and commodity markets share a nearly universal characteristic. This research focuses on cointegration relationship between gold price, crude oil price, palm oil price, Islamic and conventional stock market Index by using Johansen Cointegration method and Autoregressive Distributed Lag (ARDL) model. The variables involved in this research are Gold Price (GP), Crude Oil Price (COP), Palm Oil Price (POP), Islamic Stock Market Price (ISMP), and Conventional Stock Market Price (CSMP). Using monthly data covering from January 2013 to December 2021, this study also aims to forecast gold prices for future years with integration of significant variables using the Long Short-Term Memory (LSTM) and Vector Autoregression (VAR) Model. The findings in study show that there is existence of long run relationship between GP with COP and POP only but not with other variables. Thus, we forecast 3 years ahead of gold price with causal relationship with COP and POP.

ABSTRAK

Emas adalah salah satu logam yang berharga dalam ekonomi kerana ia dikatakan sebagai komoditi utama negara. Demi untuk melindung kewangan status terhadap inflasi dan kemerosotan ekonomi yang lain, banyak pelabur emas menyimpan aset mereka dalam bentuk syiling atau bar emas. Sebagai lindung nilai komersial terhadap inflasi, emas, pasaran saham Islam, dan pasaran komoditi berkongsi ciri yang hampir universal. Oleh itu, kajian ini memberi tumpuan kepada hubungan kointegrasi antara harga emas, harga minyak mentah, harga minyak sawit, indeks pasaran saham Islam dan konvensional dengan menggunakan kaedah Johansen Cointegration dan model Autoregressive Distributed Lag (ARDL). Di samping itu, pembolehubah yang terlibat dalam kajian ini adalah Harga Emas (GP), Harga Minyak Mentah (COP), Harga Minyak Sawit (POP), Harga Pasaran Saham Islam (ISMP), dan Harga Pasaran Saham Konvensional (CSMP). Seterusnya, kajian ini menggunakan data bulanan yang meliputi dari Januari 2013 hingga Disember 2023, dengan bertujuan untuk meramalkan harga emas untuk tahun-tahun akan datang dengan integrasi pembolehubah signifikan menggunakan model *Long Short-Term Memory (LSTM)* dan *Vector Autoregression (VAR)* model. Hasil kajian menunjukkan bahawa terdapat hubungan jangka panjang antara GP dengan POP dan COP sahaja tetapi tidak dengan pembolehubah lain. Oleh itu, kami meramalkan harga emas untuk 3 tahun ke hadapan dengan hubungan kausal dengan harga POP dan COP.

TABLE OF CONTENTS

TITLE	PAGE

x

LIST OF TABLES

xi

LIST OF FIGURES

LIST OF ABBREVIATIONS

ADF	-	Augmented Dickey-Fuller test
AIC	-	Akaike Information Criterion
ARDL	-	Autoregressive Distributed Lag
COVID-19	-	Coronavirus disease
FBM	-	Fulfillment by Merchant
FBMAI	-	FBM Ace Index
FBMESI	-	FBM Emas Syariah Index
FBMKLCI	-	FBM Kuala Lumpur Composite Index
FTSE	-	Financial Times Stock Exchange
GATCH	-	Generalized Autoregressive Conditional Heteroscedasticity
GDP	-	Gross Domestic Product
IFS	-	Islamic Financial System
KLCI	-	Kuala Lumpur Composite Index
KPSS	-	Kwiatkowski-Phillips-Schmidt-Shin
LSTM	-	Long Short-Term Memory Model
UECM	-	Unrestricted Error Correction Model
VAR	-	Vector Autoregressive Model
VECM	-	Vector Error Correction Model

LIST OF SYMBOLS

xiv

yit	-	Time series of each independent variable
Dt	-	Vector of deterministic variables
Γj	-	Matrices for each differenced lag
Π	-	Long run impact matrix
A	-	Coefficient matrix for the first lag

CHAPTER 1

INTRODUCTION

1.1   Introduction

Gold is a valuable metal to the economy as it is said to be the main commodity to the country. According to M. Garside, (2023), China, Australia, Russia, and Canada are the world's largest gold producers as until 2022. It was one of early metals that worked and has been known since the beginning of recorded history, primarily because it was easy to find as small atoms in stream beds. Gold has been extensively applied in a variety of industries around the world, including gemstone production, finance and investment, healthcare and dentistry, electronics production, components used in aircraft and computers. Most often, gold is used to hedge against the macroeconomic events such as currency depreciation, inflation and deflation. The reason is gold preserves its purchasing power over long periods of time. Hence, when the stock price and other assets fluctuate dramatically, the price of gold might be in more stable state (Tim Maxwell, 2022). As a result, when purchasing power for goods and services falls, it can act as a hedge against inflation.

One of Malaysia's most significant businesses is mining, and gold is one of the main minerals extracted in Malaysia. The eastern states of Pahang, Kelantan, and Terengganu are home to most of this gold (Sheba Gumis, 2020). The modern gold dinar coin concept has some success in the national economy, and Malaysia is similar to other nations that hold gold as an investment, store of value, and currency hedge. Gift -giving of gold is common in Malaysia during weddings and festive seasons like Muslim festivals and the Chinese New Year. Physical bar gold is accessible in many Malaysian jewellery stores as well as through banks. According to Public Gold executive chairman Datuk Wira Louis Ng, the Malaysian gold market is anticipated to trade lower this year due to lingering concerns about a global recession and the Bank

Negara Malaysia's (BNM) planned increase of the OPR by four times in 2022 (Bernama, 2023).

Bildirici & Türkmen, 2015, stated that gold serves as a means of wealth storage in industrial commodities, which is crucial especially during times of political and economic disruption. This is related to the upward trend in gold prices and the volatility of fiat currency values. Many gold investors preserve their assets in the form of bullion coins or bars as a hedge against inflation and other economic downturns. As an outcome, gold price time series estimates have become essential tools for helping investors select the best time to carry out gold buying or selling activities. Aside from investors, gold can also protect our family's economy. It can compete with the rate of inflation while also protecting against currency depreciation. According to Habib Jewels Sdn Bhd senior general manager, Mohd Zaruddin Mahmud, due to consumers' increased awareness of the investment value of gold bars in the face of inflation risks, demand for gold bars has increased by at least 30% since last year (Asila Jalil, 2022).

Based on Gold Price Malaysia, the graph pattern shows the price of gold fluctuating due to the current economy. According to (Yun, 2020), due to the threat of Covid-19 which has affected the global economy, the gold price rose due to high demand carried on by increased global hesitation and historically low real interest rates. Investors choose gold as a safe asset because it is a physical commodity, and its value is unaffected by government interest rate decisions. After all, when scientists found a vaccine for Covid -19, the gold price declined sharply because it has provided relief to people that the global economy will recover.

There is a nearly common characteristic among gold, Islamic and conventional stock, and commodity markets, all of which have been commercialized as inflation hedges. (Ibrahim et al., 2018a) in their research about whether the price of gold follows or lag the Islamic stock market and other markets found that the price of gold fails to keep up with the Islamic stock market in Malaysia. They also found that the price of crude oil and crude palm oil affects the Islamic stock market and gold, marked as the one variable which moves independently contrary to other variables. Through an understanding of the relationship between these markets and commodities and

describing their changes over time can thus have significant implications for international investors, risk managers, and policymakers. This will motivate them to invest because they need to be well informed in order to plan their investment portfolio. Among the decisions that they must consider is determining the portion or weightage of assets that should be included in the investment portfolio.

Forecasting is a process for estimating future situations and making decisions. Gold price forecasting is useful for investors, analysts, and academics. The forecasting model used in our studies is time series, using Long Short-Term Memory (LSTM) method. Long Short-Term Memory (LSTM) is one kind of recurrent neural network (RNN) that works particularly well for time series forecasting is the long short-term memory (LSTM) network, while the other one is Vector Autoregression (VAR) method. Their ability to detect long-term relationships and interplay among several time series makes them perfect for predicting gold prices in conjunction with cointegration variables like crude oil prices, stock market indices, and other relevant economic indicators. The price of gold fluctuates a lot, responding to changes in the price of commodities around the world. Gold investors expect to pay a low price at the time of purchase and sell a high price at the time of sale (Heidi Airisha Abdul Rahman et al., 2022). By lowering uncertainty, the volatility of the gold price can be managed.

In the current study, we analyse the impact of oil price and stock market on gold price by examining their causation and cointegration using the Granger Causality test, Johansen Cointegration method and Autoregressive Distributed Lag (ARDL) model and forecast the gold price using Long Short-Term Memory (LSTM) and Vector Autoregression (VAR) methods. We use gold price as a dependent variable, while oil price and stock market as independent variables.

1.2   Problem Background

Given the interdependence of these financial variables, there has long been interest in the impact of oil prices and stock market performance on gold prices. One of the most important precious metals in the world economy is gold, which is

frequently used as a hedge against inflation and economic downturns. Research, politicians, and investors can all benefit from the interactions between the price of gold, crude oil, and stock market indices. In Malaysia, the economy is greatly influenced by the mining industry, especially by the extraction of gold. Pahang, Kelantan, and Terengganu in the east of the country are the primary gold-mining regions in Malaysia (Gumis, 2020). Besides that, the contemporary gold dinar coin in Malaysia emphasises the cultural and economic significance of gold by acting as a store of value and an investment. Similar to other countries, Malaysia's gold price is impacted by a number of macroeconomic variables, such as the price of crude oil and the state of the stock market (Bernama, 2023).

Numerous factors, including as market demand, economic policies, and geopolitical developments, can impact gold prices, which are recognised for their extreme volatility. As an illustration, during the COVID-19 epidemic, demand for gold grew as investors looked for a haven amid anxiety about the state of the world economy. As a result, gold prices rose. However, when optimism about an economic recovery increased, the discovery of a vaccine caused gold prices to drop precipitously (Yun, 2020). Additionally, gold price movements are also significantly influenced by the stock market. The influence of gold prices on Malaysia's conventional and Islamic stock markets has been examined. Unlike traditional stock markets, the Shariah-compliant Islamic stock market has demonstrated different dynamics with gold prices. Previous research has shown that there is a considerable cointegration between crude oil prices and the Islamic stock market, but there is not a strong long-term association between the Islamic stock market and gold (Ibrahim et al., 2018).

Accurate analysis and forecasting of gold prices require complex econometric models due to the intricacy of these linkages. The cointegration and causation links between these variables can be determined using techniques including the Autoregressive Distributed Lag (ARDL) model, Granger Causality test, and Johansen Cointegration test. These models aid in comprehending dynamic interactions and offer information to help policymakers and investors make wise decisions (Bildirici & Türkmen, 2015). Therefore, the purpose of the study is to examine the patterns and connections that exist between the indices of the Islamic stock market, conventional

stock market, gold prices, crude oil prices, and palm oil prices between 2013 and 2023. The research aims to provide significant insights for future forecasting and investing strategies in Malaysia's financial markets by comprehending these relationships.

1.3   Problem Statement

Bank Negara Malaysia, Governor Tan Sri Nor Shamsiah Mohd Yunus has warned that Malaysia will sail into a challenging economic climate in 2023 (Vasu, 2022). This is resulting from the worsening supply chain, geopolitical uncertainty and market volatility that plays a huge role in economic growth. Higher inflation on the domestic front would be a primary risk leading to eroding household spending power and reducing investment activity. This situation wreaks havoc on levels of society, especially to the public where people are looking for alternative ways to survive this critical situation. With the rising and fears looming recession, investing in gold as such for a haven for their money in uncertain times may be a benefit (Tim Maxwell, 2022). However, investing in gold is not the only alternative way preferred by people. Apart from that gold prices are affected by many external economic factors such as oil and stock market prices. Thus, avoiding these factors would underestimate future trends on gold prices. This study is then to analyze the trend of gold, oil, and stock prices from 2013 to 2023.

Based on past studies, it has been justified that there is a cointegration relationship between the gold, oil, and stock market prices. It is however, the findings are not consistent and yet they varied depending on the data and method used in determining the cointegration. Thus, this study is to investigate the cointegration relationship between gold, crude oil, palm oil, Islamic and conventional stock market prices in Malaysia and hence supporting past-related research on general.

Compared to past research, several models have been applied such as Generalized Autoregressive Conditional Heteroscedastic model, Exponential Smoothing Autoregressive Integrated Moving Average (ARIMA), Long Short-Term Memory (LSTM), Vector Autoregression (VAR) and so on. Among these models, the

most widely used and popular model is ARIMA since it provides instantaneous and short-term forecasting. However, ARIMA model presented poorer forecast than LSTM and VAR for highly correlated variable and yet most of the forecasted result is not applicable for future use due to different method used and the data sources from. Ergo, the forecasting gold price process in this study is carried out on Malaysia sourced data using LSTM and VAR model.

Even though research and study on gold has been decades and centuries year done. There are relatively few amounts of study focusing specifically on the impact of oil and stock market prices on the gold price. Most of the study that has been done is emphasizing on other economic factors such as inflation rate, gross domestic profit (GDP) and others. Hence, this study is to figure out how far oil and stock market price could affect the gold price.

1.4 Research Questions

The proposed project aims to achieve the following objectives:

I. How do the trends in the prices of gold, crude oil, palm oil, and the conventional stock market and Islamic stock market indexes look?

II. Which variables have the causation and cointegration to the price of gold when using the Malaysia data?

III. How to forecast the price of gold by considering significant variables that affect the gold price?

1.4.1 Research Objectives

The objectives of the research are:

(a)   To analyse the trend of gold price, crude oil price, palm oil price, Islamic and conventional stock market Index during year 2013 to 2023.

(b)   To validate the causation and cointegration relationship between gold price, crude oil price, palm oil price, Islamic and conventional stock marker Index using Granger Causality test, Johansen Cointegration method and Autoregressive Distributed Lag (ARDL) model.

(c)   To forecast gold price for future years with integration of significant variables using the Long Short-Term Memory (LSTM) and Vector Autoregression (VAR) model.

1.5   Significance of Study

This research is made with the aim of providing crucial information and knowledge regarding the chosen topic from the recent studies and related sites needed for the expected importance to the individual specifically for government, industry, public and future researchers.

The government will take advantage of this study by supervising economic inflation, restoring, and overcoming the black economy. As a necessary consequence, the government should keep an eye on the gold price mechanism. By doing that, the government can help to reduce the risks associated with oil price volatility and stock market price, which has an impact on global economies.

Our research will benefit investors and investment portfolio managers by assisting them in choosing the most appropriate investment strategy for their needs. This is also to ensure that if they want to invest in Kijang Gold, they will need to include conventional stock market as well as commodities such as crude oil price in their investment portfolio. Besides, it also important for policymakers because they provide shareholders with a clear and comprehensive picture of their investments in Islamic or conventional markets. Furthermore, it will create new opportunities for portfolio managers and speculators in both the Islamic and traditional stock markets.

The public can get benefits such as subsidies from our study if the government and industry take actions due to the changes of economic in our country. Furthermore, the study is vital for policymakers because it will help them understand how crucially important the stock market is to any contemporary economy since it gives people access to their money and makes it available for usage by businesses. The future researchers might enhance further analysis and implications of the study by using different analyses of data, the longer sample periods and become acquainted with other macroeconomic variables that may potentially affect gold price.

1.6 Scope and Limitation

This research covers the relationship of gold price, crude oil price, palm oil price, Islamic and conventional stock market Index in Malaysia. One of data that will be used in the study is daily of gold price per 1 troy ounce (1 Troy Ounce = 31.1034768 grams), obtained from Malaysia Informative Bullion rate official website (https://www.indexmundi.com). The daily price of palm oil per ton, which can be found on Trading Economics' official website at https://tradingeconomics.com/commodity/palm-oil, is another piece of information that will be included in the study. Additionally, information on the monthly price of crude oil per barrel was gathered from the official index Mundi website (https://www.indexmundi.com). Furthermore, conventional stock market data, particularly for the FTSE Bursa Malaysia KLCI, was obtained from the finance.yahoo.com website (KLSE). The most recent data of Islamic stock market is from the website Investing.com; specifically, it refers to the FTSE Bursa Malaysia EMAS Shariah (FTFBMS).

This study only covers the countries in Malaysia; thus, the results cannot represent other countries because they have different economic situation and different data. Next, this research only focuses on the gold price, as the indicator to know the effect on other commodities which are oil price and stock market. Whilst oil price is an important factor on gold price, other factors such as exchange rate, interest rate, inflation and rate of currency exchange will not be discussed further, even if these

factors have major effect on gold price. Besides that, there may be some unpredictably occurring events that will interfere with the research analysis results, this study is unable to cover all research pertaining to changes in government policy. War is also excluded as an unpredictable event.

CHAPTER 2

LITERATURE REVIEW

2.1   Introduction

This study of the literature concentrates on the definition of all variables, such the price of crude oil, the price of palm oil, and microeconomic factors such as the Islamic Stock Market, and the Conventional Stock Market. Then the methods that will be used in our study are Johansen Cointegration test and ARDL methods to check the cointegration of all variables. Then we will apply Long Short-Term Memory (LSTM) method for forecasting. The empirical research on the influences of commodities, microeconomic and the gold price is then given. This analysis of the literature focuses on earlier studies of the problem. The authors carefully analyzed the literature to have a better understanding of the topic. The definitions are clear and succinctly presented to aid readers in understanding them. The presentation in this chapter begins with definitions of each variable before moving on to the techniques used to forecast each variable.

Literature has long acknowledged the role that nation's gold price plays on microeconomic and commodity determinants, and other studies have approved with this statement. The gold price has a significant role in the economy because they influence the direction of the microeconomics and commodities determinant by improving the policy context, market conditions, and key driving forces (Chai et al., 2021). Meanwhile, gold acts as a diversified portfolio, aiding investors in recovering from significant losses. Regardless of where gold works, due to its unique chemical characteristics, it cannot be emptied and remains in existence forever. As a result, the foundation of the gold price is eroded. According to the research study we have been looking at, gold prices have less impact on macroeconomic issues than commodity factors do (Michael Bromberg, 2023).

As a result, this research will acquire the best approach, which are Long Short-Term Memory (LSTM) model and Vector Autoregression (VAR) to forecast gold prices. In addition, this research learns about the strengths and weakness of knowing each variable's relationship to gold price by using Johansen Cointegration test, Granger Causality and Autoregressive Distributed Lag (ARDL). Therefore, this research applies them wisely and carefully to avoid utilizing the forecasting method and receiving inaccurate results. In order to apply contemporary methods in accordance with the most recent time distribution, we may also avoid underrated or out-of-date ways.

2.1.1 Gold Price

For centuries, gold has been a significant precious metal. It is a significant financial asset for nations and an important part of the world's monetary reserves for trading and currency hedging (Capie, 2005). Gold is important in investing as well, particularly as a buffer against unfavourable financial occurrences. In fact, the prices of precious metals typically move in the other way during periods of financial unrest that cause stock indices to decline. For investors, mining ventures, connected businesses, and generally for any person who views gold as a leading indicator of the future performance of the global economy, anticipating gold price fluctuations is a crucial issue (Jabeur et al., 2021).
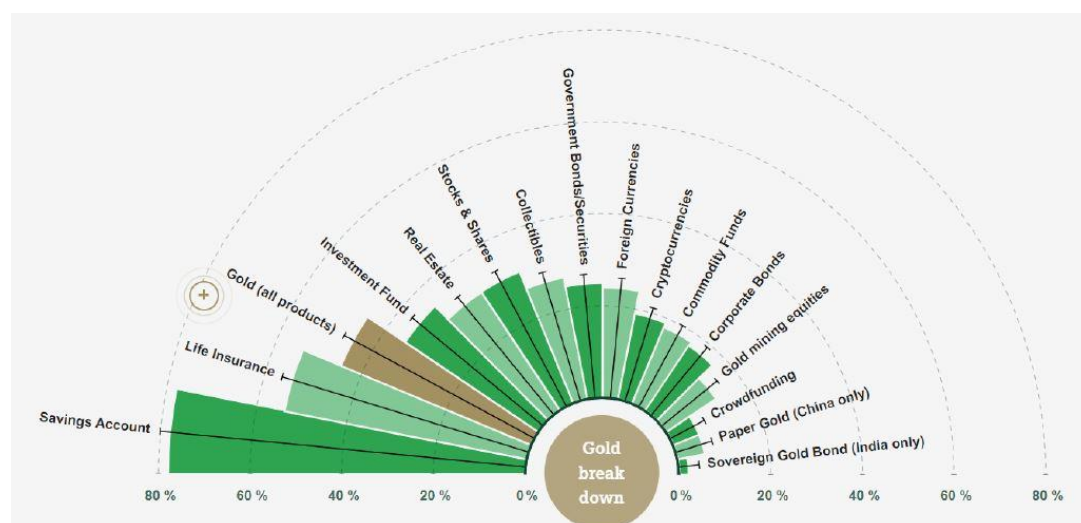
Figure 2.1 Percentage of Investors That Have Ever Bought Each Product (World Gold Council, 2019)

According to the figure above, the World Gold Council study, the annual increase in the demand for gold as an asset and investment has been roughly 15% since 2001 (Chai et al., 2021). In terms of investment products that investors have purchased, gold ranks third with 46%, behind savings accounts (78%) and life insurance (54%), according to the most recent gold retail market survey study from 2019. In the global market, gold is rapidly becoming a commonplace financial strategy. The total amount of gold bought by central banks in 2019 was 651 tons, up 74% from the previous year. This marked the highest level of gold purchases by central banks since the Bretton Woods system collapsed in the 1970s. The world's central bank bought 374.1 tons of gold in the first half of 2021, an increase of 57% compared to the same period last year. The demand for gold from central banks has been rising. In reserve assets, gold is more significant.

The question of whether gold may be used as a safe haven or hedge has been the subject of a lot of recent research. The risk of investing in gold has increased over the past few years due to frequent price swings, and at the same time, outside factors like wars and economic crises have further impacted the price of gold. To reduce the risk associated with gold investments, it is crucial to understand the gold price's volatility characteristics, especially the fundamental regularities. According to Wen (2017), the worldwide gold market price mechanism is quite complicated. Multiple factors operating at multiple levels, such as the price of oil and stock market, affect it with a fluctuation period of around three months (Wen et al., 2017). However, some researchers found that the gold price shows long-term mean-reverting behaviour, as proven that the gold price period takes around seven years (Boubaker et al., 2020). Thus, war and economic crises have a more obvious impact on the price of gold, and the fluctuation cycle is often shorter when these events occur.

2.1.2   Palm Oil Price

Another name for the oil palm tree is Elaeis Guineensis Jacq. It was created in West Africa. This plant was brought to Malaya (now Malaysia) by the British in the 1870s as one of the agricultural plants for the growth of the agricultural industry. In the agricultural sector of Malaysia, palm oil has historically contributed more than other plantations like those for rubber and timber. Approximately 570,000 individuals were employed in this industry alone in 2009 (Basiron, 2009). In addition, Malaysia is the world's second-largest volume exporter of palm oil after Indonesia, and people from 150 different nations currently use goods made from Malaysian palm oil. This evidence from the Department of Statistical Research in 2022 shows that in 2020, palm oil exports were close to 16.2 million metric tons, about five times the amount consumed domestically. It helped to emphasize the value of Malaysia's palm oil sector. Malaysian palm oil is used in two different industries: biofuels and food. Malaysia has long advertised palm oil as a healthful and nutritious food source because it is the world leader in palm oil production. Nearly 80% of Malaysians were of the belief that palm oil is healthier than soybean oil. It was proved that this had an impact on the population (Statista Research Department, 2022).

The price of palm oil itself is a sign of the sector's full development, together with other indications. The stakeholders and the nation's income from export earnings would both gain from an increase in the price of palm oil, and vice versa (Zaidi et al., 2021). Therefore, it is extremely important for stakeholders and policymakers to comprehend how the price of palm oil is changing (Karia & Bujang, 2011). According to Hayati et al. (2011) analyses research, Malaysia's palm oil sector has clearly contributed significantly to both the growth of the global palm oil market and the country's economy. The fact that there is a successful the cointegration test between the price of palm oil and its production in Malaysia (Hayati & Rahman, 2011). Therefore, this indicates that this country's production of palm oil can affect the price level of this commodity.

According to several earlier studies, there is a connection between the price of palm oil and gold. Based on You-How Go and Wee-Yeap Lau's (2017) research paper,

the price of crude palm oil (CPO) will increase in the future if gold prices continue to climb. Investors can long CPO futures contracts to hedge against a high inflation rate and bet on the rise in CPO prices. Second, when the price of CPO is anticipated to decline, a decline in the price of gold would be a signal for investors to invest in short selling activities (You-How Go, 2017).

However, some studies claim that there is no connection between the price of palm oil and the price of gold. According to Norhafiza Nordins (2014) research, neither the price of gold nor price of palm oil appeared to have a significant impact on stock market performance. This is due to that the fuel prices are subsidized in Malaysia, which is one reasonable explanation for the oil price's insignificant outcome (Nordin et al., 2014). Thus, the subsidized price may eliminate or reduce the impact of changes in the price of oil on Malaysian businesses. In other words, firms are somewhat protected from the negative effects of changes in the price of oil. For instance, if oil prices rise, they might only see a small impact. The data don't support earlier research (Wang, 2010), which established a connection between gold price and oil price.

2.1.3 Crude Oil Price

Malaysia's oil industry began over a century ago when the first oil well was discovered by Shell in Sarawak in 1910. This industry contributes significantly to the Malaysian economy as it is Southeast Asia's second-largest oil producer and the world's third largest exporter of liquefied natural gas (LNG). Oil production and consumption is one of the most widely used economic indicators. The price of oil is volatile and sensitive towards world oil price fluctuations as it is a commodity with the highest volume of trade. According to Md Anuar et al., 2010 the increase in oil price causes the other prices to increase due to the significant role of price in determining other prices. Oil price fluctuations impact also varies across countries depending on the economic performance of oil producing countries and non-oil producing countries. The oil price fluctuation will have an impact on several economic sectors such as agriculture, transportation, and manufacturing.

A considerable amount of research has focused on the relationship between gold and oil prices. These include studies by Satish Kumar (2017) who highlights the evidence that gold prices are relatively more sensitive to increasing oil prices. Furthermore, Ahmad (2019) examines the cointegration and the causation of both gold and oil and finds that long run relationship equilibrium exists, and oil price is highly significant influencing gold price. In other country, study such in Mexico (Shelly, Sangita and Pratap, 2019) finds that gold prices positively affect the stock price of Mexico while oil on the other hand, affects them negatively. Nonetheless, based on the previous study highlighted there is still lack of studies in specifically in Malaysia regarding the causality and relationship between gold and crude oil price (Ahmad, 2019).

According to Ibrahim et al. (2018) while gold is traditionally used as a hedge against inflation, crude futures tend to be supported during periods of high inflation. This positive cointegration has often meant higher oil prices have coincided with higher gold prices even though one does not directly affect the other. Meanwhile, study conducted by Chikri & Hamiche (2020) proves that due to influences of common factors, many empirical studies indicate that crude oil and gold prices are positively associated and have risk-related movement mechanisms. Also, in their study supporting Zhang et al (2008) and Ewing and Malik (2013) research find that fluctuations in gold prices can affect volatility of crude oil prices and occasionally produce relationships between them. One of the reasons for this is that both gold and crude oil are regarded as top commodities in the world and are traded in the U.S on the global market.

2.1.4   Islamic Stock Market Price

There is a nearly common characteristic among gold, Islamic stock, and commodity markets, all of which have been commercialized as inflation hedges. Ibrahim et al., (2018) in their research about whether the price of gold follows or lag the Islamic stock market and other markets found that the price of gold fails to keep up with the Islamic stock market in Malaysia. It also has been proved that gold and

Islamic stock markets are not able to offer a hedge against inflation and instead serve as multifariousness with the price of crude oil, crude palm oil and the Islamic stock market because they move in opposite directions. They also found that the price of crude oil and crude palm oil affects the Islamic stock market and gold mark as the one variable which moves independently contrary to other variables.

The Islamic Financial System (IFS), on the other hand was designed with several unique features based on the Shariah principle prohibiting interest and investment in Shariah-prohibited activities. The Islamic finance industry has evolved significantly in recent decades, and it now offers investors a diverse range of investment choices. Over the years, the Islamic capital market has accounted for more than 60% of Malaysia's capital market, as the Islamic finance industry has expanded fast. (S Birruntha, 2022).

Based on previous research and studies such as Yahya et al., (2013) and (Chikri & Hamiche, 2020) there is no direct relationship or significant cointegration between Islamic stock market and the gold price. The studies however do highlight the existence of significant cointegration between Islamic stock market index with the oil price. Recent study from Walid (2022) also supports other studies where there is negative, or absence relationship uncovered between gold market and Islamic stock markets hence indicating that the gold can be hedge and safe haven during extreme market conditions.

Recent study by Bahloul & Khemakhem (2021) verified that the dynamic connectedness and between return and volatility of commodity and Islamic stock markets equals 67.5% and 66.1% covering the entire period data. The information of this study was gathered during Covid-19 and yet after the outbreak, the connectedness between both commodity and Islamic stock market rose to up to 71.6% and 68.8% respectively. This research's finding of a directional connection suggests that whatever the period is, commodities are the biggest source of shocks for Islamic stock markets. Conventional Stock Market.

The Islamic stock market is parallel to the Conventional stock market but with different value-based system. It complies to the rules and regulations of Islamic shariah that are ignored by the conventional market efficiency theory. Md. Mahmudul et al, (2017) they also stated that the outcomes of current financial crisis, it is suggested that market should be run by a system that ensure efficiency, justices and fairness as to which Islamic stock market could offer or as the alternative. In addition, the Financial Services Authority of Indonesia classifies stocks as shariah compliant do not involve any sort of non-halal activities such as gambling, trading with non-deliverance of goods or service or with counterfeit offering and demand, conventional banks, conventional leasing companies, bribery, and others.

Mohd Yahya et. al (2013) studied the link between gold price, oil price and Islamic stock market in Malaysia. Their research discovered that Islamic Share prices (FBMES) do not have a significant long run relationship with crude oil price and Kijang gold price. This study also proves that both commodities are not valid indicators to predict changes in Islamic share prices in Malaysia specifically in long run. Beyond that, another study empirically shows that there is positive relationship between oil and Islamic stock market indicating the existence of financialization process of the crude oil price. Contrarily, gold has a negative relationship with Islamic equity market. However, gold highlights the role as strong hedge for Islamic market volatility (Chkili, 2022).

2.1.5 Conventional Stock Market Price

Kuala Lumpur Stock Exchange (KLSE) is conventional stock market price in Malaysia and now known as Bursa Malaysia. It is fully automated and one of the largest exchanges in the Association of Southeast Asian Nations. The Conventional Financial System is primarily a debt- and interest-based system that generates excessive debt and leverage via the credit multiplier. The assets are risk-bearing, and their risk-reward trade off is determined by the degree of risk they hold. (S Birruntha, 2022).

The long run cointegration value from cointegration test equations confirms the inverse relationship between stock and gold prices. This finding lends credibility to the belief that gold is a safe haven for Turkish investors seeking to protect their investments (Tursoy & Faisal, 2018). Furthermore, the Granger causality proves the interaction between stock prices and gold prices. The causality provides evidence for gold prices influencing stock prices in the short, long, and joint runs. As a result, the commodity prices such as gold and oil influence the stock market price in Turkey. These global prices (oil and gold) are effective indicators for investors to revise their portfolios or investments based on these indications.

Naliniprava (2016) investigates the integration between gold price and stock market price by using monthly time series data from July 1990 to April 2016. This study finds that there is no causal relationship between gold price and stock market price in the short run. However, they are cointegrated in the long equilibrium relationship and they move together. Another study conducted in India, Anil Kumar and Ajit (2018) examining the direction and the cointegration and causal relationship between gold prices and the stock market which known as NSE Nifty returns. The study evidence the same result as the previous study where there is a long- run equilibrium relationship between the gold and stock prices yet there is no causal relationship between those two.

The gold and the stock market have many different characteristics. One of them is, gold is perceived as a commodity that has been able to remain and even rise in value despite adverse circumstances (Mukhuti & Bhunia, 2013) whereas the stock market is not, as it is regarded as a return of value (Syed Wajahat Haider, 2018). Many investors prefer to invest in both the stock market and gold in order to reduce or avoid systematic risk. Investing in gold is also considered risk insurance, as is using gold as a hedging tool (Hammad et al., 2018).

Moreover, changes in the gold price have a positive significant effect on Indonesia Stock Market's fluctuation (Syahri & Robiyanto, 2020). People are concerned about their investments as a result of the crisis period during the COVID-19 pandemic. There is evidence that stock investors on the Indonesia Stock Exchange

are skeptical in response to changes in the gold price, making them hesitant to invest in gold. The public are getting more interested in investing in gold due to the printed and electronic social media reports claiming that gold is the safest investment during a pandemic.

2.2   Research Methodology

2.2.1   Cointegration and Causality Relationship of Gold Price on Oil Price and Stock Market

Cointegration theory is clearly the advancement in theoretical econometrics that has caught economists' interest the most during the past ten years. The definition in the straightforward scenario of two time series, xt and yt, which are both integrated of order one (I(1), which denotes the presence of a unit root in the process) (Bent E. Sørensen, 2019). Moreover, it combines nonstationary variables in a linear way (Stevans, 2012). Hence, the results of the cointegration test show that there is a long-term relationship among the chosen variables, and they also look at long-term equilibrium relationships (Abbas et al., 2017).

Causality refers to when two sets of events (the effects) follow one another directly, this relationship between them. Besides that, this method using which one can infer causal linkages from data is known as causal inference. Since determining causal connections is one of the main goals of science, there has been much discussion on this subject in the fields of philosophy, statistics, and the sciences (F. Daniel Hidalgo & Jasjeet S. Sekhon, 2009). Until now, the causality test showed a one-way relationship between one variable and another, to put it simply. Moreover, this test can define the long-term and short-term causal relationships between each variable (Abbas et al., 2017).

2.2.2   Granger Causality Test

The Granger Causality test is used to check individual variable direction and relationships with another individual. It is also an econometric test employed to verify the usefulness of whether one variable can accurately predict another (Zach, 2021). A variable is a granger cause if it influences in the forecasting of another variable and is a failed granger cause if it does not. Two indicators that cause the variable to fail Granger are i) when the lags are not statistically in the equation for another variable and ii) when the past values are not significant in predicting the future value of another. The use of granger causality signifies the forecasting ability rather than the actual causal relationship between two variables.

According to Friston et. al, (2014) link between variable showed from Granger causality test on autoregressive model can become unreliable when underlying dynamics is dominated by unstable model such as present of substantial measurement noise. It is however, Granger causality test is widely employed due to its ability to characterize oscillatory and multivariate data (Patrick et. al, 2017).

According to Le, Thai-Ha and Chang (2011), using the granger causality test, there is causal relationship between rising oil price and the demand for gold that hence pushes up the price of gold price. The same method was used in a study conducted by Zuriyati (2019), where it reveals that the gold price granger causes the oil price. However, the oil price does not granger cause the gold price. The causation is found from the gold price to the oil price and not another way round. Another study conducted in Czech Republic where from Granger Causality testing that have been carried out, it was found out that a change in oil prices precedes the development of gold prices by one month. Causality was not demonstrated in the opposite direction (Stoklasová, 2018). Kumar (2017) on the other hand, in his study, found evidence that there is unidirectional Granger causality from oil prices to gold prices in both short- and long- run. A study carried out by Yap Wai Weng (2011) on relationships between oil prices, gold price and stock indices using the same method proves that the stock market and commodity market are interrelated among each other. He also suggested

that if the policymakers who attempted to stimulate the stock market during stock market crises should consider including the commodity market.

In addition, findings of Granger Causality test in a study of M. E. Bildirici & Turkmen, (2015) proves that in the balanced situation for positive and negative fluctuations in crude oil profit in the short- long run and strong cointegration, there are unidirectional causalities extending from oil profits to gold profits. They also revealed that there is significant causal relationship for gold returns and all three indices employed in the study which are oil price, Islamic and conventional stock market indices.

According to Yahya et al., (2013) as result of granger causality analysis, there was bi-directional causality relationship between the Islamic stock market with oil prices. Gold on the other hand was not causal of the Islamic stock market and vice versa. A variable is a granger cause if it influences in the forecasting of another variable and is a failed granger cause if it does not. Two indicators that cause the variable to fail Granger are i) when the lags are not statistically in the equation for another variable and ii) when the past values are not significant in predicting the future value of another. The use of granger causality signifies the forecasting ability rather than the actual causal relationship between two variables.

According to Friston et. Al, (2014) link between variable showed from Granger causality test on autoregressive model can become unreliable when underlying dynamics is dominated by unstable model such as present of substantial measurement noise. It is, however, Granger causality test is widely employed due to its ability to characterize oscillatory and multivariate data (Patrick et. al, 2017).

According to Le, Thai-Ha and Chang (2011), using the granger causality test, there is causal relationship between rising oil price and the demand for gold that hence pushes up the price of gold price. The same method was used in a study conducted by Zuriyati (2019), where it reveals that the gold price granger causes the oil price. However, the oil price does not granger cause the gold price. The causation is found from the gold price to the oil price and not another way round. Another study

conducted in Czech Republic where from Granger Causality testing that have been carried out, it was found out that a change in oil prices precedes the development of gold prices by one month. Causality was not demonstrated in the opposite direction (Stoklasová, 2018). Kumar (2017) on the other hand, in his study, found evidence that there is unidirectional Granger causality from oil prices to gold prices in both short- and long- run. A study carried out by Yap Wai Weng (2011) on relationships between oil prices, gold price and stock indices using the same method proves that the stock market and commodity market are interrelated among each other. He also suggested that if the policymakers who attempted to stimulate the stock market during stock market crises should consider including the commodity market.

In addition, findings of Granger Causality test in a study of M. E. Bildirici & Turkmen, (2015) proves that in the balanced situation for positive and negative fluctuations in crude oil profit in the short- long run and strong cointegration, there are unidirectional causalities extending from oil profits to gold profits. The author also revealed that there is significant causal relationship for gold returns and all three indices employed in the study which are oil price, Islamic and conventional stock market indices.

According to Yahya et al., (2013) as result of granger causality analysis, there was bi-directional causality relationship between the Islamic stock market with oil prices. Gold on the other hand was not causal of the Islamic stock market and vice versa. Granger causality is an econometric test that is used to verify the causation of variables and usefulness of one variable to forecast another. The output from this test is either a vari able is granger cause or failed to granger-cause another variable.

Granger Causality test starts with:

1. State the null hypothesis and alternate hypothesis.

$H0: x(t)\ does\ not\ granger-cause\ y(t)$

$H1: x(t) granger-cause\ y(t)$ \hspace{2cm} (3.2)

2. Choose lags i and j.

3. Find the f- value.

$$y(t) = \sum_{i=1}^{\infty} \alpha_i y(t-i) + c_1 + v_1(t) \qquad (3.3)$$

$$y(t) = \sum_{i=1}^{\infty} \alpha_i y(t-i) + \sum_{j=1}^{\infty} \beta_j x(t-j) + C_2 + v_2(t) \qquad (3.4)$$

4. Calculate the F- statistics using the equations below.

$$F = \frac{\dfrac{EES_R - ESS_{UR}}{q}}{\dfrac{ESS_{UR}}{n-k}} \qquad (3.5)$$

5. Reject null hypothesis if the F- statistics is greater than f- value.

2.2.3 Johansen Cointegration Test

Cointegration can be calculated using various methods that have been described in past literature. In this study, we used the Johansen Test to calculate cointegration. Maximum likelihood is used in the Johansen test and its estimation strategy. When there are more than two variables, the test can be used to estimate all cointegration. Besides that, the test facilitates the estimation of all cointegration vectors with multiple variables that may contain at least two cointegration vectors. Time series analysis is used in the Johansen test.

The ADF test is based on an autoregressive model, which regresses a value from a time series on previous values from the same time series. When there are multiple variables, you can still write the relationship between current prices as a linear function of past prices in an autoregressive model, but this model is referred to as the Vector Error Correction Model (VECM). This test is intended to evaluate the existence of cointegration and determine the cointegration between equity returns from various

stock markets and changes in price of gold and crude oil price in the long or short term of period (Vveinhardt et al., 2018). If cointegration is not approved, it clearly shows that there is no long-term relationship between the economic indicators. Cointegration tests are used to see if two variables are highly related to one another and how sensitive they are to a certain average price over a period.

Based on the past study by (Thakolsri, 2021), the findings indicate that all price series in the Thai stock market, foreign exchange market, international gold market, and crude oil market have a significant long-run relationship. The results of the Johansen cointegration test proved the presence of a cointegration relationship, as well as the assumption of a long-term relationship between the commodities studied. It prevents the difficulty of selecting a dependent variable as well as the problems that arise when errors are carried from one step to the next. As a result, the test can detect multiple cointegrating vectors.

According to Stoklasová, (2018), by using the Johansen cointegration test, it proves that there is a relationship between the price of gold and oil over a long period of time. The reason for employing this approach is that some research findings in finance and economics have used this Vector Autoregression (VAR) budgeting method in addition to economic research methods.

Johansen Cointegration test is said to be more powerful than the Granger Causality method due to the accessibility number of variables in the model. Johansen test can estimate the cointegrating relationship of more than two variables compared to Granger test. The Johansen cointegration test is based on the regression parameters test, whereas the Engle-Granger method is based on the residual test. According to Gao et al., (2018), the potential endogeneity of the regressors is not taken into account by the Engle-Granger method because it assumes that one variable is endogenous, and the other is exogenous.

The Johansen cointegration test will be employed in order to determine whether a long run equilibrium exists between gold prices, oil price, and stock market. This method creates cointegration between series of similar orders by constructing a

cointegration equation and can be applied using R. There are two Johansen cointegrating tests: the trace test and the maximal eigenvalue test.

H0 = There is no Cointegration among variables.
H1 = There is Cointegration among variables.

We will reject null hypothesis if the test statistic is bigger than the critical value at 0.05. That is means, the cointegration variables have existed in the model. The Johansen testing procedure consists of two general steps:

1. Estimate the Vector Error Correction Model (VECM) model using maximum likelihood under the following conditions:

- Consider with and without a trend.
- Consider with and without a constant.
- With a variable number of cointegrating vectors, k.

2. Using likelihood ratio tests to compare the models.

It is a likelihood ratio test comparing an unrestricted VECM to a restricted VECM with k cointegrating vectors, where k=m-1.

$$\Delta y_t = \Gamma_0 D_t + \Pi Y_{t-1} + \sum_{j=1}^{p-1} \Gamma_j \Delta Y_{t-j} + \varepsilon_t \tag{3.6}$$

t= 1,2,3

Where;

$$\Pi = \sum_{j=1}^{p} A_{i-1} \quad \text{and} \quad \Gamma_j = \sum_{k=i+1}^{p} A_{j-1} \tag{3.7}$$

'yit' = time series of each independent variable,

" Dt " = Vector of deterministic variables

Γj = matrices for each differenced lag

$\Pi = \Upsilon A'$ long run impact matrix; A and Υ are m x k matrices.

"A" = coefficient matrix for the first lag

In conclusion, prior research has widely used the correlation analysis and feature engineering methodologies used in this study, indicating their applicability and efficacy in analysing financial datasets. These strategies enable in the discovery of underlying patterns and linkages, which improves the predictive capacity of models used to anticipate financial measures. These methods are reliable, but they also depend on a number of presumptions, including the linearity of relationships and the accuracy of the input data. Thus, in order to get accurate and dependable findings, it is imperative that the data preprocessing stages are carefully carried out.

2.2.4 Autoregressive Distributed Lag (ARDL)

According to Singhal (2019), the ARDL technique provides a number of benefits over the Johansen Cointegration test (Le and Chang, 2016) when examining the long-term relationships between gold prices, stock market prices, and crude oil prices. Besides that, ARDL model established by (M. Hashem Pesaran et al., 2001), who employs an error correction model and a linear transformation to include short-term modifications into the long-term equilibrium. Then, ARDL bound can be employed regardless of whether the study's variables are stationary variables I(0) and non-stationary variables I(1) in same estimation (Othman & Masih, 2018). To perform the ARDL bound test, however, the series must not be I(2). The bound test approach of ordinary least squares may be used to verify cointegration after the model's lag order has been determined (OLS). Lagged variables are employed in the ARDL technique, which helps in avoiding the endogeneity problem.

Roberts and Whited (2013) stated that endogeneity is defined as a cointegration between the explanatory variables and the error term in a regression (Roberts & Whited, 2013). The absence of explanatory factors in the regression that may lead to endogeneity, which would violate a basic element of ordinary least squares (OLS) regression analysis by causing the error term to be correlated with the explanatory

variables. It could also be carried on by one or more explanatory variables that are impacted by the dependent variable, which in turn is influenced by one or more explanatory factors (Abdallah et al., 2015).

M. Ali et al. (2022) tried to develop and compare an ARDL model and a non-linear ARDL model that can examine the relationship between the price of gold, oil, and renewable energy on South African carbon emissions (Ali et al., 2022). According to that article, the study concludes that ARDL is for linear data whereas non-linear ARDL is for non-linear data. The data must first be examined for linearity using a simple regression method, for example, in order to verify linearity. Therefore, the study will use the ARDL model to analyze the cointegration between the gold price since most of our data is linear. The general ARDL (p, q_1, q_2...... q_k) Model is as follows:

$$\Phi(L)yt = \varphi + \theta\ 1(L)x1t + \theta\ 2(L)x2t + \theta\ k(L)xkt + \mu t \qquad (3.8)$$

The lag polynomial $\Phi(L,p)$ is easily defined by applying the lag operator L to each element of a vector, L^k y=yt-k (L,p). The ARDL models may be estimated by ordinary least squares as long as the error term ut is assumed to be a white noise process, or more specifically, is stationary and independent of xt, xt-1, ... and yt, yt-1, ...

The ARDL model established by Pasaran et al. (2001) employs an error correction model and a linear transformation to include short-term modifications into the long-term equilibrium (ECM). The gold price model is present as below:

$$yit = \beta0 + \beta1yit-1 + \cdots + \Sigma ni=1\ \alpha\Delta yt + \varepsilon t \qquad (3.9)$$

Where ε_t as random disturbance term or error term.

In conclusion, ARDL may be considered as an appropriate technique to ascertain the link between the variables. Researchers must consider the cointegration relationships between the variables in order to determine which factors contribute to the dependent variable most cointegration. However, there are a few assumptions that

must be considered while using this approach, and it can only predict outcomes reliably for linear processes.

2.3   Gold Price Forecasting Model

The Long Short-Term Memory (LSTM) and Vector Autoregression (VAR) network has been chosen to estimate the price of gold because it has a track record of successfully identifying complicated patterns and long-term dependencies in time series data. Recent research has shown that LSTM and VAR models are more effective in financial forecasting than more conventional methods like ARIMA. A study by (Azreen et al., 2017) stated that VAR model outperform ARIMA model in predicting the economic growth in term of lowest forecasting accuracy measurement. The model provides more precise forecasts than univariate time series models and theory-based, complex simultaneous equation models.VAR model forecasts are extremely adaptable since they can be conditioned on the anticipated future courses of specified variables. The findings from (Fritzer et al., 2002) showed that ARIMAs have smaller forecasting errors at shorter horizons, whereas VARs perform better at longer horizons. Besides that, Phaladisailoed and Naruetharadhol (2019), for example, discovered that LSTM networks outperformed traditional models in their ability to predict gold prices. Furthermore, Kristjanpoller et al. (2021) demonstrated how the integration of several data sources in LSTM model was enhanced by a large margin when sentiment analysis was added. Additionally, Chen et al. (2020) improved the model's ability to capture both short- and long-term trends by combining a hybrid LSTM model with wavelet transformations.

2.3.1   Long Short-Term Memory (LSTM) Model

The effectiveness of long short-term memory (LSTM) networks in time series forecasting has drawn a lot of interest lately, especially in the financial sector where gold price prediction is concerned. LSTM networks are well-suited for forecasting volatile and non-linear financial measures like gold prices due to their distinctive

architecture, which enables them to capture complex patterns and long-term dependencies in time series data.

The accuracy of LSTM networks in gold price predictions has been supported by recent research. For example, Phaladisailoed and Naruetharadhol's (2019) study used LSTM networks to estimate gold prices and discovered that LSTM performed better than more conventional models such ARIMA and exponential smoothing techniques. Their findings showed that LSTM networks may more accurately predict gold prices by efficiently capturing the temporal relationships in the data. In order to improve predicting performance, the study emphasised how important it is to properly preprocess data and choose the right LSTM hyperparameters.

Recent literature has examined further developments in LSTM architectures and their applications in gold price predictions. To increase the precision of gold price predictions, Chen et al.'s 2020 study presented a hybrid model that combines wavelet transform and LSTM networks. The original time series data were broken down into various frequency components using the wavelet transform, and these components were then supplied into the LSTM model. This strategy made it possible for the model to more successfully identify both short- and long-term patterns in the data. In comparison to solo LSTM models and conventional forecasting methods, the hybrid model performed better.

In addition, cutting-edge studies have concentrated on combining sentiment analysis and LSTM networks to improve the predicted gold price. In order to forecast gold prices, a study by Kristjanpoller et al. (2021) included sentiment analysis of social media data and financial news into the LSTM model. In order to increase the predictive power of the model, sentiment scores were added to the other input characteristics in addition to historical gold prices. The findings showed that the addition of sentiment analysis considerably improved forecast accuracy since it offered insightful information about investor behaviour and market sentiment.

On the other hand, Jena et al. conducted an exhaustive investigation in 2022 of several deep learning models, including LSTM, for financial time series forecasting.

According to their research, LSTM models perform consistently better in terms of accuracy and resilience for predicting the price of gold than other deep learning models like GRU (Gated Recurrent Unit) and CNN (Convolutional Neural Network). In addition to investigating hybrid approaches that integrate LSTM with other machine learning techniques, the authors highlighted the need for additional study on enhancing the interpretability and scalability of LSTM models.

In conclusion, the research from 2019 to 2023 gives strong evidence that LSTM networks are exceptionally effective in forecasting gold prices. An effective technique for financial forecasting, LSTM can manage non-linearities in time series data and capture long-term dependencies. Due to recent developments in the field of financial time series forecasting, such as the incorporation of sentiment analysis and hybrid models, LSTM networks are now a preferred option for researchers and practitioners due to their improved predictive accuracy.

2.3.2   Vector Autoregression (VAR) Model

Vector Autoregression (VAR) is a forecasting algorithm that can be utilized when two or more time series influence one another, i.e., when the relationship between the time series is interdependent (Christiano, 2012). In his paper, introduced the VAR model by modelling the causal relationships and joint dynamics of numerous macroeconomic variables. It is said to be one of the most successful and flexible models for the analysis of multivariate time series.

Aydin & Cavdar (2015), use VAR model to test the relationship between different variables to predict financial distress or stock market crashes. (Guglielmo et al., 2013) examines the nature of the relationships between stock market prices and exchange rates in six developed nations which are the US, the UK, Canada, Japan, the euro area, and Switzerland. Muhammad Akbar et al (2019) used VAR model in examining the dynamic linkages among gold price, stock prices, exchange rate and interest rate nexus. All these studies share the same methodology for analysing the relationship between macroeconomic variables.

Taha Abdullah (2022), utilized VAR model in analysing the relationship between time series as well as forecasting the oil price and gold price. In the research of (Rajab et al., 2022) VAR model shows a high level of accuracy in forecasting the spread of the COVID-19 infection. Numerous other fields, such as finance, tourism, and commodity prices, have also utilized vector autoregression.

2.4   Research Gap

Firstly, the research not enough attention to non-linear interactions and multivariate relationships. The complicated and non-linear interactions between various economic indicators, such as the price of crude oil, palm oil, and stock market indexes (both Islamic and conventional), may not have been sufficiently captured by earlier research, which frequently concentrated on univariate time series analysis or more straightforward multivariate models. The complex relationships and time-varying impacts among these variables are often ignored by conventional models like ARIMA or even simple multivariate regression. Further exploration of these multivariate interactions is made possible by the Long Short-Term recollection (LSTM) and Vector Autoregression (VAR) model, which can handle non-linear relationships and recollection of past states. However, the use of LSTM models and VAR to simultaneously analyse the combined impact of these several economic factors on gold prices is still underexplored. This gap highlights the need for research that uses LSTM and VAR capabilities to understand how these variables interact and influence gold prices over time, potentially discovering hidden patterns and better predicting future trends.

Secondly, lack of comprehensive studies comparing with conventional studies Models. Although LSTM and VAR model and other advanced machine learning models have been proposed for financial forecasting, there is a notable lack of comprehensive studies that compare the performance of LSTM and VAR models against traditional econometric models such as the ARDL and GARCH in the context of predicting gold prices that are impacted by crude oil, palm oil, and stock market prices. The majority of research that is currently available either emphasises the overall

superiority of machine learning models or the specific uses of these models without a strong comparative analysis. Therefore, a full comparative analysis would aid in understanding the practical benefits and limitations of LSTM and VAR models in comparison to previous approaches. These studies could give researchers and practitioners significant insight into the selection and use of models by showing scenarios in which LSTM models perform better than traditional models and which points out situations in which traditional models may still be more advantageous because of their well-established theoretical underpinnings and ease of interpretation.

Finally, the studies lack of research on the effects of policy changes and macroeconomic shocks, such as the COVID-19 epidemic, major geopolitical events, or policy changes, have not been thoroughly examined using LSTM and VAR models in regard to how commodities prices and stock markets relate to one another and, in turn, to gold prices. These shocks can cause significant volatility and system disruptions, which traditional models cannot capture. LSTM and VAR models, with their capacity to adapt to shifting patterns and integrate exogenous variables, offer a unique chance to model these effects more effectively. However, there is a lack of research that incorporates macroeconomic shocks and policy changes into the LSTM and VAR framework for forecasting gold prices. To close this gap, models would be developed that not only predict price changes under regular conditions but also respond to extraordinary events, resulting in more flexible and strong forecasting tools. In dynamic economic contexts, this method has the potential to greatly improve the prediction accuracy and dependability of models utilised by policymakers and investors.

CHAPTER 3

RESEARCH METHODOLOGY

3.1   Introduction

This section explains the methodology and applications that will be used in the research. Before getting to the data gathering, this chapter will examine the data description. The data must first be examined in order to accomplish the research's goal. The procedure would begin with gathering and evaluating raw data from many websites, such Trading Economics', index Mundi and Malaysia Informative Bullion Rate. The information must then be calculated using a particular formula. First, the data will be checked for cointegration between all variables and the price of gold using Johansen Cointegration model and Autoregressive Distributed Lag (ARDL). Long Short-Term Memory (LSTM) model and Vector Autoregression (VAR) are used in this study to predict the price of gold in Malaysia. Throughout discussion of the research findings and methodology will be covered in this chapter.

3.2   The Framework

  I.   Problem Formulation
 II.   Data Collection
III.   Data Pre-processing
IV.   Modelling
 V.   Performance Validation and Evaluation

The details of the research framework for this study are shown in the Figure below

**Phase 1: Problem
Formulation**

Start

Problem Definition & Literature Review

**Phase 2: Data
Collection**

Download Gold Price,

Crude Oil Price, Palm Oil Price,

FTSE Bursa Malaysia EMAS Shariah &

FTSE Bursa Malaysia KLCI Histor

**Phase 3: Data
Preprocessing**

Upload the dataset to
Jupyter Notebook

Preliminary Analysis → Data Wrangling → Perform
Exploratory Data

Phase 4: Modelling

Cointegration Test for All Variables

Johansen Cointegration Test

Autoregressive Lag
Distributed (ARDL)

**Phase 5:
Testing and
Validation**

Test both models based on testing set

Evaluate the performance of each model by MSE

Forecast Gold Price using Long
Short-Term Memory (LSTM)

Forecast Gold Price using
Vector Autoregression (VAR)

**Phase 6:
Performance
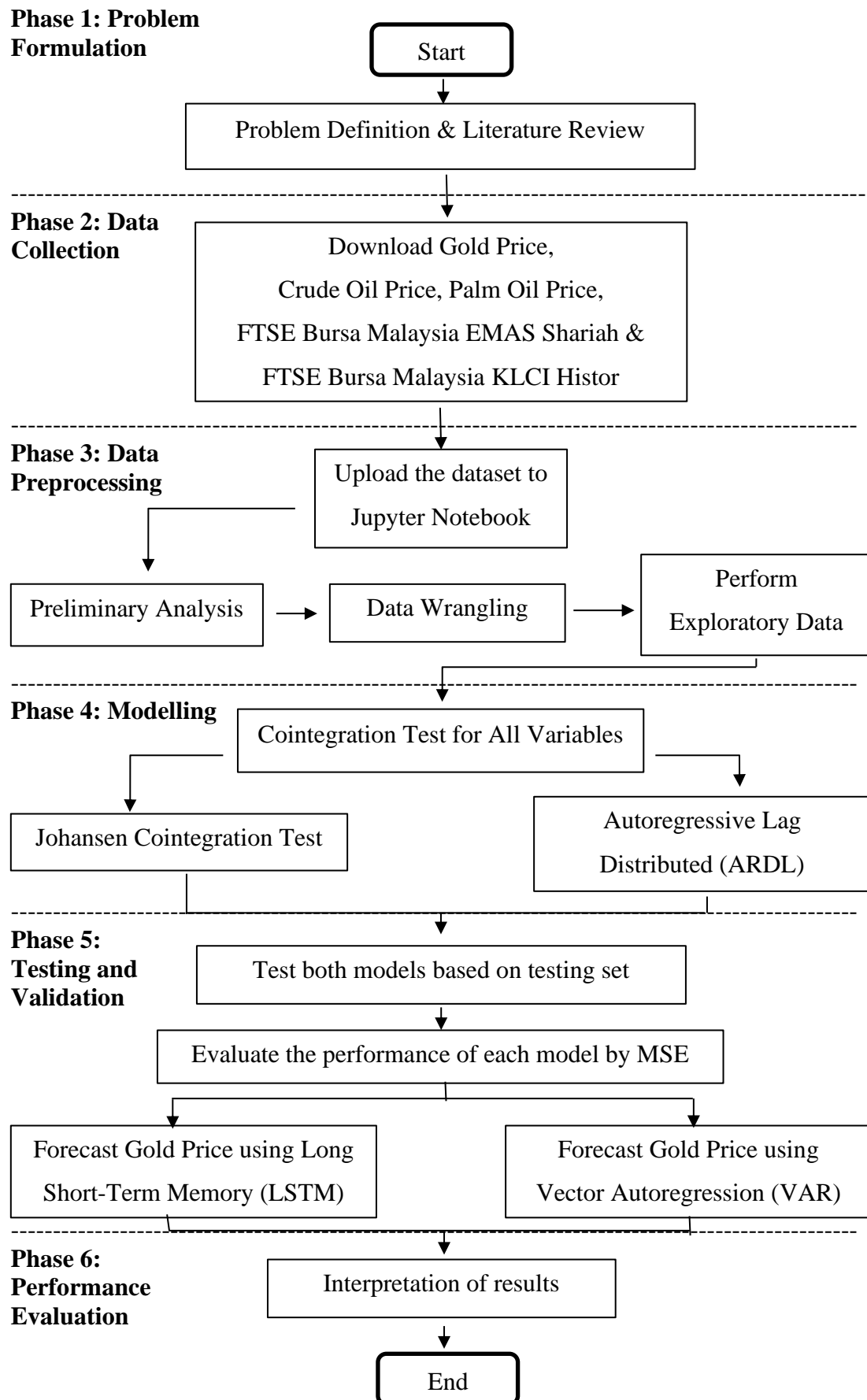Evaluation**

Interpretation of results

End

Figure 3.1 Research Framework of Gold Price Prediction

3.3   Problem Formulation

The principal objective of this research is to employ modern econometric approaches to model the influence of oil and stock market prices on gold prices, thereby offering valuable information to Malaysian policymakers and investors. However, in order to guarantee accurate and trustworthy analysis, a number of issues need to be resolved.

I.   Ensuring data quality and consistency is a major issue, as the analysis is based on monthly data from January 2013 to December 2023 for gold, crude oil, palm oil, Islamic stock market, and conventional stock market prices. Addressing potential problems with data gaps, outliers, and various data formats falls under this category.

II.   It is essential to choose and use the proper econometric models, such as the Granger Causality test, the Autoregressive Distributed Lag (ARDL) model, the Johansen Cointegration test, and the Long Short-Term Memory (LSTM) and Vector Autoregression (VAR) model. In order to handle the complexity of time series data, these models need to be able to capture the causality and long-term relationships between the variables.

It is critical to account for the dynamic character of the variables involved, as gold, oil, and stock market indices are all influenced by a variety of external factors such as geopolitical events, economic policy, and market mood. In order to keep the models accurate and relevant throughout time, they must be updated and improved on a regular basis while taking these dynamic factors into account.

3.4   Data Collection

The following datasets are carefully selected to assist in achieving our objectives. The data is obtained from official website of The World Bank Group and TradingEconomics consist of Inflation Rates, Interest Rates, and commodity prices

including monthly crude oil and palm oil prices. The data includes different number of observations respectively for all datasets. Some missing data are interpolated to provide a consistent result. Furthermore, this study focuses on analysing and study the trend of commodity prices movement, relationships of different macroeconomic variables, forecasting the future inflation rate and interest rate. Each data is measured in percentage (%) for inflation and interest rates while crude oil and palm oil are measured in MYR (Malaysian Ringgit) per barrel and metric tonne.

Table **3.1** Data of Each Variables

Data	Crude Oil Price	Palm Oil Price	Islamic Stock Market Price	Conventional Stock Market Price
Year Period	Jan 2013 – Dec 2023	Jan 2013 – Dec 2023	Jan 2013 – Dec 2023	Jan 2013 – Dec 2023
Frequency	Monthly	Monthly	Monthly	Monthly
Dataset Size	12 KB	12 KB	9 KB	10 KB

From the table 3.1, the data that represents the Islamic stock market is represented by FTSE Bursa Malaysia EMAS Shariah. While the data from the FTSE Bursa Malaysia KLCI History index provides more conventional stock market information. This research chose this website and this stock market because all Malaysian businesses listed on the Bursa Malaysia Main Market and ACE Market are eligible for inclusion, subject to achieving FTSE's worldwide standards of free float, liquidity, and invest ability. Investors can conduct international analysis and comparison using the FTSE Bursa Malaysia index methodology, and the management of the index series is transparent thanks to a set of Ground Rules. Therefore, it can be said that this data is particularly suitable for usage as one of the variables, aids in achieving the study's main goal.

Every item of data used in this study is secondary data. To be more specific, the data we collected did not match because the data on crude oil prices and palm oil prices is collected monthly rather than daily like other data. In order to synchronize the data with one another and get an accurate result, all data were evaluated and converted into monthly. It is expressed in monetary terms, specifically as Malaysian Ringgit (RM). In order to forecast the gold prices, this study chose to use 10 years period of data, from January 2013 to December 2023. This is because prior study has found that 10 years of data is sufficient to produce accurate forecasts.

Table 3.2 Gold Price, Crude Oil Price, Palm Oil Price, FTSE Bursa Malaysia EMAS Shariah and FTSE Bursa Malaysia KLCI Histor

Datasets	Attributes
Gold Price csv	- Date: Date of collected price - Gold Price (MYR): Gold Price in Malaysia Ringgit.
Crude Oil Price csv	- Date: Date of collected price - Crude Oil Price (MYR): Crude Oil Price in Malaysia Ringgit per Barrel.
Palm Oil Price csv	- Date: Date of collected price - Palm Oil Price (MYR): Palm Oil Price in Malaysia Ringgit per Metric Ton.
Islamic Stock Market Price csv (FTSE Bursa Malaysia EMAS Shariah)	- Date: Date of collected price - Price: The current trading value of the stock. - Open: The price at which the stock begins trading when the market opens. - High: The highest price at which the stock traded during a given period. - Low: The lowest price at which the stock traded during a given period. - Change %: The percentage change in the stock's price compared to the previous trading period.

Conventional Stock Market Price csv (FTSE Bursa Malaysia KLCI Histor)	• Date: Date of collected price • Open: The price at which the stock begins trading at the start of the trading day. • High: The highest price at which the stock traded during the trading day. • Low: The lowest price at which the stock traded during the trading day. • Close: The price at which the stock last traded when the market closed. • Adj Close: The closing price adjusted for corporate actions like dividends, stock splits, and new stock offerings. • Volume: The total number of shares traded during the trading day.

3.5   Data Pre-processing

It is necessary to complete preliminary analysis prior to moving on to further pre-processing. A data merging procedure is necessary to bring all of the raw data into one data frame once we have a firm grasp of the features provided in the dataset. Several data wrangling and data transformation procedures will be used on the dataset in an effort to further unify the disorganised raw data. Table 3.3 below lists every detail of the data pre-processing that was used.

Table 3.3 Data Pre-processing Methods

Data Pre-processing	Purpose
Preliminary analysis	To evaluate the provided dataset and obtain insightful knowledge for the modelling phase that follows.
Data Cleaning	Find the missing value and eliminate the rows that do not have it.

Data Concatenation	Compile every CSV file from January 2013 to December 2023.
Data Visualization	Plotted a chart illustrating the trend of each variable over ten years of Malaysian data.

3.5.1 Preliminary Analysis

Preliminary analysis is an important step in any data analysis since it helps you become acquainted with the data collection, understand its structure, format, and the sorts of variables it contains. Early investigation can identify problems that must be fixed for reliable analysis, such as missing values, outliers, or contradictions. The function ".info()" is used to retrieve the data information and gives a brief description of the dataframe. It displays every attribute information from the exported dataset, including the datatype, count of rows, and count of null counts. Figure 3.2 displays the gold price dataset information. The command "gold.info()" searches the dataframe "gold" for missing (NaN) values. The result indicates that all values are present. The dataset comprises 132 entries, suggesting that it is a medium-sized dataset. The dataframe comprises two columns: date and price, with datetime64[ns] and float64 as their respective datatypes.


```
gold.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 132 entries, 0 to 131
Data columns (total 2 columns):
 #   Column            Non-Null Count  Dtype
---  ------            --------------  -----
 0   Date              132 non-null    datetime64[ns]
 1   Gold Price (MYR)  132 non-null    float64
dtypes: datetime64[ns](1), float64(1)
memory usage: 2.2 KB
```

Figure 3.2 Data Information of Gold Price Dataset

Figure 3.3 displays the palm oil price dataset information. The command "palm_oil.info()" searches the dataframe "palm oil" for missing (NaN) values. The result indicates that all values are present. The dataset comprises 132 entries,

suggesting that it is a medium-sized dataset. The dataframe comprises two columns: date and price, with datetime64[ns] and int64 as their respective datatypes.

```
palm_oil.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 132 entries, 0 to 131
Data columns (total 2 columns):
 #   Column               Non-Null Count  Dtype
---  ------               --------------  -----
 0   DATE                 132 non-null    datetime64[ns]
 1   Palm Oil Price (MYR)  132 non-null    int64
dtypes: datetime64[ns](1), int64(1)
memory usage: 2.2 KB
```

Figure 3.3 Data Information of Palm Oil Price Dataset

The dataset information for crude oil prices is shown in Figure 3.4 The dataframe "crude oil" is searched for missing (NaN) values using the command "crude_oil.info()". According to the outcome, every value is present. Given that there are 132 entries in the dataset, it appears to be of medium size. The date and price columns in the dataframe have the datatypes datetime64[ns] and int64, respectively.

```
crude_oil.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 132 entries, 0 to 131
Data columns (total 2 columns):
 #   Column                Non-Null Count  Dtype
---  ------                --------------  -----
 0   DATE                  132 non-null    datetime64[ns]
 1   Crude Oil Price (MYR)  132 non-null    float64
dtypes: datetime64[ns](1), float64(1)
memory usage: 2.2 KB
```

Figure 3.4 Data Information of Crude Oil Price Dataset

The information on the Islamic stock market price dataset is shown in Figure 3.5 The dataframe "Islamic Stock Market" is searched for missing (NaN) values using the command "islamic_stock.info()". According to the outcome, every value is present. Given that there are 132 entries in the dataset, it appears to be of medium size. Six

columns make up the dataframe: date, price, open, high, low, and change percentage. Each column contains the datatype for each item.

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 132 entries, 0 to 131
Data columns (total 6 columns):
 #   Column     Non-Null Count  Dtype
---  ------     --------------  -----
 0   Date       132 non-null    object
 1   Price      0 non-null      float64
 2   Open       0 non-null      float64
 3   High       0 non-null      float64
 4   Low        0 non-null      float64
 5   Change %   0 non-null      float64
dtypes: float64(5), object(1)
memory usage: 6.3+ KB
```

Figure 3.5 Data Information of Islamic Stock Market Price Dataset

The traditional stock market price dataset information is shown in Figure 3.6. The dataframe "conventional stock market" is searched for missing (NaN) values using the command "conventional_stock.info()". According to the outcome, every value is present. Given that there are 132 entries in the dataset, it appears to be of medium size. The dataframe has six columns: date, open, high, low, close, adj close, and volume. The datatypes for each column are objects and float64.

```
conventional_stock.info()
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 132 entries, 0 to 131
Data columns (total 7 columns):
 #   Column     Non-Null Count  Dtype
---  ------     --------------  -----
 0   Date       132 non-null    object
 1   Open       132 non-null    float64
 2   High       132 non-null    float64
 3   Low        132 non-null    float64
 4   Close      132 non-null    float64
 5   Adj Close  132 non-null    float64
 6   Volume     132 non-null    int64
dtypes: float64(5), int64(1), object(1)
memory usage: 7.3+ KB
```

Figure 3.6 Data Information of Conventional Stock Market Price Dataset

3.5.2 Data Cleaning

In order to identify missing values and eliminate rows and columns with no values, data cleaning is done in this part. Figure 3.7 shows that while all datasets are free of missing values, some of the columns are not relevant to our research. It is therefore necessary to eliminate the following columns: 'Open', 'High', 'Low', 'Change %' from the Islamic stock market price dataset; and 'Open', 'High', 'Low', 'Close', 'Volume' from the conventional stock market price dataset. The process of removing these columns is depicted in Figure 3.8. The Islamic stock market price dataset now consists solely of date and price columns, whereas the traditional stock market price dataset only includes date and adj close columns.

```python
# Check duplicate data for each datasets
gold_dup = gold.duplicated().sum()
print("Number of Duplicate Rows of gold price dataset:", gold_dup)

palm_oil_dup = palm_oil.duplicated().sum()
print("Number of Duplicate Rows of palm oil price dataset:", palm_oil_dup)

crude_oil_dup = crude_oil.duplicated().sum()
print("Number of Duplicate Rows of palm oil price dataset:", crude_oil_dup)

islamic_stock_dup = islamic_stock.duplicated().sum()
print("Number of Duplicate Rows of palm oil price dataset:", islamic_stock_dup)

conventional_stock_dup = conventional_stock.duplicated().sum()
print("Number of Duplicate Rows of palm oil price dataset:", conventional_stock_dup)

Number of Duplicate Rows of gold price dataset: 0
Number of Duplicate Rows of palm oil price dataset: 0
Number of Duplicate Rows of palm oil price dataset: 0
Number of Duplicate Rows of palm oil price dataset: 0
Number of Duplicate Rows of palm oil price dataset: 0
```

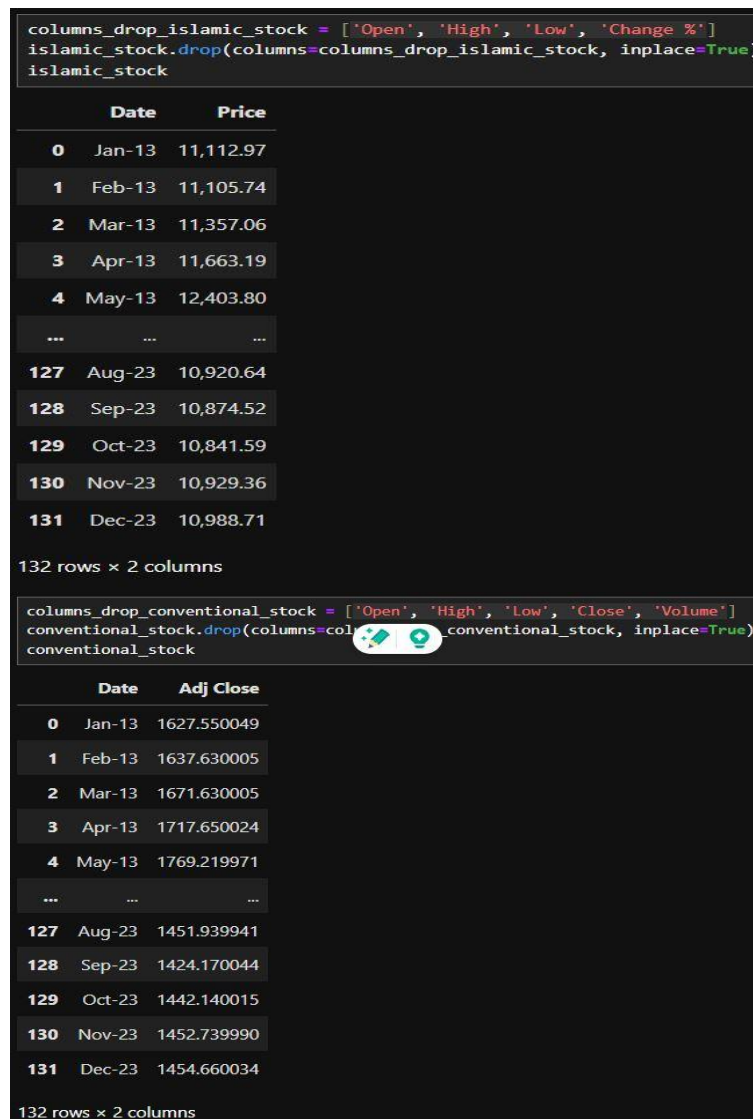Figure 3.7 Data Cleaning for All Datasets

```
columns_drop_islamic_stock = ['Open', 'High', 'Low', 'Change %']
islamic_stock.drop(columns=columns_drop_islamic_stock, inplace=True)
islamic_stock
```

	Date	Price
0	Jan-13	11,112.97
1	Feb-13	11,105.74
2	Mar-13	11,357.06
3	Apr-13	11,663.19
4	May-13	12,403.80
...	...	...
127	Aug-23	10,920.64
128	Sep-23	10,874.52
129	Oct-23	10,841.59
130	Nov-23	10,929.36
131	Dec-23	10,988.71

132 rows × 2 columns

```
columns_drop_conventional_stock = ['Open', 'High', 'Low', 'Close', 'Volume']
conventional_stock.drop(columns=col          conventional_stock, inplace=True)
conventional_stock
```

	Date	Adj Close
0	Jan-13	1627.550049
1	Feb-13	1637.630005
2	Mar-13	1671.630005
3	Apr-13	1717.650024
4	May-13	1769.219971
...	...	...
127	Aug-23	1451.939941
128	Sep-23	1424.170044
129	Oct-23	1442.140015
130	Nov-23	1452.739990
131	Dec-23	1454.660034

132 rows × 2 columns

Figure 3.8 Drop Unnecessary Column

3.5.3 Data Concatenation

A method for combining data from related datasets into a single, cohesive dataset in data analysis is called data concatenation. Since our data is gathered gradually in batches, it is crucial to this research that we combine all datasets from January 2013 to December 2023. This enables us to combine all of the datasets into one for analysis. An example of how we concatenate data across all datasets is shown in Figure 3.9.

```
# Merge all dataset in one dataframe
merged_df = pd.concat([palm_oil, crude_oil, islamic_stock, conventional_stock, gold], axis=1)

merged_df.drop(columns=['Date'], inplace=True)
merged_df
```

	DATE	Palm Oil Price (MYR)	Crude Oil Price (MYR)	Islamic Stock Market Price	Conventional Stock Market Price	Gold Price (MYR)
0	2013-01-01	2557	319.49	11,112.97	1627.550049	5082.220000
1	2013-02-01	2397	333.47	11,105.74	1637.630005	5042.270000
2	2013-03-01	2378	318.73	11,357.06	1671.630005	4952.770000
3	2013-04-01	2286	301.46	11,663.19	1717.650024	4537.530000
4	2013-05-01	2397	299.80	12,403.80	1769.219971	4266.100000
...	...	...	...	...	...	...
127	2023-08-01	4010	396.13	10,920.64	1451.939941	8834.737500
128	2023-09-01	3767	431.20	10,874.52	1424.170044	8875.566667
129	2023-10-01	3679	416.52	10,841.59	1442.140015	9061.206667
130	2023-11-01	3895	380.37	10,929.36	1452.739990	9368.556667
131	2023-12-01	3721	353.61	10,988.71	1454.660034	9494.305000

132 rows × 6 columns

Figure 3.9 Data Concatenation on Merge Dataset

3.6 Data Modelling

The primary aim of this research is to model the impact of oil price and stock market price on gold price using advanced econometric techniques. The process begins with the collection of time series data, encompassing historical records of gold price, crude oil price, palm oil price, Islamic stock market price, and conventional stock market price, measured over monthly intervals from January 2013 to December 2021. This data must then undergo a series of pre-processing steps to ensure its suitability for modeling. Pre-processing includes handling missing values, converting data types, and ensuring the data is stationary—a requirement for many time series models. Stationarity is achieved through techniques like differencing to remove trends and seasonal structures. Figure 3.10 will show the framework of how LSTM and VAR model methodology for forecasting gold price.

Data Pre-processing   Forecasting Model

Times Series Data → Granger Causality Test

Johansen Cointegration Test

Autoregressive Distributed Lag (ARDL)

→ Data Split Train/Test →

Long Short-Term Memory (LSTM)

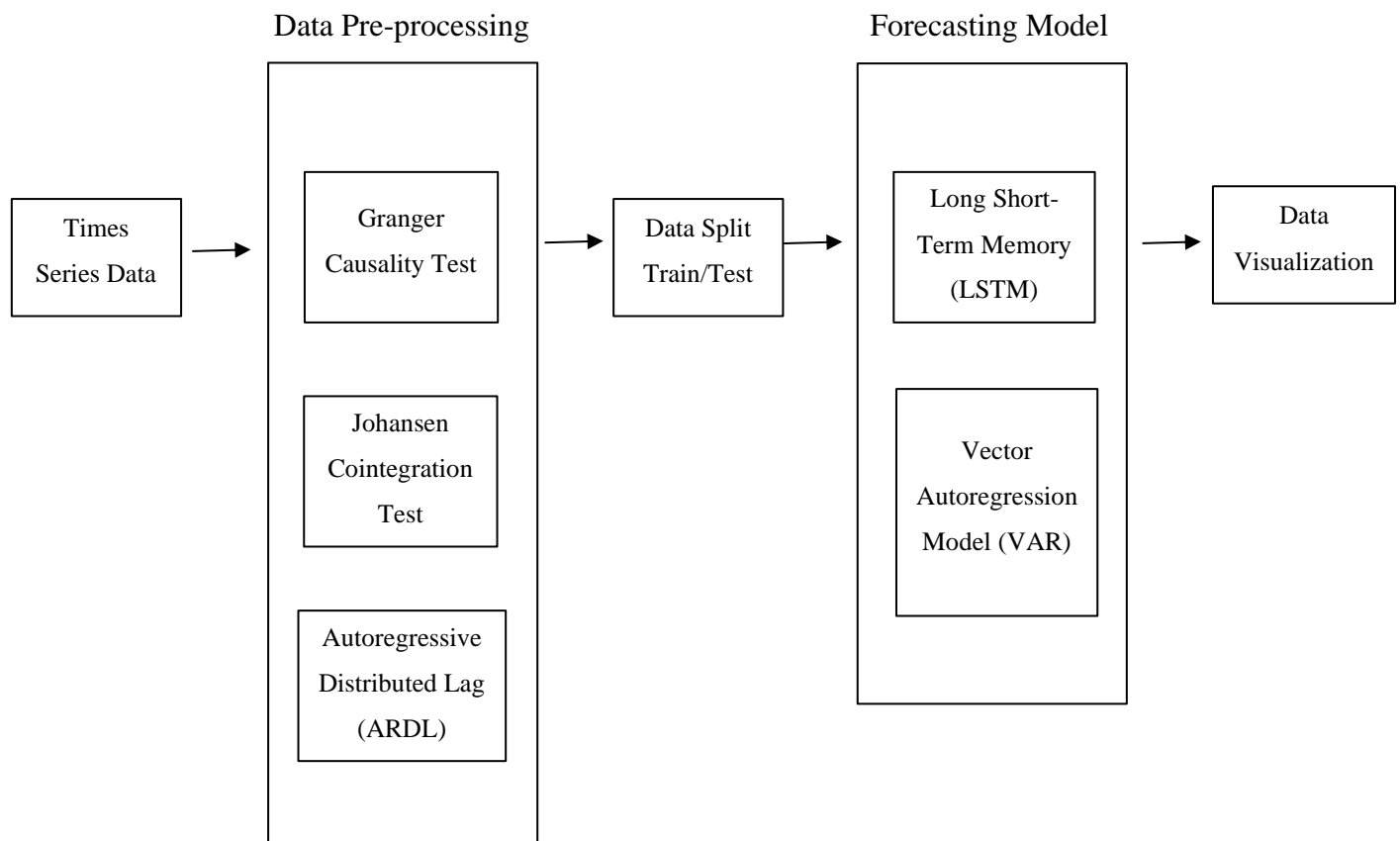Vector Autoregression Model (VAR)

→ Data Visualization

Figure 3.10 LSTM Model for Gold Price Forecasting Methodology

Once the data is prepared, it is divided into training and testing datasets. This division is essential for validating the model's effectiveness at making forecasts. For this research, the Johansen Cointegration test is employed to determine the long-term equilibrium relationships between the variables. Additionally, the Granger Causality test is used to identify the directional influences between the time series.

The Autoregressive Distributed Lag (ARDL) model is then applied, which is suitable for analyzing the dynamic relationships between the variables over both the short and long term. The ARDL model parameters—lag orders of autoregressive (AR) and moving average (MA) components—are meticulously selected using criteria like the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC). This step is crucial as it lays the foundation for how well the model will understand and predict the time series data's behavior.

The model fitting is the next phase, where the ARDL model, armed with the optimal parameters, is trained on the historical data. Upon training, the model's accuracy is evaluated using metrics such as the Root Mean Squared Error (RMSE) and the Mean Absolute Percentage Error (MAPE), which provide quantitative measures of the model's predictive performance. Additionally, the Long Short-Term memory (LSTM) model and Vector Autoregression Model (VAR) model are employed for forecasting future values of the time series. These forecasts can be particularly valuable for planning and decision-making processes in the financial sector.

Lastly, the model's predictions are visualized against actual data for a comparative analysis, providing an intuitive and clear assessment of its forecasting capabilities. The visualizations include time series plots and scatter plots that compare predicted and actual values, helping to identify the model's strengths and areas for improvement.

CHAPTER 4

INITIAL RESULTS

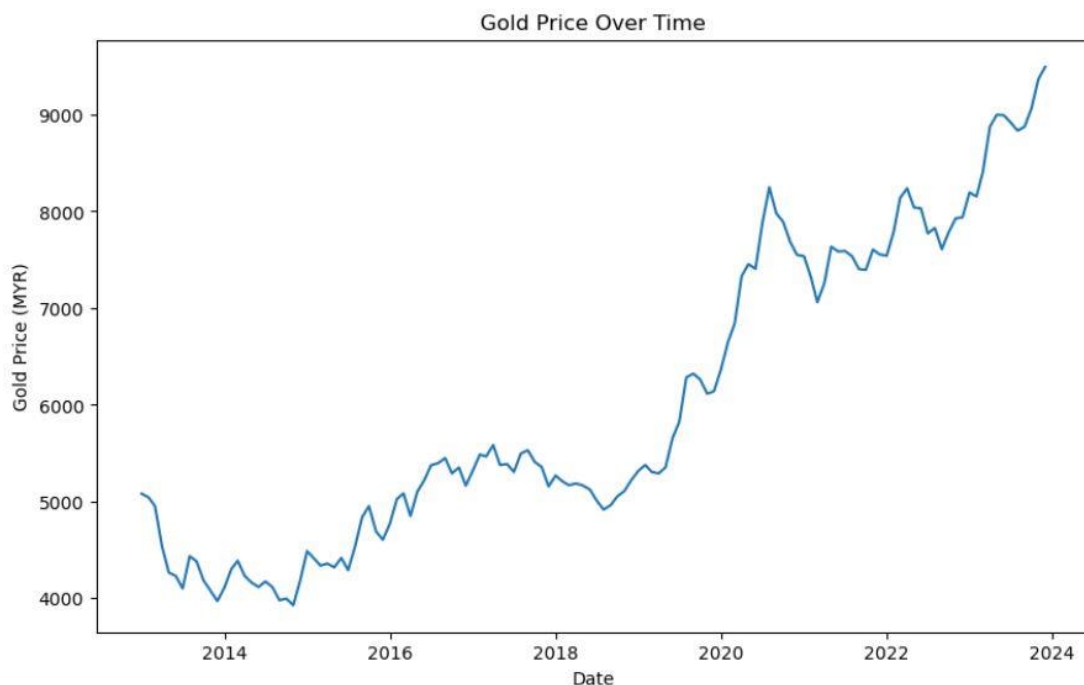## 4.1 Data Visualizations

4.1.1 Gold Price

Figure 4.1 Trend of Gold Price

Gold is a valuable metal to the economy as it is said to be the main commodity to the country. It also serves as a means of wealth storage in industrial commodities, which is crucial especially during times of political and economic disruption. The overall trend was upwards, with natural fluctuations occurring during the time period. The price of gold was at its highest from 2022 to 2023, during COVID-19 which has affected the global economy and caused people to be afraid to spend. According to (Wee Chian Koh & John Baffes, 2020), the price of gold is predicted to increase by an average of 13% in 2020 compared to 2019 due to high demand carried on by increased

global hesitation and historically low real interest rates. The threat of COVID-19 is also causing investors to choose gold as a safe asset (Yau et al., 2021). Even so, as news of the discovery of COVID-19 vaccine spread, it reduced the risk of the COVID-19 threat, with economists and investors expecting the global economy to recover.

Based on the figure 4.1, the price of gold was at the lowest in 2014. The conflict between Ukraine and Russia is not showing any signs of continuing in 2014, which is causing the global economy to recover (Dan Caplinger, 2014). Besides, the manufacturing Purchasing Managers Index (PMI) assesses business conditions in the economy's manufacturing sector (Trefis Team, 2014). When the PMI is greater than 50, it indicates that business activity is expanding, while a value less than 50 indicates that business activity is contracting. In 2014, the manufacturing PMI has consistently registered values above 50 for all months. This has caused the US dollar to strengthen, boosting expectations of an increase in interest rates. Hence, as investors turn to interest-bearing assets, an increase in interest rate is likely to cause a drop in the price of gold.
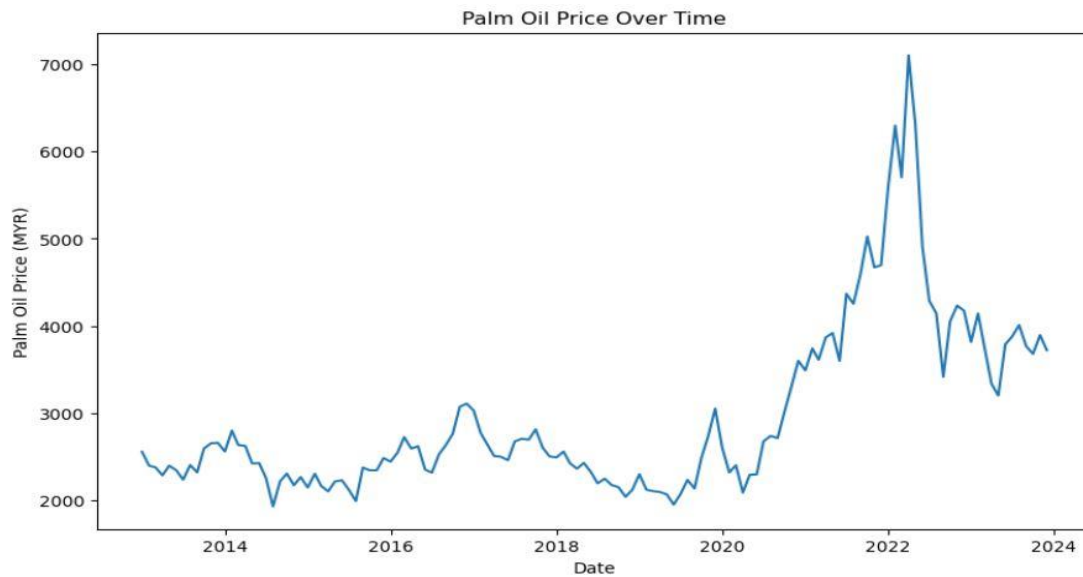
4.1.2   Oil Price
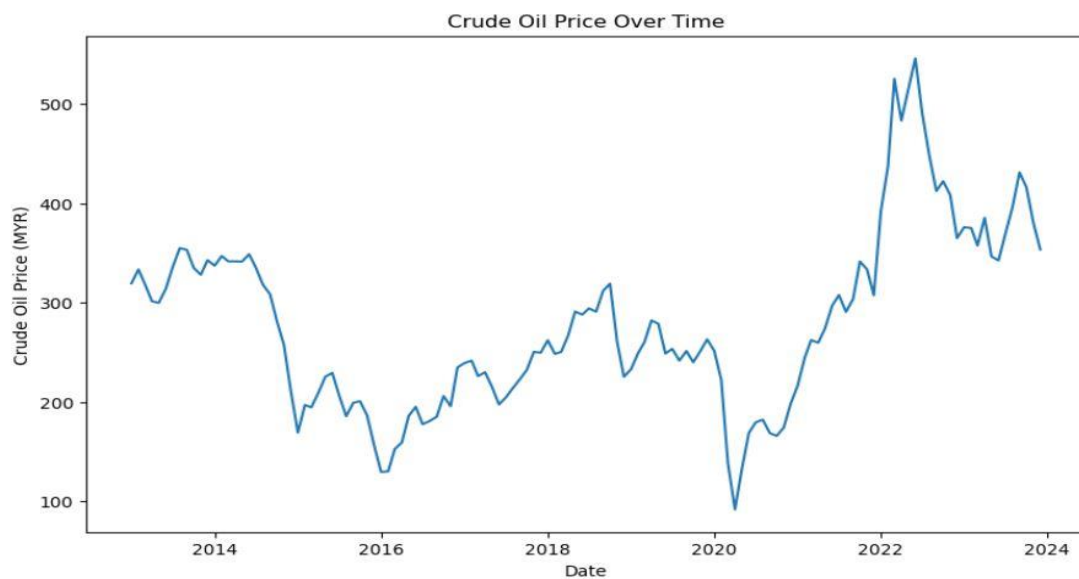
Figure 4.2 Trend of Oil Price

Figure 4.2 shows the fluctuation through the period of 2013 until 2023 for crude oil price and palm oil price. It presents the crude palm oil price drop drastically in the year 2020. The COVID-19 pandemic in 2020 caused crude oil prices to plummet as oil demand fell sharply as a result of lockdowns and travel restrictions. Due to encompassing stay-athome orders, it moves the world toward low-cost green or clean energy that could have an impact on crude oil prices (Ayisy Yusof, 2021). According to Mead and Stiger (2015) petroleum prices rose sharply influenced by various factors and it continues to exert upward pressure in 2013. Strong economic growth in developed countries but lower interest rate like, United States and China strengthen worldly crude oil price including the Malaysian crude Oil Price. Sudden drops of crude price after 2013 is believed due to the global crisis where the supply gut is growing yet there was a sharp contraction in energy investment in the United States. This has to be one of the largest oil prices declines where the other two biggest price declines were during World War II and Supply-Driven collapse of 1986 (Stocker et. al,2018).

The next graph is palm oil price that present seasonality over the year. Based on the graph, it can be seen that the price of Palm Oil is having an average of RM 3000 per tons over the period of 2013 to 2019 before an increase from to 2020 and the following years. Being one of the biggest palm oil producers in East Asia yet not producing an efficient amount of the oil, it is believed due to the lack's infrastructure.

50

Across Peninsular Malaysia, land for palm oil expansion is limited which mostly has been placed with urban development (Mark, 2022). Although there are growing palm oil land in Sabah and Sarawak but the only expendable palm oil plantation areas are in Sarawak. Apart from that, the price of oil increase drastically from 2020 because of low CPO production, rising soybean oil prices, Brent Crude Oil price increases, and strong palm oil exports in key markets all contributed to the increase in CPO prices. The price became the highest compared to past year before COVID-19 pandemic hit the world (Cheryl Poo, 2022).

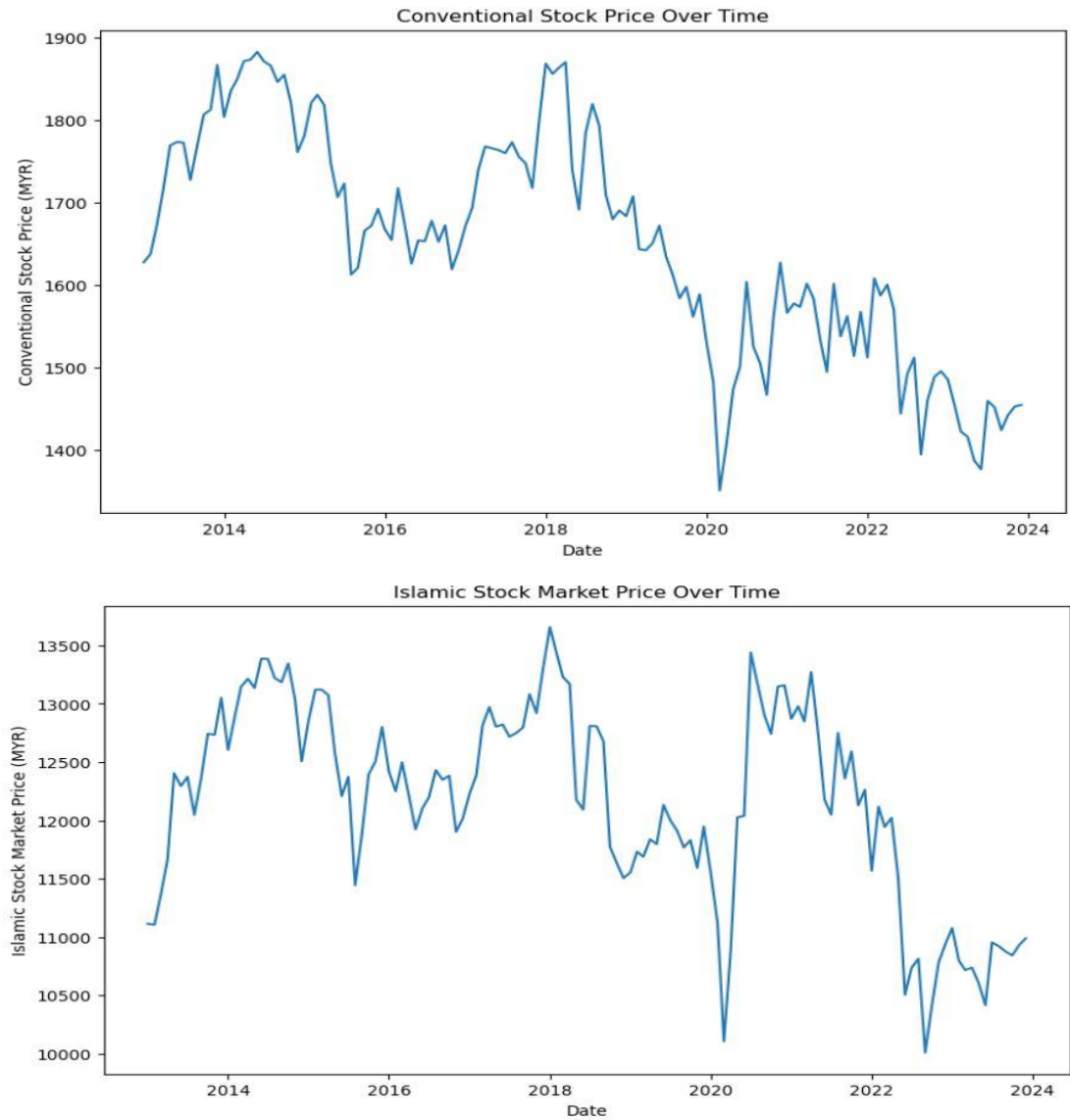### 4.1.3 Stock Market Price

Figure 4.3 Trend of Stock Market Price

Lastly, the figure 4.3 shows the graph of stock market for both conventional and Islamic stock market price shows the fluctuation from 2013 to 2021 but was at the lowest during 2020. It slowed down because investors were afraid to invest due to the worst economic downturn crisis. Financial system crises, such as the current pandemic, information about Islamic investment systems has piqued the curiosity of investors who view the returns of stocks as uncertain (Nomran & Haron, 2021).

As they are traded on the same market in Bursa Malaysia yet have distinct results, this also suggests that there are important performance concerns to be investigated among the indices. In order to help investors, fund managers, and other market players in making decisions about their investments and finances, it is necessary to study the information on the integration between these two graphs. Additionally, this stock market integration will make it possible to gather some crucial data, allowing decision-makers to create efficient market strategies and suitable regulations to guarantee Malaysia's financial markets remain strong and stable. Information about this integration is also crucial because it will increase domestic investment and savings, which will increase productivity and accelerate economic growth (Bank for International Settlements. Monetary and Economic Department, 2005). It will also lower capital costs in an integrated market because it will share risk with domestic and international economic activities (Tai, 2007).

4.2   Descriptive Analysis

Table 4.1 Descriptive Analysis

Statistic	Palm Oil Price (MYR)	Crude Oil Price (MYR)	Islamic Stock Market Price (MYR)	Conventional Stock Market Price (MYR)	Gold Price (MYR)
count	132.00	132.00	132.00	132.00	132.00
mean	2956.55	278.57	12168.67	1649.53	6018.09
std	985.30	89.12	845.34	137.10	1565.96
min	1929.00	91.64	10008.03	1350.89	3928.61

25%	2305.75	210.73	11655.75	1555.76	4847.53
50%	2576.00	261.50	12256.17	1653.67	5377.01
75%	3517.25	338.29	12814.04	1764.22	7551.68
max	7104.00	546.13	13658.05	1882.71	9494.30

The table above provides a complete descriptive analysis of several financial parameters over a 10-year period, with a focus on Palm Oil Price (MYR), Crude Oil Price (MYR), Islamic Stock Market Price (MYR), Conventional Stock Market Price (MYR), and Gold Price (MYR). Statistical metrics including count, mean, standard deviation (std), minimum (min), 25th percentile (25%), median (50%), 75th percentile (75%), and maximum (max) values are displayed for each distinct financial indication that is represented by a column. This data gives information about the central tendency, dispersion, and overall distribution of several financial variables.

With an average price of 2956.55 and a standard deviation of 985.30, the palm oil price (MYR) exhibits significant price volatility. A broad range of values is suggested by the fact that the smallest recorded price is 1929.00, while the maximum is substantially higher at 7104.00. Comparably, the value of the Crude Oil Price (MYR) exhibits a mean of 278.57 and a standard deviation of 89.12, with values varying between 91.64 and 546.13. These numbers demonstrate how several market and geopolitical events impact the price of commodities.

Both the Islamic and Conventional stock market indices, as well as the gold price (MYR), exhibit unique patterns. The range of values for the Islamic Stock Market Price (MYR) is 10008.03 to 13658.05. Its mean is 12168.67 and its standard deviation is 845.34. Compared to the Islamic index, the Conventional Stock Market Price (MYR) exhibits much lower volatility, with a mean of 1649.53 and a standard deviation of 137.10. Besides that, the gold price (MYR), which reflects its status as a safe-haven asset during times of economic instability, ranges from 3928.61 to 9494.30, with a mean of 6018.09 and a standard deviation of 1565.96. Throughout the observed period, these statistics offer a comprehensive insight of the behaviour and trends within key financial variables.
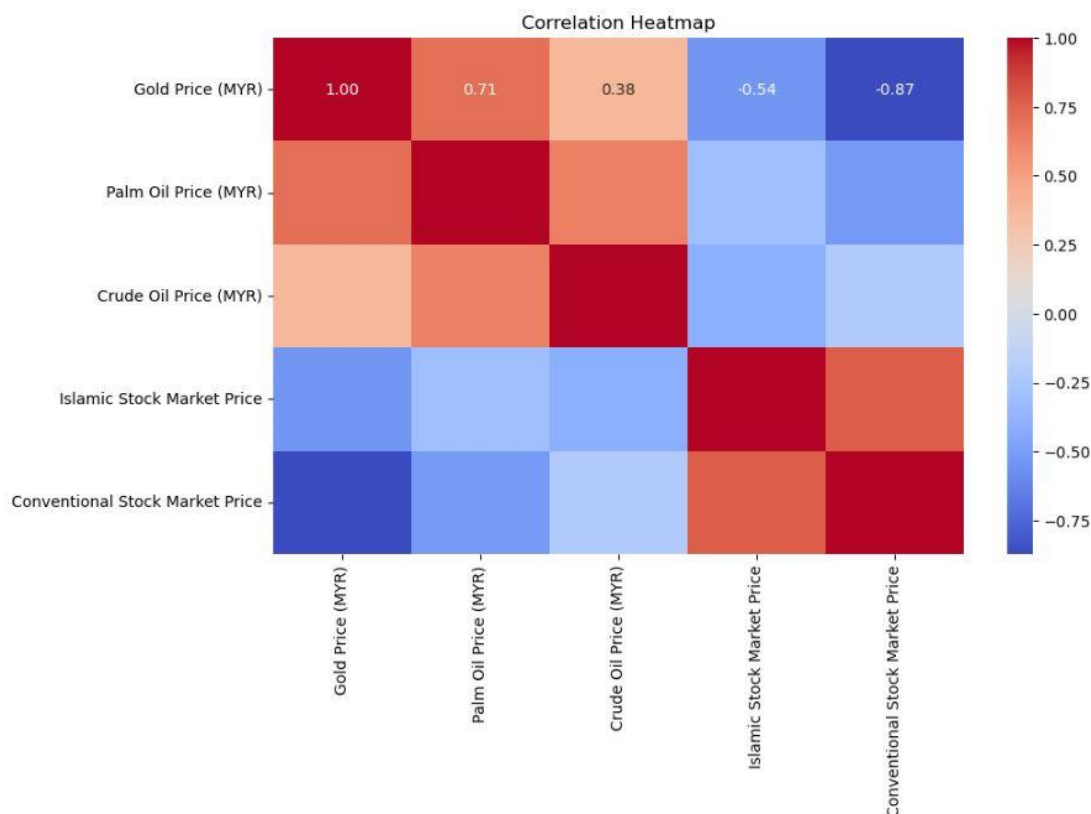
4.3   Initial Insights

Figure 4.4 Correlation Heatmap Analysis

The relationships between five financial metrics, which are price of gold (MYR), price of palm oil (MYR), price of crude oil (MYR), price of the Islamic stock market, and price of the conventional stock market—are visually represented by the correlation heatmap that is provided. Blue denotes negative correlations and red denotes positive correlations, and the colour gradient between them shows the intensity and direction of the relationships. The colour's intensity represents the correlation coefficient's value; greater correlations are shown by darker hues.

The correlation value of 0.71 between Gold Price (MYR) and Palm Oil Price (MYR) indicates a significant positive relationship, which is clearly visible from the heatmap. This means that the price of gold tends to rise along with the price of palm oil. On the other hand, there is a substantial negative correlation (-0.87) between the price of gold and the price of conventional stocks, suggesting that gold prices tend to

decline in tandem with increases in the price of conventional stocks. Further evidence of an unfavourable association between gold prices and stock market indices comes from the moderately negative correlation (-0.54) between the price of gold (MYR) and the price of Islamic stocks.

Furthermore, relationships between various financial variables are displayed in the heatmap. For example, the moderate positive correlation (0.38) between the price of palm oil (MYR) and the price of crude oil (MYR) indicates that both commodities frequently move in the same direction, albeit not very substantially. Given that they are stock market indices, it is not surprising that the prices of the Islamic and Conventional stock markets have a strong positive association. Therefore, Investors and policymakers can make more educated decisions about investments and policies by using this heatmap, which offers insightful information about the relationships between various financial parameters.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1   Summary

This study aims to analyze the trend of gold price, crude oil price, palm oil price, Islamic and conventional stock market Index. From the analysis, it can be concluded that gold, crude oil, palm oil, Islamic and Conventional stock market prices are having a linear trend and fluctuates throughout the period due to the recent pandemic COVID-19. This finding proves that the market for commodities and stock indexes are influenced by the economic and financial situation. The second objective is to investigate the cointegration between gold, oil and stock market prices.

Through the use of the ARDL model, which emphasises the significant correlations between the prices of gold, crude oil, and the conventional stock market, the study explores deeper into the dynamic interactions between these factors. Gold prices are significantly impacted by changes in the price of crude oil and conventional stock markets, as shown by this approach's ability to capture both short-term adjustments and long-term equilibrium relationships. Furthermore, the Granger causality test is employed in the study to determine the direction of impacts among the time series data, hence proving the interdependence of various economic indicators. The comprehensive research highlights how crucial it is to comprehend these connections in order to develop investment plans and anticipate the economy.

Lastly, the study uses the significant variables found to forecast gold prices using the Long Short-Term Memory (LSTM) model and Vector Autoregression (VAR) model. The LSTM and VAR model are suitable for forecasting multivariate time series data. It can show which variables the price of gold has a causal relationship with. As a result, this discovery offers insightful information to policymakers and

investors on the ability of integrated economic models to predict market movements and help them make well-informed decisions.

5.2   Future Works

Few gaps have been identified as a result of this research, and these could be addressed in the future. Therefore, this study proposes a few suggestions and ideas that may be useful for potential researchers to further expand research on the cointegration between macroeconomic factors in Malaysia or globally, as well as for predicting the future price. Additionally, there are few suggestions for what the authority can do to improve both major and minor sectors in the future.

The focus of this study, which only takes place in Malaysia, is one of our limitations that was previously mentioned. Since other nations are involved in the transactions involving the international price of gold, we advise future researchers to examine other nations or make some comparisons with other nations while computing their study. For instance, data on the stock markets and oil prices by groups of nations may be utilized to enhance knowledge of the links that are dynamic and change over time. Second, while stock market prices are a significant economic indication in our nation, other indicators, such as inflation and currency rates, may also be considered because they may have an impact on gold prices.

Second, this study only used monthly data from 2013 onwards due to the lack of data from prior years. Therefore, more data might be considered to produce clearer conclusions on future values should subsequent researchers be motivated to further their studies in this area. Aside from that, other exogenous regressors, in this example the principal economic sectors of Malaysia, might be considered for calculation. The conclusions of this study may be biased since they only cover five important industries variables. Future researchers are advised to avoid using converted data, which in this case refers to data that has been transformed from daily to monthly, and to apply accurate data instead. This is because the outcomes will be more dependable, precise, and timely if exact values or daily data are used.

Analysts believe that gold will continue to serve as a safe-haven asset, particularly for portfolio diversification purposes, despite the fact that gold's relationship as an inflation hedge is becoming increasingly tenuous in light of the current period of high inflation. Moreover, to hedge against volatility and inflation, investors are currently investing in real estate, REITs, ETFs, and other commodities. Malaysia's retail gold purchases have been severely impacted by the Covid-19 recession and government restrictions. As a result of the current period of high inflation, gold's role as an inflation hedge is becoming increasingly precarious. Government plays an important role in the price of gold. However, although the government does strongly influence the gold market, they do not control the gold market, but the government does have some control over interest rates. The interest rates set by central banks are frequently a predictor of the future price of gold. Lower rates typically indicate that the price of gold will rise, whereas higher rates are frequently followed by falling prices. Thus, to ensure that gold remains being a safe haven asset in investment, the government must alert and respond promptly towards the interest rate and inflation. The researcher can expand their research area, studying on the relationship between interest rate, inflation, gold price and stock market price as it benefits the future and would assist government in making economic decisions.

REFERENCES

Abbas, G., Bhowmik, R., Koju, L., & Wang, S. (2017). Cointegration and causality relationship between stock market, money market and foreign exchange market in Pakistan. *Journal of Systems Science and Information, 5*(1), 1-20. https://doi.org/10.21078/jssi-2017-001-20

Abdallah, W., Goergen, M., & O'Sullivan, N. (2015). Endogeneity: How failure to correct for it can cause wrong inferences and some remedies. *British Journal of Management, 26*(4), 791-804. https://doi.org/10.1111/1467-8551.12113

Ahmad, Z. (2019). Analyzing causation of dynamic oil and gold prices in Malaysia. *Journal of Global Business and Social Entrepreneurship (GBSE), 5*(15). www.gbse.com.my

Ali, M., Tursoy, T., Samour, A., Moyo, D., & Konneh, A. (2022). Testing the impact of the gold price, oil price, and renewable energy on carbon emissions in South Africa: Novel evidence from bootstrap ARDL and NARDL approaches. *Resources Policy, 79.* https://doi.org/10.1016/j.resourpol.2022.102984

Asila Jalil. (2022, January 1). Demand for gold bars increase 30pc this year, says Habib Jewels. *New Straits Times.*

Aydin, A. D., & Cavdar, S. C. (2015). Comparison of prediction performances of artificial neural network (ANN) and vector autoregressive (VAR) models by using the macroeconomic variables of gold prices, Borsa Istanbul (BIST) 100 index and US Dollar-Turkish Lira (USD/TRY) exchange rates. *Procedia Economics and Finance, 30*, 3-14. https://doi.org/10.1016/s2212-5671(15)01249-6

Ayisy Yusof. (2021, February 1). Oil price faces Covid-19 threat. *New Straits Times.*

Azreen, N., Razak, A., Khamis, A., Asrul, M., & Abdullah, A. (2017). ARIMA and VAR modeling to forecast Malaysian economic growth. *Journal of Science and Technology, 9*(3).

Bahloul, S., & Khemakhem, I. (2021). Dynamic return and volatility connectedness between commodities and Islamic stock market indices. *Resources Policy, 71.* https://doi.org/10.1016/j.resourpol.2021.101993

Bank for International Settlements. Monetary and Economic Department. (2005). *Globalisation and monetary policy in emerging markets.* Bank for International Settlements.

Basiron, Y. (2009, March 1). Trends and potentials of Malaysia's plantation sector. In A presentation by Tan Sri Datuk Dr Yusof Basiron at the Perdana Leadership Foundation Seminar.

Bernama. (2023, January 1). Public gold: Malaysian gold market to move south in 2023, bucking international trend. *Borneo Post.*

Bildirici, M. E., & Turkmen, C. (2015). Nonlinear causality between oil and precious metals. *Resources Policy, 46*, 202-211. https://doi.org/10.1016/j.resourpol.2015.09.002

Bildirici, M., & Türkmen, C. (2015). The chaotic relationship between oil return, gold, silver and copper returns in Turkey: Non-linear ARDL and augmented non-linear Granger causality. *Procedia - Social and Behavioral Sciences, 210*, 397-407. https://doi.org/10.1016/j.sbspro.2015.11.387

Boubaker, H., Cunado, J., Gil-Alana, L. A., & Gupta, R. (2020). Global crises and gold as a safe haven: Evidence from over seven and a half centuries of data. *Physica A: Statistical Mechanics and Its Applications.* https://www.measuringworth.com/datasets/gold/

Bromberg, M. (2023). Why gold matters: Everything you need to know. *Investopedia.* https://www.investopedia.com/articles/economics/09/why-gold-matters.asp

Capie, F., Mills, T. C., & Wood, G. (2005). Gold as a hedge against the dollar. *Journal of International Financial Markets, Institutions and Money, 15*(4), 343-352.

Caplinger, D. (2014, January 1). Price of gold in 2014: Why it's gone nowhere. *The Motley Fool.*

Chai, J., Zhao, C., Hu, Y., & Zhang, Z. G. (2021). Structural analysis and forecast of gold price returns. *Journal of Management Science and Engineering, 6*(2), 135-145. https://doi.org/10.1016/j.jmse.2021.02.011

Chikri, H., & Hamiche, M. (2020). The impact of the oil and gold price shock on Islamic and conventional stock market indices: Evidence from the DCC-GARCH model. *PJAEE, 17*(6).

Chkili, W. (2022). The links between gold, oil prices and Islamic stock markets in a regime switching environment. *Eurasian Economic Review, 12*(1), 169-186. https://doi.org/10.1007/s40822-022-00202-y

Christiano, L. J. (2012). Christopher A. Sims and vector autoregressions. *Scandinavian Journal of Economics, 114*(4), 1082-1104. https://doi.org/10.1111/j.1467-9442.2012.01737.x

Fritzer, F., Moser, G., & Scharler, J. (2002). Forecasting Austrian HICP and its components using VAR and ARIMA models. http://hdl.handle.net/10419/264665

Gao, X., Huang, S., Sun, X., Hao, X., & An, F. (2018). Modelling cointegration and Granger causality network to detect long-term equilibrium and diffusion paths in the financial system. *Royal Society Open Science, 5*(3). https://doi.org/10.1098/rsos.172092

Garside, M. (2023). Gold production ranked by major countries 2022. *Statista.*

Go, Y. H., & Lim, W. Y. (2017). The relationship of crude palm oil spot-futures under inflationary expectation in gold market. *Capital Markets Review.*

Guglielmo, M., Caporale, J., Hunter, F., & Menla, A. (2013). On the linkages between stock prices and exchange rates: Evidence from the banking crisis of 2007-2010. http://www.diw.de/discussionpapers

Gumis, S. (2020). Malaysia: Investment in the gold mining sector in Malaysia. *SKRINE.*

Hammad, W., Hamdan, A., Al-Ameer, M., & Ismail, A. (2018). The relationship of gold price with the stock market: The case of Frankfurt stock exchange. *International Journal of Energy Economics and Policy, 8*(5), 357-371. http://www.econjournals.com

Hatemi-J, A., & Hacker, R. S. (2008). Optimal lag-length choice in stable and unstable VAR models under situations of homoscedasticity and ARCH. *Journal of Applied Science.*

Hayati, N., & Rahman, A. (2011). A time series analysis of the relationship between total area planted, palm oil price and production of Malaysian palm oil. *World Applied Sciences Journal.* https://www.researchgate.net/publication/295460953

Hidalgo, F. D., & Sekhon, J. S. (2009). Causality. In *International Encyclopedia of Political Science.*

Ibrahim, S. N., Hasan, R., & Nor, A. M. (2018). Does gold price lead or lag Islamic stock market and strategy commodity price? A study from Malaysia. *International Journal of Business, Economics and Management, 5*(6), 146-163. https://doi.org/10.18488/journal.62.2018.56.146.163

Jabeur, S. B., Mefteh-Wali, S., & Viviani, J. L. (2021). Forecasting gold price with the XGBoost algorithm and SHAP interaction values. *Annals of Operations Research.* https://doi.org/10.1007/s10479-021-04187-w

Jain, A., & Biswal, P. C. (2016). Dynamic linkages among oil price, gold price, exchange rate, and stock market in India. *Resources Policy, 49*, 179-185. https://doi.org/10.1016/j.resourpol.2016.06.001

Jena, S., et al. (2022). A comprehensive review on deep learning models for financial time series forecasting. *Journal of Computational Finance and Data Science, 10*(3), 215-233.

Karia, A. A., & Bujang, I. (2011). Progress accuracy of CPO price prediction: Evidence from ARMA family and artificial neural network approach. *International Research Journal of Finance and Economics.* http://www.eurojournals.com/finance.htm

Khan, Md. S., & Khan, U. (2020). Comparison of forecasting performance with VAR vs. ARIMA models using economic variables of Bangladesh. *Asian Journal of Probability and Statistics, 33*-47. https://doi.org/10.9734/ajpas/2020/v10i230243

Koh, W. C., & Baffes, J. (2020). Gold shines bright throughout the COVID-19 crisis. *World Bank.*

Kristjanpoller, W., Fadic, A., & Minutolo, M. (2021). Forecasting volatility of gold price using an LSTM model with news sentiment analysis. *Expert Systems with Applications, 163*, 113829.

Mani. (2019). Gold price vs stock market: Gold and equity have an inverse relationship. *Get Money Rich.*

Maxwell, T. (2022). Why you should buy gold during inflation. *CBS News.*

Mukhuti, S., & Bhunia, A. (2013). Is it true that Indian gold price influenced by Indian stock market reaction? *E3 Journal of Business Management and Economics, 4*(8), 181-186. http://www.e3journals.org

Nomran, N. M., & Haron, R. (2021). The impact of COVID-19 pandemic on Islamic versus conventional stock markets: International evidence from financial

markets. *Future Business Journal, 7*(1). https://doi.org/10.1186/s43093-021-00078-5

Nordin, N., Nordin, S., & Ismail, R. (2014). The impact of commodity prices, interest rate and exchange rate on stock market performance: An empirical analysis from Malaysia. *Malaysian Management Journal, 18.*

Othman, N., & Masih, M. (2018). Granger-causality between palm oil, gold and stocks (Islamic and conventional): Malaysian evidence based on ARDL approach. *Munich Personal RePEc Archive.*

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bound testing approaches to the analysis of long run relationships. *Journal of Applied Econometrics, 16*(3), 289-326.

Phaladisailoed, T., & Naruetharadhol, P. (2019). Machine learning models comparison for gold price prediction. *Procedia Computer Science, 156*, 287-295.

Rahman, H. A. A., Azizi, M. F. R., Saruand, M. F., & Shafie, N. A. (2022). Forecasting of Malaysia gold price with exponential smoothing. *Journal of Science and Technology.*

Rajab, K., Kamalov, F., & Cherukuri, A. K. (2022). Forecasting COVID-19: Vector autoregression-based model. *Arabian Journal for Science and Engineering, 47*(6), 6851-6860. https://doi.org/10.1007/s13369-021-06526-2

Roberts, M. R., & Whited, T. M. (2013). Endogeneity in empirical corporate finance. In *Handbook of the Economics of Finance (Vol. 2, Issue PA, pp. 493-572).* Elsevier B.V. https://doi.org/10.1016/B978-0-44-453594-8.00007-0

Sørensen, B. E. (2019). Cointegration. In *Economics 266.*

Statista Research Department. (2022). Palm oil consumption in Malaysia from 2011/2012 to 2020/2021. *Statista.* https://www.statista.com/statistics/489441/palm-oil-consumption-malaysia/

Stevans, L. K. (2012). Time series review. *SSRN Electronic Journal.* https://doi.org/10.2139/ssrn.1767999

Stoklasová, R. (2018). Short-term and long-term relationships between gold prices and oil prices.

Syahri, A., & Robiyanto, R. (2020). The correlation of gold, exchange rate, and stock market on COVID-19 pandemic period. *Jurnal Keuangan dan Perbankan, 24*(3). https://doi.org/10.26905/jkdp.v24i3.4621

Taha Abdullah, L. (2022). Forecasting time series using vector autoregressive model. *International Journal of Nonlinear Analysis and Applications, 13*, 2008-6822. https://doi.org/10.22075/ijnaa.2022.5521

Tai, C.-S. (2007). Market integration and contagion: Evidence from Asian emerging stock and foreign exchange markets. *Emerging Markets Review.*

Thakolsri, S. (2021). Modeling the relationships among gold price, oil price, foreign exchange, and the stock market index in Thailand. *Investment Management and Financial Innovations, 18*(2), 261-272. https://doi.org/10.21511/imfi.18(2).2021.21

Trefis Team. (2014). Reasons for the recent decline in gold prices. *Forbes.*

Tursoy, T., & Faisal, F. (2018). The impact of gold and crude oil prices on stock market in Turkey: Empirical evidences from ARDL bounds test and combined cointegration. *Resources Policy, 55*, 49-54. https://doi.org/10.1016/j.resourpol.2017.10.014

Vveinhardt, J., Streimikiene, D., & Raheem Ahmed, R. (2018). Asymmetric influence of oil and gold prices on Baltic and South Asian stock markets: Evidence from Johansen cointegration and ARDL approach. *SALU-Commerce & Economics Review, 4*(1). https://www.researchgate.net/publication/322900068

Wang, M. L., Po, W. C., & Yang, H. T. (2010). Relationships among oil price, gold price, exchange rate and international stock markets. *International Research Journal of Finance and Economics, 47*, 1450-2887.

Wen, F., Yang, X., Gong, X., & Lai, K. K. (2017). Multi-scale volatility feature analysis and prediction of gold price. *International Journal of Information Technology and Decision Making, 16*(1), 205-223. https://doi.org/10.1142/S0219622016500504

Yahya, M., Muhammad, F., Razak, A. A., Gan, P.-T., Hussin, M., Tha, G. P., & Marwan, N. (2013). The link between gold price, oil price and Islamic stock market: Experience from Malaysia. *International Journal of Business and Social Science, 4*(2), 161-182. https://www.researchgate.net/publication/306536880

Yau, D. L. I., Ching, C. P., Hwang, J. Y. T., Sin, K. Y., & Janang, S. K. Y. (2021). Does the factors affecting gold price change during COVID-19 period in

Malaysia? *International Journal of Academic Research in Business and Social Sciences, 11*(9). https://doi.org/10.6007/ijarbss/v11-i9/10761

Yun, Y. X. (2020). Gold prices drop in wake of vaccine development. *The Star.*

Zaidi, A., Shah, A., Karim, N., Roman, M., Azlan, M., Zaidi, S., Karim, Z. A., & Zaidon, N. A. (2021). External and internal shocks and the movement of palm oil price: SVAR evidence from Malaysia. *Economies.* https://doi.org/10.3390/economies

Zach. (2021). How to perform a Granger-causality test in R. *Statistics Globe*. https://www.statology.org/granger-causality-test-r/