EXPLORING A MODEL FOR VOLATILITY OF THE GOLD PRICE AMONG THE WORLD GOLD PRODUCING COUNTRIES

THONG MENG SENG

BACHELOR OF ECONOMICS (HONOURS)

GLOBAL ECONOMICS

UNIVERSITI TUNKU ABDUL RAHMAN

FACULTY OF ACCOUNTANCY AND MANAGEMENT

DEPARTMENT OF ECONOMICS

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BY

THONG MENG SENG

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Name of Student:	Student ID:	Signature:
Thong Meng Seng	2103962	

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LIST OF ABBREVIATIONS

ABS	Australian Bureau of Statistics
ADF	Augmented Dickey–Fuller
ARDL	Autoregressive Distributed Lag
ARIMA	Autoregressive Integrated Moving Average
AUD	Australian Dollar
BOC	Bank of Canada
BoG	Bank of Ghana
BLS	U.S. Bureau of Labor Statistics
CAD	Canadian Dollar
CNY	Chinese Yuan
COP	Crude Oil Price
CPI	Consumer Price Index
DCC	Dynamic Conditional Correlation
EIA	Energy Information Administration
ETC	Energy Transitions Commission
ETF	Exchange Traded Fund
EUR	The Euro
EXR	Exchange Rate
Fed	Federal Reserve
FEM	Fixed Effect Model

FTSE	Financial Times Stock Exchange
GBP	Great British Pound
GHS	Ghanaian Cedi
GSS	Ghana Statistical Service
GOP	Gold Price
GP	Gasoline Price
IMF	International Monetary Fund
IPS	Im, Pesaran & Shin
IR	Inflation Rate
ITA	International Trade Administration
JPY	Japanese Yen
LLC	Levin-Lin & Chu
MAE	Mean Absolute Error
MAPE	Mean Absolute Percentage Error
MIDAS	Mixed Data Sampling
NBS	National Bureau of Statistics of China
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of the Petroleum Exporting Countries
PBC	People's Bank of China
POLS	Pooled Ordinary Least Square
RBA	Reserve Bank of Australia
REM	Random Effect Model
RMSE	Root Mean Squared Error
SDG	Sustainable Development Goals
USD	United States Dollar

VIF	Variance Inflation Factors
WB	World Bank Group
WGC	World Gold Council
WTI	West Texas Intermediate

ABSTRACT

Gold is a dense, thick, lustrous, heavy metal, known for its value throughout history. However, due to recent geopolitical upheavals—such as the Covid-19 pandemic, the Russia-Ukraine war, and the Israel-Gaza conflict—gold prices have been highly volatile amid global economic instability. Therefore, the research objective of the study is to explore how the commodity factors and macroeconomic factors affect gold price in five gold producing countries such as Australia, Canada, China, Ghana, and the United States. The data were used as the panel data from 2014 to 2023, and the total observation of the study is 300 observations. A Cross-Section and Period Fixed Effect Model was selected for this study and inflation rate, consumer price index, and crude oil price revealed significant short run relationships with gold price at the 0.10, 0.05 and 0.01 level, respectively. Based on Granger Causality analysis, exchange rate, gasoline price, inflation rate and crude oil price were the long run relationships with gold price in the study. Gold price has unidirectional analyses with exchange rate, gasoline price, and inflation rate whereas crude oil price and gold price have bidirectional analysis. Both the short run and long run analyses suggested that crude oil price is most significant in the study. The novelty of the study is based on the actual data and ex-post forecast data of the five countries; it is discovered that all five countries showed an increasing trend in gold price. Hence, this study provided insights for policymakers and investors that crude oil price may be a primary tool when forecasting gold price.

Keywords: Gold Price, Panel Model, World Gold Producing Countries, Volatility

JEL Classifications: C23; C58; E44; G15; Q02; Q31

CHAPTER 1: INTRODUCTION

1.0 Introduction

This study discusses "Exploring a Model for Volatility of the Gold Price among the World Gold Producing Countries", followed by the research background of the study, the current situation and the problem statements of the study. Furthermore, this chapter proceeds with the research questions and research objectives of the study, the significance of the study, the chapter layout of the study, and the conclusion of the study.

1.1 Research Background

Gold, or the scientific name "Au", is solid and thick, like a dense and lustrous yellow precious metal. Known for its beauty, durability, malleability, and rarity, gold has held immense value throughout history (Britannica, 2025). It's one of the densest metals, an excellent conductor of heat and electricity, and highly malleable—an ounce can be beaten into a sheet of 187 square feet. Historically significant for its role in crafting jewellery, coins, and decorative objects, gold's economic importance surged with the gold standard in the 19th century, though its official monetary role ended in the 1970s. Found in low concentrations in the Earth's crust, gold often occurs in hydrothermal veins and placer deposits. Significant gold highest production has come from various regions including South America, Russia, the United States, and Australia, with China leading in the early 21st century. Alloys

of gold are used to enhance its hardness for practical use in jewellery and coinage, with its purity measured in karats (Britannica, 2025).

Figure 1.1: Gold Production Countries in 2015
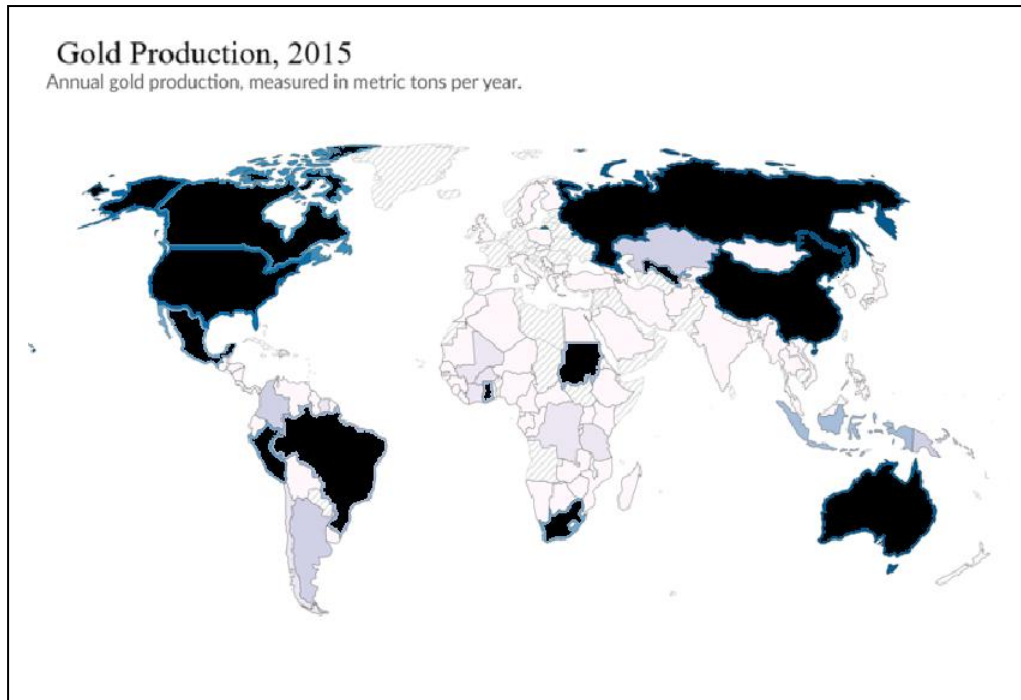
Source: (Ritchie & Rosado, 2017)

Figures 1.1 shows the region of the gold production in 2015. China leads the gold production industry at 450 metric tons, followed by other major countries like the United States with 214 tons, Australia with 278 tons, Canada with 153 tons, Russia with 252 metric tons, and South Africa with 145 tons. Argentina, Brazil, Indonesia, and Chile also produced gold, but it did not pass the 100-ton threshold (Ritchie & Rosado, 2017).

Figure 1.2: Gold Deposits around the Globe
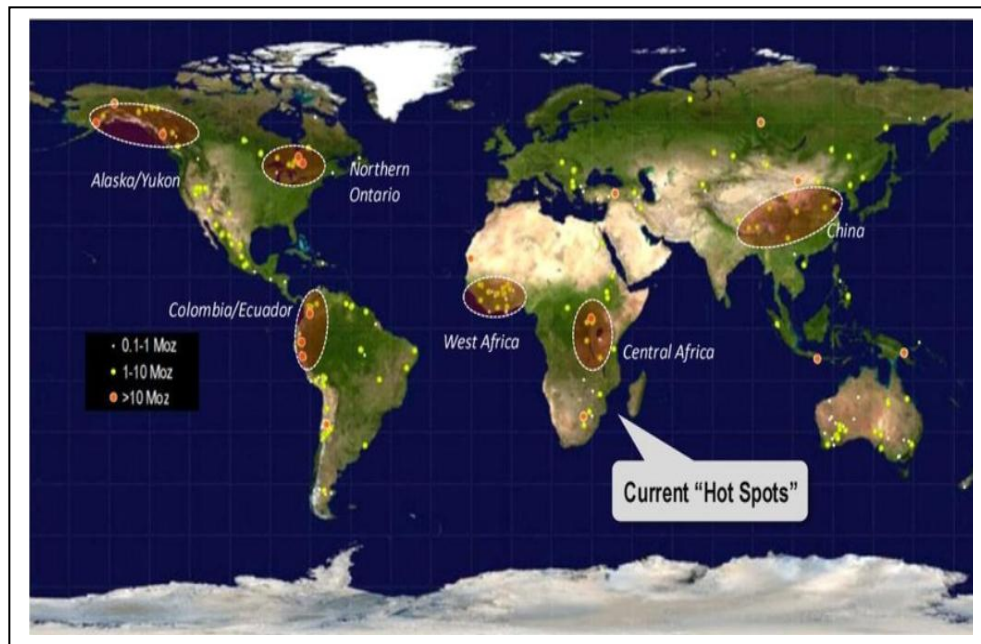
Source: (Schodde, 2011)

Figure 1.2 illustrates gold deposits from around the globe. It is differentiated into three colours that represent how much of gold had been mined at the local area. Those with an orange indicator includes Alaska, Northern Ontario, Columbia, West Africa, Central Africa, and China which means that mass mining and highest production of gold had taken place there. The second colour is a big yellow dot that represents a moderate amount of gold production had taken place there. Countries that have the big yellow dots are Australia, parts of Russia, Peru, and Mexico. The last colour is a small yellow dot indicating a low gold production. The countries with the corresponding small dots are parts of Russia, Argentina, and Cuba (Schodde, 2011).

Figure 1.3: Gold Production in 2023

Source: (World Gold Council [WGC], 2020)

Figure 1.3 shows the highest gold producing nations in 2020, with China taking the lead at 368.3 metric tons (as shown in dark yellow colour); followed by Russia with 331.1 tons, Australia with 327.8 tons, and the United States with 190.2 tons (as shown in yellow colour); Canada with 170.6 tons, Ghana with 138.7 tons, Brazil with 107 tons, Uzbekistan with 101.6 tons, Mexico with 101.6 tons, and Indonesia with 100.9 tons (as shown in bright yellow colour) (WGC, 2023).

Figure 1.4: % of Gold Production Volume in the World Market in 2022
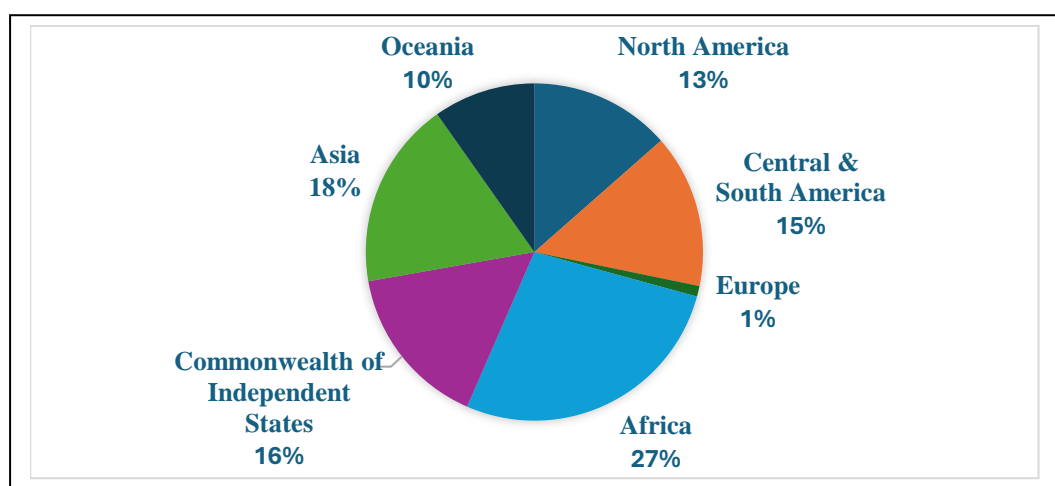
Source: (WGC, 2024)

Figure 1.4 shows the highest volume of gold production in 2022 in terms of continents in the world market. Except for Europe (36.9 tonnes), other continents had each produced 10% or more of gold, with Oceania contributing 10% (355.4 tonnes), North America contributing 13% (491.2 tonnes), Central and South America contributing 15% (535 tonnes), the Commonwealth of Independent States contributing 16% (569.8 tonnes), Asia contributing 18% (654.1 tonnes), and Africa contributing 27% of the world's gold (991.5 tonnes) (WGC, 2024).

Figure 1.5: Gold Price and Demand for Gold from 2014 to 2018
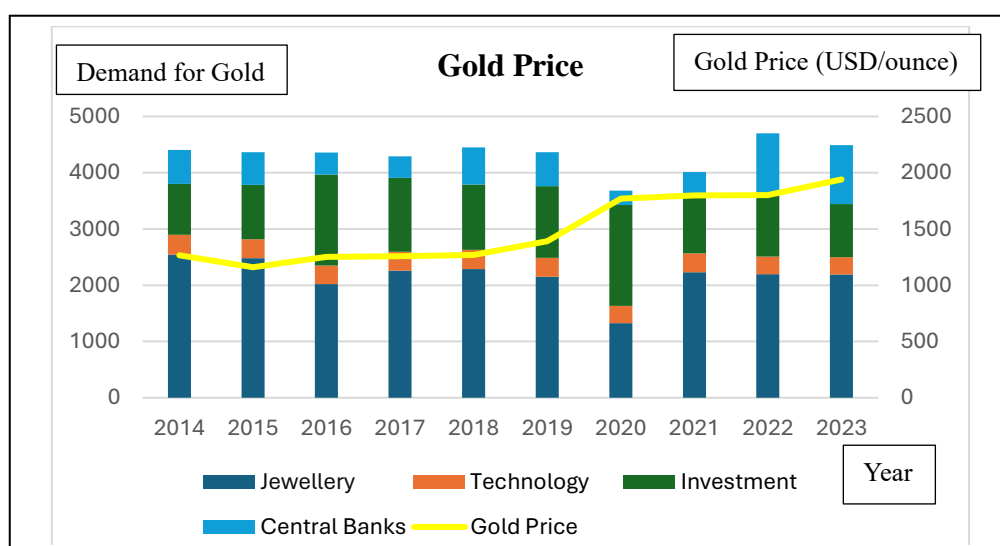
Source: (WGC, 2025)

Figure 1.5 shows what gold is used for internationally. Throughout 2014 to 2023, except for 2020, the usage for gold in jewellery (as shown in the purple bar) is the highest; and the least gold used is technology (as shown in the orange bar). Gold for investment and central bank purposes are strong throughout the years. In 2020, the pandemic caused investors to turn towards gold as a traditional haven asset (WGC, 2025).

Figure 1.5 also shows the demand and price for gold. Although demand for gold maintained relatively stable, as depicted by the horizontal bar graph, the price of gold had remained unpredictable, as depicted by the yellow line. This phenomenon provokes the thoughts of researchers as it contradicts with the traditional concept of

demand and supply, resulting in a price equilibrium. It may imply that other situations like economic uncertainty, political uncertainty, or geopolitical instability may be a cause of concern when discussing about gold price (WGC, 2025).

According to McFarlane (2023), a surplus of supply of gold compared to demand and changes in market mood are two factors that could cause gold prices to decline. Gold price can also be negatively impacted by low inflation, rising interest rates, and a strong dollar. Gold prices may decline when the economy is strong and expanding because investors may find stocks and other investments more alluring and decide to sell their gold holdings.

In reality, geopolitical events may also alter gold prices (Chiang, 2022). Market volatility can be brought on by geopolitical conflicts. Investors want gold for both pragmatic and emotional reasons, since it has long been considered a dependable store of value in uncertain times. Gold prices usually rise as a result of this increased demand. In the past, gold prices have increased during periods of conflict and war as investors look for reliable assets in the face of mounting uncertainty. For instance, gold prices rose by over 6% in a single day after the terrorist attacks of September 11, 2001, as investors shifted towards safer investments in response to the shock to global stability. The invasion of Ukraine by Russia in February 2022 caused a 10% increase in gold prices.

1.2 Current Situation of the Study

1.2.1 Gold Price

The current situation of the gold price in the world market in early June 2019 rose to $1,340 per troy ounce, the second-highest level in roughly a year, following an

earlier decline in August 2018 (Koh & Baffes, 2024). Strong demand from emerging market central banks, a breakdown in trade talks between the US and China, and increased prospects of an interest rate decrease by the US Federal Reserve have all helped to support prices. Hence, it was forecasted that gold prices are expected to rise by 3.2%.

2020 kickstarted with the global surge in gold price. Since COVID-19's economic effects, the price of gold has risen to an all-time high. Over the previous 14 months, spot gold prices have risen 53%, surpassing the record high of $1,920.30 an ounce set in 2011 to reach an all-time high of $1,943. According to analysts, gold's most recent gain was triggered by the decline in the rival safe-haven dollar, which caused the greenback to drop to a two-year low.

In 2021, due to a stronger dollar and concerns that the U.S. Federal Reserve would continue to raise interest rates, gold prices were on track to see their largest monthly loss since June 2021 (Reuters, 2023). Early in February, gold prices reached their highest level since April 2022, but they quickly fell back. Strong economic statistics raised anticipation of additional rate hikes, which caused the price of gold to drop more than 5% so far this month. However, Daniel Pavilonis, senior market strategist at RJO Futures, suggested that people can take advantage of these recent lows to purchase gold and go long term.

In 2022, Carlos (2022) provided justifications as to why gold prices have not increased in value. More risk and uncertainty have bolstered gold in 2022, with global tensions being the most evident source. Although not all investors have had the same perspective on the inflation risk, high inflation may have played a role. The most obvious example of this is the large discrepancy between the US CPI and the long-term inflation forecasts that the bond market suggests.

In 2023, gold prices had hit an all-time high of close to USD 2000 per ounce of gold. Sa (2023b) noted that 2023 is filled with a variety of considerations. Shortly after 2023 begins, in January, the price of gold soars to a six-month high. As the year progressed, analysts' predictions that the rally may rise even higher in 2023 didn't seem far off. However, this early January increase in the gold rate was primarily inspired by market volatility rising interest rates and high inflation brought on by the

Covid pandemic, in addition to the conflict in Ukraine; A potential downturn in the economy A 61% risk of a recession in 2023 was warned by economists; The demand for gold by central banks in Q1 was 34% larger than it had ever been.

Apart from that, the escalation of the Russia-Ukraine war, especially when Bakhmut, a significant city in Ukraine, was seized by Russian forces, paired with the banking crisis in Silicon Valley, had pushed gold prices higher. Also, for a brief period, gold prices rose to above USD 2,000 during the start of the Israel-Hamas war, a conflict in the Middle East. These events further solidify that geopolitical events could affect gold prices.

Figure 1.6: Gold Price from 2019 to 2023

Gold Price from 2019 to 2023

Gold Price (USD/ounce)

Australia   Canada   China   Ghana   United States   Year
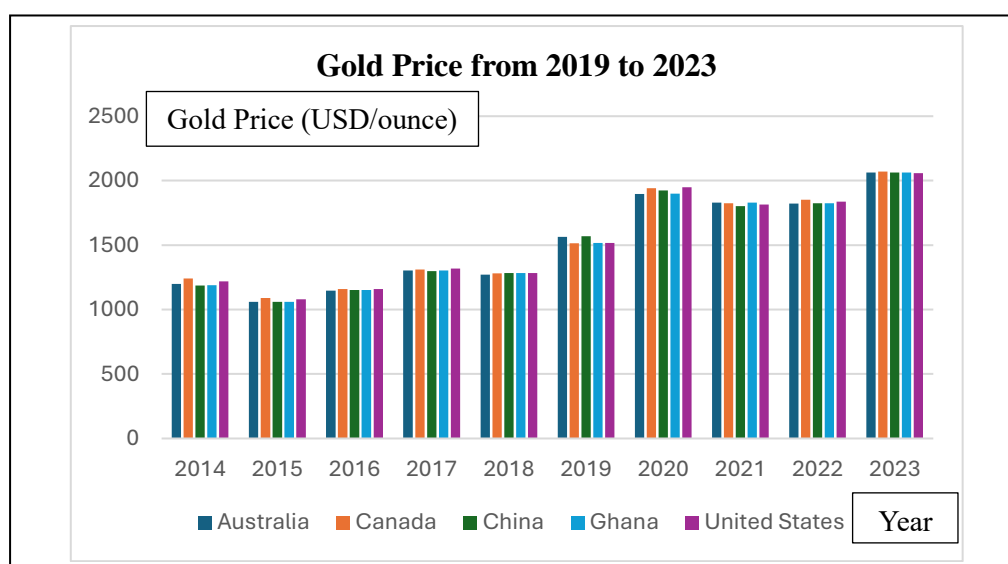
Source: (WGC, 2025)

Figure 1.6 shows the gold price between 2019 and 2023. The gold price in 2019 started at a relatively low price of below USD 1,400 in all countries and remained relatively stable until 2019. In 2020, the Covid-19 pandemic started, which caused a slew of actions by most governments. This indirectly increased gold prices to astronomical highs and continued to stay high. In 2021, although there was a slight decline in gold prices, it maintained relatively stable and increased in value. In 2022, the start of the Russia-Ukraine war was offset by the policies that will be implemented by the United States due to high inflation from the Covid-19 economic relief packages, which only increased gold prices minimally. 2023 started off with an increase in gold prices primarily due to the ongoing Russia-Ukraine war and the start of the Israel-Hamas war in the Middle East (WGC, 2025). Generally, the gold price as of 2023 are all above USD 2,050.

1.2.2 Gasoline Price

Gold price and gasoline price are positively related with one another (Syuhada et al., 2022). Gasoline is defined as a type of fuel processed from the extraction of crude oil or other petroleum products. It is widely used in the combustion of motor engines in vehicles that can include motorcycles, boat engines and aircraft engines. Extracting gasoline from crude oil is a rather complicated process as it requires distilling the crude oil into different types of products, each with their own uses (U.S. Energy Information Administration (EIA), 2023).

In 2020, Sanicola (2021) explained why gasoline prices have risen tremendously. To lower prices after The Organization of Petroleum Exporting Countries (OPEC) producers consistently disregarded pleas for additional gasoline, U.S. President Joe Biden's administration stated Tuesday that it will release millions of barrels of oil from strategic reserves in cooperation with China, India, South Korea, Japan, and Britain. He has become frustrated after repeatedly requesting more oil from the OPEC and its partners, or OPEC, but receiving little answer.

In 2021, the gasoline prices rose due to a list of different reasons (Energy Transitions Commission (ETC), 2022). The reasons can be an earlier winter season in the northern hemisphere, which was expected to exhaust gasoline storage levels by up to 33%, demand of gasoline had increased exponentially as the Covid-19 pandemic restrictions are lifted, banning of coal as an energy source by Europe, and the carbon tax accompanied with the ban, resulting in a higher prioritization on gasoline resources. A lower-than-expected wind output had also reduced renewable energy sources, causing large energy-consuming countries like China and the United States to turn to gasoline to fuel their energy needs.

2022 was an unpredictable year for gasoline prices (Isidore & Hickey, 2022). At the start of the turmoil in February, the price of crude oil skyrocketed due to Russia's

invasion into Ukraine, diverting manpower into the war, and the economic sanctions that it imposed on Russian oil. Furthermore, US drivers were not immune to a surge in gasoline costs, even though a small amount of Russian crude oil was ever shipped to US refineries. Both when and right before the pandemic shook the oil markets, prices were substantially more erratic in 2022 than they had been in previous years.

The average prices in June reached higher than expected, before slowly sliding down and stabilizing. This was brought on by a number of factors, such as the US Strategic Petroleum Reserve's oil spill, worries about a potential global and US recession, and an increase in Covid cases that resulted in new lockdowns in Asia. In 2023, consumers in the United Staes are greeted with glee as gasoline prices dropped consecutively for 2 months (Egan, 2023b).

Europe had also demonstrated strong resilience against Russian oil (Nakhle, 2025). By reducing its reliance on Russian natural gas, the European Union has managed to prevent the gasoline shortages and blackouts that many people were afraid of at the worst of the energy crisis last year.

Figure 1.7: Gasoline Price of Australia, Canada, China, Ghana and the United States from 2019 to 2023
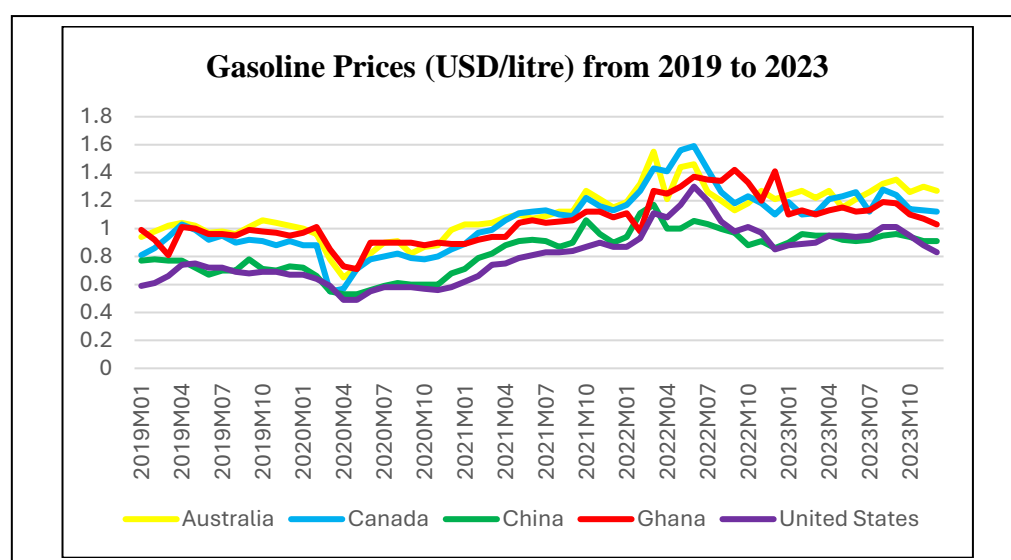
Figure 1.7 shows the gasoline prices in USD per litre of Australia, Canada, China, Ghana, and the United States from 2019 to 2023 in USD per litre. All the gasoline prices follow a similar trend over the years; a dip happened in 2020 as countries

initiate lockdown procedures all over the world, causing gasoline prices to drop by about 20 cents a litre; and gasoline prices surged in between April to July 2022 because of the shortage in gasoline prices, increasing gasoline prices to 1 USD per litre across all countries. Thus, gasoline price trend has a similar trend with gold price (TRADING ECONOMICS, 2024).

1.2.3 Exchange Rate

Exchange rate is correlated with commodity prices, especially during the times of crises (Hussain et al., 2023). Exchange rate means the price of a currency relative to the price of another currency. Normally, the U.S. Dollar (USD) would be used as a form of international currency due to its strong geopolitical position, the stable value of the greenback, and the size of the U.S. market (Siripurapu & Berman, 2023).

According to the Reserve Bank of Australia (RBA) (2025), there are fixed exchange rate and floating exchange rate. Supply and demand forces for foreign exchange often determine exchange rates under a floating regime. The major currencies of the world, including the US dollar, the euro of the euro area (EUR), the Japanese yen (JPY), and the pound sterling of the United Kingdom (GBP), have been operating under floating exchange rates for a long time. A fixed exchange rate aims to maintain a currency's value within a specific range by linking the official currency exchange rate of a nation to the currency of another nation or the price of gold (Majaski, 2024).

In 2020, the Covid-19 pandemic had impacted countries around the world. Hence, the exchange rates of all countries depreciated (Bank of Canada (BOC), 2020). In 2021, both Australia and Canada had showed stable exchange rate changes against the greenback partly because of stabilizing economic factors and policy measures. They both benefited from strong commodity prices which supported foreign inflows (BOC, 2021) (RBA, 2021).

China, on the other hand, faced a slight depreciation primarily due to a mixture of economic and policy-related factors. While China maintained a firm stance to fuel economic growth, the Federal Reserve tightened the monetary policy (Federal Reserve (Fed), 2021) (Chen et al., 2022). Ghana also experienced a higher exchange rate against the United States because of internal causes. Ghana had a wider trade deficit because of a higher import cost, increasing USD and decreasing the demand for the Ghana Deci (GHS); the tourism industry is also affected by the Covid-19 pandemic. (Bank of Ghana (BoG), 2021).

In 2022, Ghana further depreciated against the USD as the account deficit further worsened, causing more investors to favour the USD (International Trade Administration (ITA), 2022). On the other hand, Australia, Canada and China stabilised their economy and it led to a sturdy exchange rate against the USD. Australia and Canada had a surge of global demand in commodity prices like oil and natural gas, which lead to favourable conditions (BOC, 2022) (RBA, 2022); China also leveraged the global demand by producing manufactured goods into the world market (People's Bank of China (PBC), 2022).

In 2023, Australia, Canada, and China continued to gain from global demand in crude oil and natural gas, so did their economy (BOC, 2019) (Organization for Economic Cooperation and Development (OECD, 2019). Although China had felt some pressure from the trade war, it is offset by the growth in the Chinese economy (IMF, 2019). Canada had a stable exchange rate against the United States because there is no major changes in their internal structures. Ghana, however, did noy have a favourable exchange rate with the United States. Apart from the wider gap in trade deficit (World Bank, 2023), Ghana had also experienced high inflation (BoG, 2023) and rising debts (IMF, 2023).

From 2020 to 2023, the United States had raised interest rates, except for 2020 (Wang & Li, 2023). Right after the pandemic, the Federal Reserve devalued the USD, which make the USD less attractive (IMF, 2021). As the United States increased the interest rates back, the greenback had received many investments (OECD, 2023).

Figure 1.8: Exchange Rate of Australia, Canada, Ghana and China from 2019 to 2023

Exchange Rates based on USD from 2019 to 2023
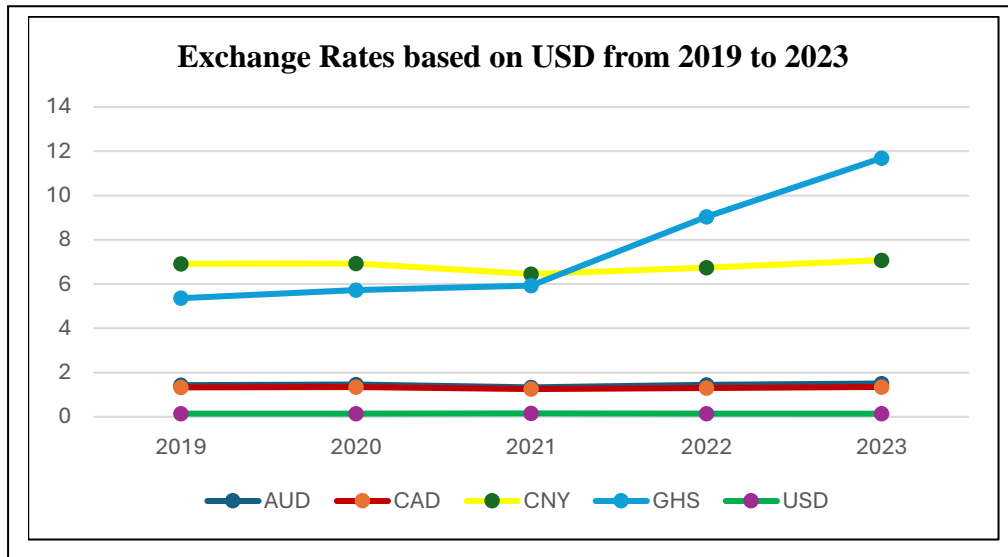
Source: (Exchange Rates ORG, 2025)

Figure 1.8 shows the exchange rate of Australian Dollar (AUD) for Australia, represented with a dark blue line, Canadian Dollar (CAD) for Canada, represented with a dark red line, Chinese Yuan (CNY), represented with a yellow line, and Ghanaian Cedi (GHS) for Ghana, represented with a light blue line. The exchange rates of AUD and CAD remained relatively stable and consistent against the USD at a range of 1.3 for CAD and 1.42 for AUD. The CNY also had a stable exchange rate of around 6.8 CNY for every USD. Only GHS had an upward trend, reaching 11 GHS per USD. For USD, the study uses 1 CNY equals to how many, which in this case, is around the 0.14 to 0.15 USD per CNY. Therefore, exchange rate can have a profound impact with gold price changes.

1.2.4 Inflation Rate

The GDP implicit deflator's annual growth rate, which measures inflation, indicates how quickly prices are changing across the board. The ratio of GDP in constant

local currency to GDP in current local currency is known as the GDP implicit deflator (World Bank, 2024). Inflation rate has a positive and significant relationship with gold prices (Binh, 2024).

According to the IMF (2021), the global economy is expected to increase 5.5 percentage points in 2021 and an additional 4.2 percent in 2022, despite extraordinary uncertainty. Expectations of a vaccine-driven uptick in productivity later in the period and more policy assistance in a few major nations have led to a 0.3 percentage point increase in the 2021 prediction compared to the previous one.

This year's anticipated economic recovery comes after a sharp decline in 2020 that had a particularly negative effect on those working in the informal economy, and those employed in contact-intensive industries. 2020 is expected to have a global growth drop of -3.5 percent, which is 0.9 percentage points more than the prior forecast. Depending on factors like being exposed to cross-country spillovers, the efficacy of governmental support, the availability of medical interventions, and structural features prior to the crisis, the degree of success of the recovery is expected to differ greatly between nations. (IMF, 2021)

In 2022, the world economy is worse than anticipated as 2022 approaches (IMF, 2022). Countries have reinstated mobility restrictions in response to the spread of the novel Omicron COVID-19 strain. Higher and more widespread inflation than expected has been caused by higher prices for energy and supply disruptions, particularly in the US and many emerging economies and developing nations. Growth prospects are further restricted by the layoffs in China's real estate industry and the slower-than-anticipated rebound of private spending.

At the end of February, unprecedented events occurred as Russia invaded Ukraine (IMF, 2022b). The conflict's economic costs will raise inflation and cause a notable slowdown in global economy in 2022. Rapid increases in the cost of food and fuel have disproportionately affected low-income countries' most vulnerable populations. According to projections, global growth will decrease from an estimated 6.1 percent in 2021 to 3.6 percent in 2022 and 2023. In comparison to the January projection, this is 0.8 and 0.2 percentage points lower for 2022 and 2023.

In 2023, from a predicted 3.4 percent in the end of 2022 to 2.9 percent in 2023 and then to 3.1 percent in 2024, global growth is expected to decline (IMF, 2023). Economic activity is still being impacted by Russia's war in Ukraine and the increase in central bank interest rates to combat inflation. Growth in 2022 was slowed by the rapid onset of COVID-19 in China, but a quicker-than-expected recovery has been made possible by the recent reopening. Global inflation is predicted to decline from 8.8% in 2022 to 6.6% in 2023 and 4.3% in 2024, but it will still be higher than the roughly 3.5 percent pre-pandemic levels in 2017–2019.

Figure 1.9: Inflation Rate of Australia, Canada, China, Ghana, and the United States
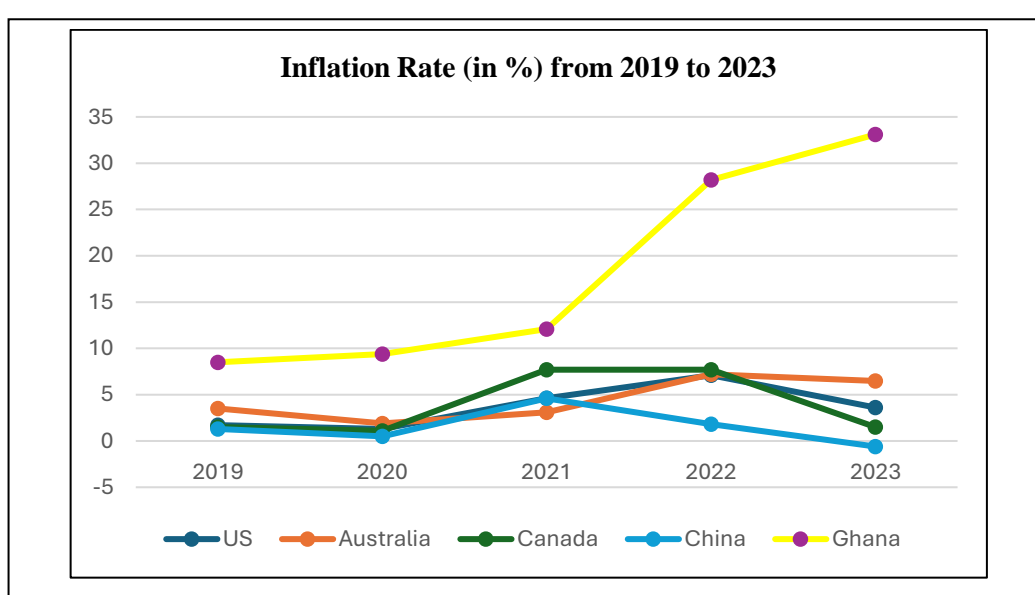
Source: (World Bank, 2025)

Figure 1.9 shows the inflation rate in percentage of Australia, Canada, China, Ghana, and the United States from 2019 to 2023. From 2019 to 2021, the inflation rate of the countries has moderate inflation of about 1% to 3%, with Ghana higher at around 8%. In 2021, a lot of countries experienced a spike in inflation rate except for Australia. After 2021, Ghana had the most inflation rate with 33.1% inflation in 2023, while other countries stabilised back to pre-pandemic levels (IMF, 2023). Hence, inflation rate is known to show significant similarities and tendencies with gold price.

1.2.5 Consumer Price Index

Consumer Price Index (CPI) has a high correlation with gold price volatility (Y. Wu, 2025). There are slight differences between consumer price index and inflation rates. The change in the cost of a basket of goods and services that particular family groups usually buy is also known as CPI (OECD, 2023). An estimate of the period-to-period proportional change in the prices of a fixed set of consumer products and services of constant quantity and characteristics that are purchased, utilised, or paid for by the reference population is called a consumer price index. According to Statista (2024), In February 2022, the worldwide consumer price index inflation rate was 7.47 percent; in March 2022, it was 9.22 percent. The rate of inflation has been rising slowly since August 2020, when it dropped to 2.27 percent, with the fastest growth taking place in the latter stages of 2021 and early 2022.

In 2020, Consumer prices increased 1.4% for all categories between 2019 and 2020 (U.S. Bureau of Labor Statistics (BLS), 2021). Canada however, experienced slower growth than anticipated (Government of Canada & Statistics Canada, 2021). After increasing 1.9% in 2019, the CPI increased 0.7% on an average yearly basis in 2020. The CPI increased in 2020 at the slowest rate since the economic slump in 2009.

In 2021, the United States reported an increase in consumer goods and services (BLS, 2023). There was also a 1.9% increase in the CPI of Australia (Australian Bureau of Statistics (ABS), 2023). The CPI increased by a noteworthy 7.8% in the 12 months preceding the December 2022 quarter. The CPI saw a 0.9% increase in 2021 in Australia (ABS, 2021). Among the various categories, tobacco experienced the most significant price rise, with a 10.9% increase, while electricity had the most notable price fall, decreasing by 7.5%. In China, the Consumer Price Index of China increased by 5.4 percent in January 2020 compared to 5.1 percent in urban areas and 6.3 percent in rural areas (National Bureau of Statistics of China (NBS), 2020).

After increasing 3.4% in 2021, the CPI of Canada increased 6.8% on a yearly average basis in 2022 (Government of Canada & Statistics Canada, 2023). In 2022, price rises were widespread, with all eight major components seeing average yearly

price increases. China had a lower increase in CPI (NBS, 2023). China's CPI rose 1.8% year over year in December 2022, with price increases in both rural and urban areas being equal.

Ghana, on the other hand, had a tremendous increase in CPI (Ghana Statistical Services (GSS), 2023). As of December 2022, the inflation rate for food and beverages that are not alcoholic was 59.7% year over year. In December 2022, the non-food group's inflation rate was 49.9% year over year.

Table 1.1 Consumer Price Index (CPI) of Australia, Canada, China, Ghana and the United States from 2019 to 2023 (base year = 2012)

Year	Countries				
	Australia	Canada	China	Ghana	United States
2019	119.8	116.8	125.1	278.5	117.2
2020	120.8	117.6	128.1	306	118.7
2021	124.3	121.6	129.4	336.5	124.3
2022	132.5	129.9	131.9	441.7	134.2
2023	139.9	134.9	132.2	610	139.7

Source: (OECD, 2023)

Table 1.1 shows the Consumer Price Index (CPI) of Australia, Canada, China, Ghana and the United States from 2019 to 2023 using 2012 as a base year. Except for China and Ghana, Australia, Canada and the United States had a CPI increase of more or less 20 points from 2019 to 2023. The two outliers are China, with an increase of CPI points of less than 10, and Ghana with an increase of CPI of above 300 points. Therefore, CPI also shows a trend in tandem with gold price trends.

1.2.6 Crude Oil Price

Crude oil prices have a significant link with gold price volatility (Li & Du, 2023). According to Kopp (2024), crude oil or fossil fuel can be any form of hydrocarbon that in the Earth's crust that can be used as a type of non-renewable energy. Crude oil prices rose in 2021 as a result of a booming economy, lessening pandemic-related limitations, and rising COVID-19 vaccination rates, which caused global petroleum demand to outpace supply (EIA, 2022a). Prices rose as a result of the world's petroleum production growing more slowly than demand. The OPEC crude oil production cuts, which began in late 2020, were largely to blame for the slower growth in production.

From January to June of 2022, the Brent crude oil price generally increased, while the second half saw a general fall (EIA, 2023a). Similar trends were seen in the spot price of West Texas Intermediate (WTI), the standard price for U.S. crude oil. Low global crude oil stockpiles and Russia's invasion of Ukraine combined to push the price of crude oil in 2022 to its most prevalent inflation-adjusted level since 2014, that occurred on March 8, 2022.

Crude oil price of the United States further decreased in 2023 (EIA, 2024a). Following the EU's prohibition on importing Russian crude oil and crude oil related products, multiple interest rate hikes by central banks around the world, and worries about inflation and the recession, crude oil prices varied in the first six months of 2023. However, compared to 2022, when prices hit multi-year highs due to Russia's full-scale invasion of Ukraine, Brent crude oil prices were noticeably less volatile in the first half of 2023. Geopolitical tensions and worries about the demand for crude oil led to larger price swings in the latter half of 2023 (EIA, 2024a).

Figure 1.10: Crude Oil Prices of Australia, Canada, China, Ghana and the United States from 2019 to 2023
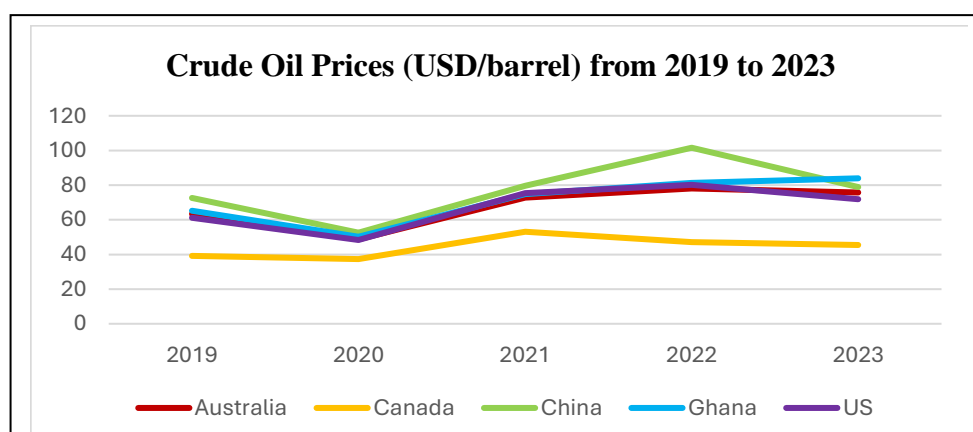
Figure 1.10 shows the crude oil price of Australia, Canada, China, Ghana, and the United States. In 2020, crude oil prices across countries dropped due to surplus in crude oil; in 2022, crude oil prices increased as countries opened up their economies. Compared to U.S. crude like West Texas Intermediate, Canadian crude—especially from Alberta's oil sands—is frequently heavier and has a higher sulphur content, which makes it less valuable and more costly to refine (CAPP, 2021). Hence, the price of crude oil in Canada is lower than average. To conclude, crude oil prices have significant correlation with gold price volatility. Generally, crude oil price of all countries has increased slightly from 75USD per barrel in 2019 to 100 USD in 2022 and stabilised back to about 80 USD per barrel.

1.3 Problem Statements

According to the WGC (2024), gold is an essential component of a well-diversified portfolio and a strategic long-term investment. By keeping a long-term allocation and leveraging gold's role as a safe haven during uncertain economic times, investors have been able to acknowledge a large portion of its value over time. One of the reasons for the attractiveness of gold is the consistent return for gold. Gold has always been seen by investors as a valuable investment in uncertain times. It is known to yield long-term gains during both prosperous and struggling economic periods.

However, gold is not as stable is price as first thought (Mahesh, 2024). Gold prices may continue to fluctuate in the near future despite tailwinds since they could be influenced by any significant volatility in risky assets. Therefore, specific objective (1) is to identify the factors affecting the volatility of the gold price among the world gold producing countries, including Australia, Canada, China, Ghana and the United States.

One of the reasons for choosing gasoline price is due to the process in which gold is produced (Spooner, 2021). Everything in society is impacted by the price of energy (gasoline), particularly gold and other precious metals. The price of gold and oil have been correlated 80% of the time during the past 50 years. However, no empirical evidence was discovered as published by Huseynli (2023). Huseynli (2023) claimed that gold prices had a Granger cause to gasoline price but not the other way around.

Next for gold price volatility is the exchange rate, especially the United States dollar. Before the Covid-19 pandemic, the link between gold and the USD is one of the most closely watched in the field of finance; Though historically believed to be heading in the opposite direction, new study shows that this dynamic is much more complex than previously believed (Ghanbari et al., 2022).

The third factor is inflation rate (Wu, 2024). Investor mood has been found to be the primary driver of the correlation between gold prices and inflation, according to Sean Mason, a spokesperson for Fresno Financial Advisors. People rush to gold when they fear inflation, prior to the dollar's value declining. This influence has been magnified by recent worldwide trends.

In addition, consumer price index may play a role in the volatility of gold price (Carpantier, 2021). The real Consumer Price Index's deflated price of gold has risen to its highest levels since July 2020 due to gold's current surge. Interest in gold as a general portfolio diversifier and, most likely, as an inflation hedge in particular has increased as a result of this recent high. An inflation hedge ought to fluctuate in tandem with inflation. The hedge should increase in value when inflation does. Thus, it is possible to test the idea that gold protects against inflation.

Thus, it is crucial for this study to not only understand what short run relationships gasoline price, exchange rate, inflation rate, consumer price index, crude oil price have on gold price but also comprehend the long run relationship between gasoline price, exchange rate, inflation rate, consumer price index, crude oil price and gold price. Therefore, specific objective (2) is to estimate the long run and short run relationships among gasoline price, exchange rate, inflation rate, consumer price index, crude oil price, and gold price among the world gold producing countries.

Lastly, the research gap of the study is one of the factors influencing the volatility of gold price can be crude oil price (Xu et al., 2024). Because they represent trends in the larger economy and operate as standards for a variety of economic activity, both commodities are vital to the global economy. According to researchers at Bernstein (2024), the oil-to-gold ratio, which calculates how many barrels of oil one ounce of gold can buy, has averaged about 19 barrels per ounce over the previous 160 years, with a standard deviation of eight barrels per ounce.

Ali et al. (2024) had provided insightful knowledge to oil prices and gold prices on the housing market in China. This article is useful for the study because it uses gold price, oil price, and real income as independent variables to determine whether it affects China's housing market. An increase in gold price results in a reduce in the housing prices, implying that the local population still prioritizes gold over any other assets. Also, the authors tested short run and long run interrelationships between the variables. Therefore, this study shares the knowledge gap of how the gold price reacts when multiple countries are having their respective macroeconomic issues.

Khan (2024) is also a good article as it dives deeper into the fluctuation of gold prices in the Saudi Arabian market. The article provided many knowledge gaps to the study by using an ARIMA model to accurately forecast the gold price of the domestic market. After understanding the article, this study utilises a panel data model for the five gold producing countries in the world. Therefore, specific objective (3) is to predict the ex-post forecast simulation of gold price in each country based on the model forecasting accuracy criteria of the study. Hence, developing a model for gold price volatility among gold-producing countries can enhance economic stability by enabling better fiscal planning and risk management, as accurate price forecasts help governments mitigate revenue fluctuations and design effective diversification strategies (Tarchella et al., 2023). Such a model can also inform policies to attract foreign investment and ensure long-term economic resilience (Bunnag, 2024).

1.4 Research Questions

1. What are the effects of the macroeconomic variables like gasoline price, exchange rate, inflation rate, consumer price index and crude oil price have on the volatility of the gold price in the world market?

2. How are the long run and short run relationships among gasoline price, exchange rate, inflation rate, consumer price index, crude oil price, and gold price?

3. What is the prediction of the future of gold price using the forecasting accuracy criteria for simulations conducted ex-post?

1.5 Research Objectives

The research objectives cover two parts, which are differentiated the general research objectives and the specific research objectives.

1.5.1 General Research Objectives

General Research Objectives

To develop a model for the volatility of the gold price among the world gold producing countries, including Australia, Canada, China, Ghana and the United States.

1.5.2 Specific Research Objectives

Specific Research Objectives

1. To identify the factors affecting the volatility of the gold price among the world gold producing countries, including Australia, Canada, China, Ghana and the United States.
2. To estimate the long run and short run relationships among gasoline price, exchange rate, inflation rate, consumer price index, crude oil price, and gold price among the world gold producing countries.
3. To predict the ex-post forecast simulation of gold price in each country based on the model forecasting accuracy criteria of the study.

1.6 Significance of Study

The significance of the study will be divided into two parts, the theoretical significance of the study and the empirical significance of the study.

1.6.1 Theoretical Significance of Study

The study will revolve around three fundamental theories, which are the theory of demand, the theory of supply, and the equilibrium point between the demand and supply. In the price theory and applications textbook by Parkin (2022), the author revealed that demand is from the perspective of the consumer. Through demand, economists can understand how much of a good or service the people need when price is at a certain

level. The theory of demand is always downward sloping, with the horizontal axis being quantity demanded and the vertical axis being demand for a good or service. Normally, as the prices are high, demand for that good will be low and vice versa.

The next theory is the theory of supply. According to Mankiw (2023), theory of supply is from the point of view of the producers. The theory of supply lets economists comprehend the relationship between prices and quantity supplied. The theory of supply, on the other hand, is typically upward sloping given that there are no hypothetical markets, with the horizontal axis labelled quantity supplied and the vertical axis labelled price of the good or service. Typically, as prices are low, supply for that good or service is also low because suppliers have no motives to capitalise on profits. On the flip side, if prices are high, producers would try to maximise profit by producing as much good as possible.

The third theory is the equilibrium point between supply and demand (Landsburg, 2023). Prices cannot be determined only by the Law of Supply and Demand. Therefore, the demand and supply curves would be intercepted to create an equilibrium point. When supply and demand factors are in balance, an equilibrium point is formed that may precisely determine the quantity and price of an item or service. This is known as an equilibrium point.

1.6.2 Empirical Significance of Study

Empirical wise, many articles can be reviewed to analyse gold price and inflation rate. One such article is by Aqilah & Dini (2024), where they determined if gold and interest rate has any linkages among them. Supported by this article, their study accurately forecasted gold prices with interest rates as the independent variable. Another article that can support positively significant relationships between inflation rates and gold prices are published by Mainal et al. (2023). In their report, inflation rate has a significant positive impact with gold prices.

The next variable that can be considered is gasoline price. It is widely considered that gasoline price has a positively significant association with gold price. The article that can support this association is the article by Joo and Park (2024). In their article, they wondered if Bitcoin is a better hedge against other hedging tools. They found out that gas price and gold price is the better tool against inflation, solidifying that gas price and gold price has a positive link.

The third variable that can explain a positive and significant correlation between gold prices are exchange rates. This can be bolstered by an article published by Boateng et al. (2024). In the article, they addressed if macroeconomic variables like exchange rates have any connections with commodity prices. They noted significant long term and short-term relationships between commodity prices, exchange rates, and inflation rate in Ghana.

The fourth variable is inflation rate. Past studies have shown that inflation rate move parallel and with statistical significance with gold prices, and there are articles supporting such movements. An article by Ergül and Karakaş (2024) examined whether gold prices and inflation rate have positive and significant effects. They realised through estimations that inflation rates influence gold prices positively.

The fifth variable is consumer price index (Ojaghlou & Satvati, 2021). Consumer price index is one of the tools for inflation rate, and ample articles suggest a positive and significant relatedness between consumer price index and gold price. Similar with inflation rates, when consumer price index increases, gold price will increase, which is consistent with what Ojaghlou and Satvati (2021) discovered.

The sixth variable is crude oil price. An increase in crude oil price tend to significantly increase gold prices as well. According to Yusoff et al. (2024), crude oil price is primarily seen as a basic necessity for other products. Hence when there is boost in crude oil price, it may increase the price of all commodities. Thus, investors will set their sights on gold, increasing gold prices.

1.7 Chapter Layout

There are five chapters in the study that will be discussed holistically:

Chapter 1: Research Overview

The first chapter provides a comprehensive overview of the study. It started with the introduction of the title, which is "Developing a Model for the Volatility of the Gold Price among the World Gold Producing Countries", followed by the research background, and the current situation of the study. Next, this chapter also discussed the problem statement, research problems, research objectives, and significance of the study. Lastly, the chapter layout was provided for the study.

Chapter 2: Literature Review

Chapter 2 will cover the relevant theories regarding gold prices. The reviews will start based on underlying theories that determine gold prices. Then, empirical reviews will be analyzed to establish any relationships between the chosen independent variables and dependent variables. Lastly, a suitable panel data model will be presented.

Chapter 3: Research Methodology

Chapter 3 covers the conceptual framework forming the dependent variable, and the hypotheses developments for the independent and dependent variables. Then, data from the independent and dependent variables will be extracted according to renowned and verified sources. Chapter 3 also covers the research methods, residual diagnosis analysis, model evaluations, data analysis and conclusion of the chapter.

Chapter 4: Data Analysis and Results

Chapter 4 will present the data analysis and empirical estimates of the study. The chapter will also discuss descriptive and preliminary analysis, research output models for panel data models, and model evaluations of the study.

Chapter 5: Discussion, Conclusion, and Implications

The entirety of chapter 4 will be brought to chapter 5 and discussed thoroughly. In addition, the study will discuss about the summary of the entire analysis, the discussions and major findings of the study, and the implications of the study. It will also discuss what are the limitations of the study, and suggestions for future scholars to further improve on the existing study.

1.8 Conclusion

To summarise, Chapter 1 provided the background of "Developing a Model for the Volatility of the Gold Price among the World Gold Producing Countries", followed by the current situation and problem statement of the study. Then, the research problems and research objectives were defined, and the significance of study, both theoretical and empirical studies will be explained closely. Lastly, the chapter layout will be provided and Chapter 1 ends with the conclusion of the study. In Chapter 2, the study will discuss the literature reviews, using both theoretical studies as well as empirical findings.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

This chapter will discuss the relevant literature reviews, which covers related theories applied in the formation of the volatility of the gold price model, as well as empirical evidence of how the independent variables affect the volatility of gold price in the real world. This chapter will present a comprehensive review of the independent variables affecting the volatility of gold price in the world gold producing countries.

2.1 Reviews of Theoretical Framework

It is of utmost importance that each and every study is supported and built by the fundamentals of theoretical models and framework. In this study, there are some vital theories that must be explored to understand the volatility of gold price. The theories are as follows, the theory of demand, supply and price and it will be further divided into two parts, which are the theory of quantity demanded and price, and the theory of quantity supplied and price.

2.1.1 Law of Demand Theory

Figure 2.1: Illustration of Law of Demand Theory
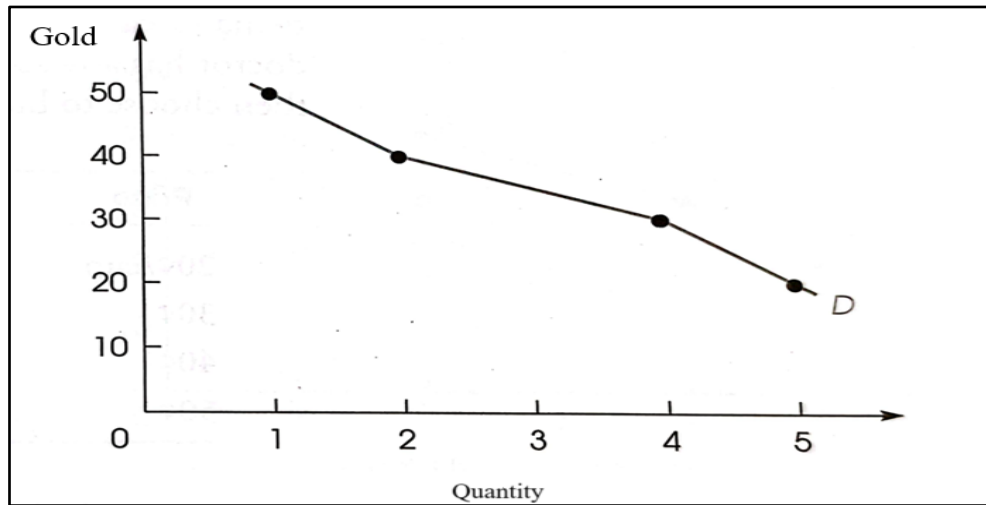
Source: (Landsburg, 2023)

According to Landsburg (2023), he explained about the price theory and applications in Figure 2.1. He also defined the law of demand that when there was an increase in price, consumers would demand less of a good or service, under the assumption of ceteris paribus. From a consumer's perspective, they think that an increase in price for that specific product was not affordable. The second reason there was a decrease in the demand for a product may also be due to the law of diminishing marginal utility (Parkin, 2022) in Figure 2.2. According to Parkin (2022), a utility can be defined as the satisfaction a person receives when he or she consumed a good or service.

Figure 2.2: Total Utility and Marginal Utility Theory
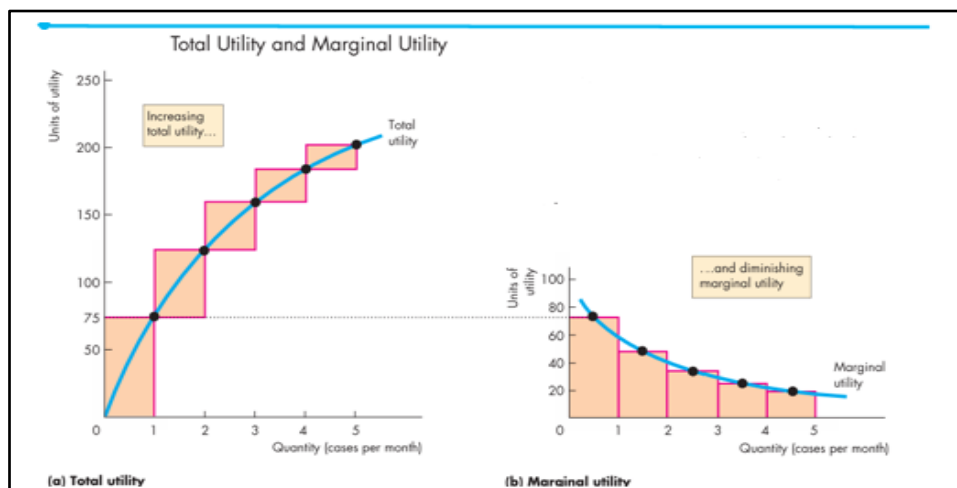
Since utility was based on personal preference, the utility of each person will be different. There are two methods for measuring utility, the first method is marginal utility, and the second method is total utility. Total utility is the total benefit that one can get from consuming a good or service while marginal utility changes in total utility resulting from a one unit increase in the consumption of a good or service. The law of diminishing marginal means that initially, there was an increase in the marginal utility of consuming a good or service, eventually, the marginal utility will decrease. Figure 2.1 shows the price and quantity of gold due to demand, and Figure 2.2 explains an example of total utility and marginal utility.

In addition, different external factors can affect the demand of a certain product, including gold (Mankiw, 2023). The external factors are income, price of related goods, tastes, and expectations. A higher income normally results in an increase in demand for goods and services; however, it also depends on which product the individual is buying. If income increases, the demand for a normal good would increase but demand for inferior products would decrease.

Next, prices of related goods also play a part in determining whether there will be an increase or decrease in demand for the product Landsburg (2023). If the related product is a substitute product, a price increase in the substitute product leads to an increase in demand for the product. If the related product is a complement product, a price increase in the complement product will lead to a decrease in demand for the product.

The third factor is tastes or preferences of the consumer (Parkin, 2022) Taking real life examples, if consumers have a taste or preference towards traditional inflation hedging tools, then the price of gold would increase; if consumers prefer a more novel inflation hedging tool, then the price of gold would slump as people would prefer Bitcoin as their inflation hedging tool.

Another factor is expectations (Mankiw, 2023). As consumers, if they expect gold prices to increase in the near future, they will demand more gold first, temporarily increasing the price of gold. Vice-versa, if consumers expect that gold prices will drop in the near

future, they will hold off on buying gold, decreasing gold prices. The consumers would wait until when gold prices drop in the future then they would buy gold.

2.1.2 Law of Supply Theory

Figure 2.3: Illustration of Law of Supply Theory
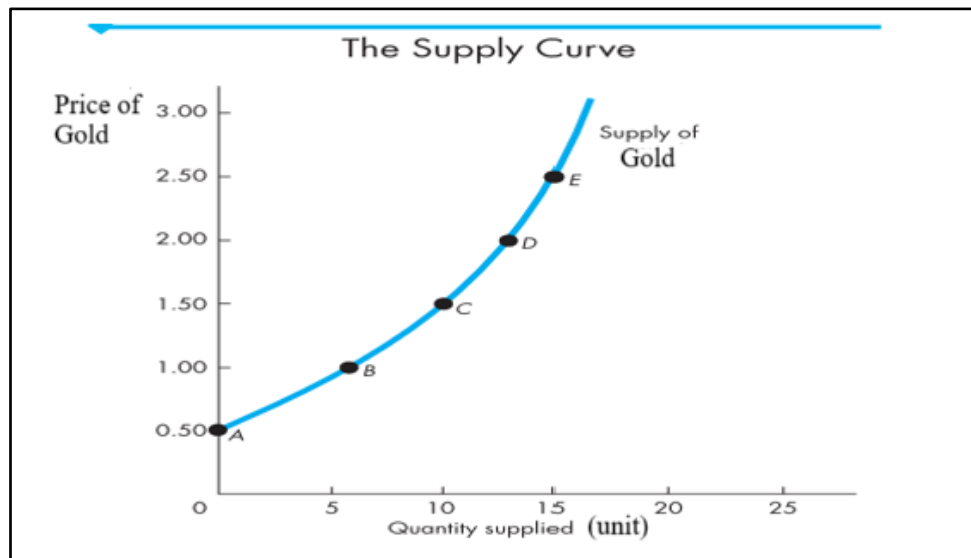
From the perspective of a producer, the opposite can be said. Referring to (Mankiw, 2023), the law of supply states that whenever there is an increase in price, supply of the goods and services will be increased, with the assumption ceteris paribus. One of the reasons for an increase in supply may be the fact that producers would try to maximize profits when there was an increase in price (especially luxury goods such as gold, diamond, silver and so on). Another reason could be due to a higher marginal cost (Parkin, 2022) as he claimed that as supply increases, the marginal cost for producing the goods or services also increases. Figure 2.3 shows the supply of energy bar as a reference.

Apart from that, there are also several factors influencing supply, which are input prices, technology, number of sellers, and expectations (Mankiw, 2023). Input prices mean the raw materials used to produce the finished product. Although gold does not seem to have any raw materials behind it, gasoline is used to extract gold.

Next, technology also has affects gold prices. As technology advances, many industries need gold to produce their products. For example, the electronics industry and even some advanced medical instruments need gold as a raw material to their final product. Hence, as technology progresses, so do gold prices (Landsburg, 2023).

The number of sellers can also play a part in determining how gold prices react (Mankiw, 2023). Under a competitive market, where there are many buyers and sellers, gold price would generally be lower than an oligopoly market, where there are many buyers but less sellers in the market.

Expectations from producers also have a major role in the market (Mankiw, 2023). If producers expect that the price of a product will increase in the future, they will supply less products in the present, and supply more in the future; if producers expect that price of a product will decrease in the future, they will supply more products now and supply less in the future. In both scenarios, the producers can benefit from the profit maximization.

2.1.3 Equilibrium Point of Demand and Supply Theory

Figure 2.4: Illustration of Equilibrium Point of Demand and Supply Theory
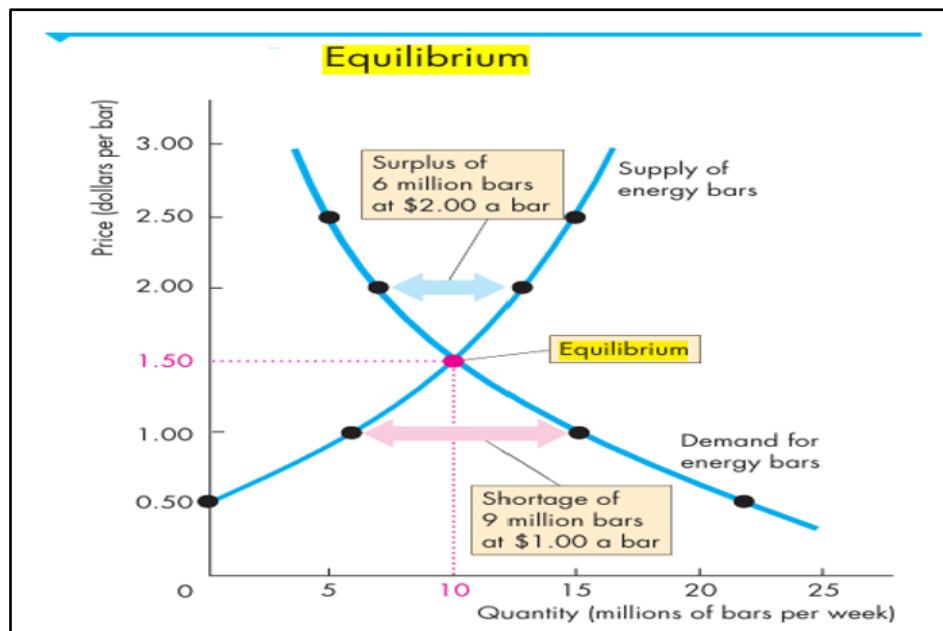
Source: (Parkin, 2022)

Only the Law of Demand and Law of Supply is not sufficient to determine prices. Hence, an equilibrium point would be formed using the interception of the demand curve and supply curve. Equilibrium can be interpreted as a situation in which the demand and supply forces balance each other, forming an equilibrium point that can accurately measure the price and quantity of a good or service (Mankiw, 2023). Referring to Parkin (2022), Figure 2.4 shows the equilibrium point of energy bars. The law of demand was represented as the demand curve and the law of supply was represented as the supply curve. When the price was at $2.00 for an energy bar, the demand was only 7 million energy bars but supply was at 13 million energy bars, and a surplus of 6 million energy bars was created; when the price of energy bars was at $1.00 a bar, demand was 15 million energy bars but supply was only at 6 million energy bars, which created a shortage of 9 million energy bars. Thus, the price and quantity adjusted itself to the equilibrium price of $1.50 and equilibrium quantity adjusted to 10 million energy prices, where both the demand and supply curve met each other Parkin (2022). Using this example, gold prices can be determined too.

2.2 Empirical Reviews of The Study

2.2.1 Gold Price

Mainal et al. (2023) wanted to unearth what factors influence gold price in Malaysia. The authors discovered that although there is a price increase in gold, it is still being widely used as a real estate and financial asset tool but remains volatile in the short run. Even in times of uncertainty, gold prices remain tenacious to hedge against potential inflation. Therefore, the authors used a panel data model with the time series data from 2005 to 2021, and cross-sectional independent variables such as gross domestic product, exchange rate, interest rate, unemployment rate, and inflation rate. In the findings, it is revealed that gross domestic product is the most significant variable that explains gold price fluctuations.

Bashir et al. (2024) wanted to discover any correlations between gold prices and environmental pollutants. This is because they want to understand if gold price has any effects with the Sustainable Development Goals proposed by the United Nations (2024). They used a cross sectional ARDL econometric approach to estimate the variables. The result shows that an increase in gold price increases environmental pollutants in the atmosphere.

Yang et al. (2024) wanted to conduct a new model to better forecast global gold prices as investors are risk averse. Hence, they developed a novel hybrid forecasting model to predict gold price movement and were able to predict with less errors. Khan (2024) wanted to research the gold prices in the Saudi Arabian market so that the policymakers can be more well informed of how gold prices fluctuate. The author used time series data from August 2003 to June 2023. After thorough investigations, the author decided that ARIMA (1,1,1,) is the most appropriate model to estimate gold prices in the Saudi Arabian market.

Ali et al. (2024) intend to find out does gold prices and oil prices affect housing prices in the Chinese market. They used a time series data from 2010 to 2021 and

used an autoregressive distributed lag (ARDL) approach to determine the estimations. The findings revealed that gold prices is statistically significant and negatively affects housing prices in both the short run and long run.

Aqilah & Dini (2024) wanted to uncover any relationship between interest. They claimed that gold price is a steady commodity that is typically driven by interest rates set by the government. Thus, they used the time series data of interest rates and gold price from January 2016 to December 2023 and conducted an Almon model. However, the found out that the Almon model can only accurately predict gold prices for up to one year only, implying that not only interest rates can accurately forecast gold prices.

Almeida et al. (2024) discussed which commodity can have hedging properties. Using a fractional cointegration vector autoregressive model spanning across 70 years ranging from January 1953 to January 2023, the authors used independent variables like housing prices, gold, S&P500 stock index, and inflation rate to determine which variables have the best hedging properties against inflation shocks, and the results were surprising. They discovered that when utilising a full sample, gold did not have any hedging properties against inflation shocks. Even with the presence of structural breaks, gold is insignificant in the study whilst housing prices and the stock index showed remarkable hedging performance.

Sahoo et al. (2024) wanted to discover relationships between gold and investor sentiment, economic conditions, and market forces. Using data from three different countries, which are United States, India, and China, it was discovered that gold prices in the United States is somewhat connected to the gold price fluctuations of India. In addition, economic conditions and inflation also significantly contribute to the rise in gold price.

2.2.2 Gasoline Price

Du & Zhang (2023) studied how economic policy uncertainties effect the commodity prices in China using two periods, before and after the Covid-19 pandemic. The study uses a quantile autoregressive distributed lag (ARDL) model to detect any short run and long run relationships with commodity prices. The study revealed that using the quantile ARDL approach, they were able detect a negative relationship between economic policy uncertainty and gold and natural gas prices. Furthermore, estimations revealed that in the pre-pandemic period, economic policy uncertainty has a negative effect on both natural gas prices and gold prices, but not on oil prices. These findings offer the authors with complex relationships of the oil, gas, and gold prices.

Dong et al. (2024) wanted to evaluate energy prices like natural gas price, gasoline price and oil price, digital governance, financial development, and gold price have any relationships with ecological footprints in accordance with the United Nation's SDG goals (2024). Using a cross sectional autoregressive distributed lag (CS-ARDL) model and a time series data ranging from 2003 to 2022, they addressed both the slope heterogeneity across the panel data and variables, and the cross functional dependence test. The estimations revealed that in the long run, energy prices negatively impact the ecological footprint, which is a novel finding. This may be due to the fact that higher energy prices may reduce aggregate demand of energy prices, decreasing the ecological footprints of Mother Earth.

Hanitha et al. (2024) intended to uncover the relationships between world commodity prices, like gold prices and gas prices, on the FTSE Indonesia stock market indices. Using a multiple linear regression starting from January 2020 to December 2023, they uncovered that not only does commodity prices have a negative effect on the Indonesia stock market index, but different commodity prices act differently with the stock market index. In their findings, it was revealed that oil, gas and tin prices have a positive effect on the index while gold and silver is statistically insignificant with the stock market index.

Recently, cryptocurrencies such as Bitcoin have also been a popular hedging tool against inflation. To determine if Bitcoin has a better hedging performance against conventional commodities, Joo and Park (2024) used the DCC and ADCC MGARCH models to estimate the hedging properties of copper, gold, gas, and crude oil futures,

as well as Bitcoin prices. Estimations revealed that Bitcoin is a more superior hedging tool when compared to crude oil but is inferior compared to gas price and gold price.

Shear et al. (2024) discussed whether commodities price co-movements normally have a high correlation with each other. Hence, instead of looking at the global commodity market, they used a national level context with Pakistan being the country of interest. They used energy sector, metal sector and agriculture sector data from 13 January 2013 to 20 August 2020 and used the ARDL method to interpret the results. The results offered the authors newfound proof that some commodity prices may not have a strong correlation with each other. In the estimations, it was uncovered that in the Pakistan market, commodity prices have relatively low co-movements with each other. This challenged the authors' original assumptions that the commodity market has high correlations with one another.

2.2.3 Exchange Rate

NDLOVU and NDLOVU (2024) examined the relationship between interest rates, exchange rates, stock price indices, and gold prices in South Africa. The data that they collected are monthly data from June 1995 to December 2022, and they used a Vector autoregression model and a Bayesian vector autoregression model. There are multiple findings in the estimations. When there is a positive shock in exchange rates, gold prices and interest rates increase; when there is a positive shock in stock prices leads to a positive increase in interest rates, exchange rates, and gold prices. A one unit increase in gold prices is associated with a negative relationship in both gold interest rates and stock prices while an increase in interest rates negatively impacts gold prices and stock indices. However, this study is only done in the context of South Africa and does not necessarily capture the full relations of the variables in the global market.

Kulaar and Kaur (2024) used monthly observations from January 2011 to December 2022 to examine the long-term equilibrium and lead-lag relationship between the US

dollar exchange rate and gold prices in India. The research revealed that the variables under consideration experienced a single cointegrating vector, supporting cointegration between Indian gold prices and US dollars, using the Granger causality analysis and the Johansen cointegration test. Furthermore, it had been noticed that there was a long-term, unidirectional causal relationship between the US dollar and Indian gold prices, which amply illustrated the US currency's hegemony over Indian gold prices. As a result, the study highlighted the fact that one important factor influencing Indian gold prices is the US dollar exchange rate.

Azis et al. (2024) conducted a moderated regression analysis using stock mutual funds, gold and coal prices and used interest rates and exchange rates as moderating effects. There are interactions among prices and interest rates, prices and gold prices, and prices and exchange rates in the estimations. Both of these factors have a high and positive link, similar to that between the age of ETF mutual funds traded on the Indonesian Stock Exchange (IDX) and the price of gold. Additionally, the second model examines the direct effects of coal, gold, and fund age on the performance of ETF mutual funds. Interest rates, coal, gold, and fund age all positively affect ETF performance; however, the effect is not statistically significant.

Rastogi et al. (2024) utilised market integration between crude oil, gold, and interest rates (IR) and the exchange rate (ER) for a variety of reasons is abundant in the literature. It is noted, therefore, that the market integration under investigation is constrained by the volatility of prices and returns. The conditional covariance connection between crude oil, gold, and the yield on the ER is found to be substantial for both shocks and persistence, with a few exceptions. It validates market connectedness economic ideas. The study's conclusions suggest that price or return integration and volatility integration should be kept apart. Price co-movement has little effect, while volatility integration has a greater and longer-lasting effect.

Boateng et al. (2024) conducted an ARDL to distinguish between short-term and long-term effects by analysing the shifting link between macroeconomic variables such as inflation and exchange rate, and commodity prices like cocoa, diesel, gold, oil, and petroleum in Ghana. Both the short-term and long-term findings show that commodity prices, inflation, and exchange rates are positively correlated. Therefore, to anchor inflationary expectations and address inflationary stagnation in Ghana, policymakers

should focus on stabilising diesel prices, make storage facility investments, encourage the use of alternative energy sources, increase domestic production and distribution of needs and implement focused fiscal and monetary policies.

2.2.4 Inflation Rate

Wardani et al. (2024) sought to ascertain how the price of gold and the rate of inflation affected the allocation of Rahn financing at PT Bank Syariah Indonesia. The public websites of Bank Indonesia, PT Antam Indonesia, and PT Bank Syariah Indonesia provided the data for this study and the study used monthly data from all three sources. It was disclosed that gold price and inflation rate significantly affect the Rahn financing.

Ergül and Karakaş (2024) wanted to examine the variables influencing gold prices for the post-2013 era, such as the tapering process in the US, they examined the hedging ability of gold against inflation. Inflation has a statistically significant positive impact on gold prices in the subperiod that excludes 2014–2019, but it has no statistically significant effect on gold prices during the entire sample period. It was concluded that in the recent past, gold has had partial hedging properties against inflation. Meanwhile, they found no statistically meaningful correlation between Bitcoin and gold prices beginning in the second half of 2016.

Changani (2024) researched numerous factors, including technological advancements, geopolitical events, and economic indicators, affect gold prices. Hence, it is vital for investors and governments to comprehend these factors. Gold prices are significantly influenced by economic variables like GDP growth and inflation rates. Past studies had also shown that gold and the US dollar have an inverse connection, with changes in the currency frequently causing matching changes in gold prices. Gold prices can also be impacted by geopolitical events;

investors may gravitate towards safe-haven assets like gold when there are international conflicts and political unrest.

Liu et al. (2024) examined the behaviour of foreign capital flows. However, the world economy had seen a period of rising inflation since the COVID-19 outbreak, and foreign investors view stocks as overweight. Therefore, they investigated if the northbound capital's forecasting power varies during times of high inflation. They also observed that northbound capital is only predictive when there was little global inflation and investigated the connection between global risk and northbound capital, showing that high global risk has little influence on the sample's lower northbound capital predictive power. Overall, the study concluded that the global economic climate and inflation have a significant impact on the role of northbound capital in China's A-share market.

Valadkhani et al. (2022) studied to pinpoint in what event that gold can be an effective hedging tool. Using observations of the US ten-year treasury bond, inflation, and gold price returns from the start of 1969 to March 2021, it was unveiled that when monthly inflation hits above 0.50%, gold reacts significantly to changes in the ten-year Treasury interest rate as well as inflation.

2.2.5 Consumer Price Index

Ghani et al. (2022) used the Pakistan stock market as the dependent variable and multiple independent variables including consumer price index, to determine if there are predictive potential to the stock market prices. Using GARCH-MIDAS model, they discovered that all the macroeconomic variables, including consumer price index, have a certain degree of predictive capabilities to determine stock market prices in Pakistan.

Gandhi and Kudare (2023) examined the complex relationships that exist between the Nifty 50 stock index and four important financial and macroeconomic indicators:

repo rates, gold prices, consumer price index (CPI), and foreign institutional investment (FII). The results of the study showed that FII investments significantly influence the performance of the Nifty 50, illustrating the interaction between international capital flows and the Indian stock market. They also looked at how changes in gold prices affect investor mood and, in turn, the performance of the Nifty 50, especially in uncertain economic times. Additionally, they examined the impact of domestic factors by evaluating the relationship between changes in the Consumer Price Index and fluctuations in the Nifty 50, highlighting the index's vulnerabilities to inflationary pressures. They also investigated how the index adapts to changes in the repo rate, which is an integral monetary policy instrument that the Reserve Bank of India uses.

Duc et al. (2023) discussed the interdependence of consumer price index and gold price, using Vietnam as the country of interest. Using two types of gold market, the authors intended to uncover if there is long run as well as short run relationships between CPI and gold prices. Estimations provided evidence that gold can hedge against inflation (using CPI) in the short run but not the long run. This causes supply-side shock in both gold markets, worsening gold price disparities.

Adnan et al. (2024) discussed the independent variable, the consumer price index, along with its effects on food imports, exports, and local agricultural output as dependent variables in the Jordanian economy, using time series data range between 2006 and 2016. Their estimations proved that a nation cannot be content with its level of productivity and self-sufficiency in the context of globalisation. However, the outside world conducts open international trade based on each nation's comparative advantage, and they think that Jordan has this edge in the agriculture sector because of its labour and land resources. Besides that, the study's conclusions and recommendations, the most significant of which was determining direct support for citizens in light of increasing costs and an increase in immigration, were supported by economic arguments and revealed a strong direct relationship between the consumer price index and the domestic product of the agricultural sector.

Darsono et al. (2024) wanted to examine how the Consumer Price Index (CPI), international gold prices, economic policy uncertainty, and geopolitical risk affect the SRI-KEHATI Index from the start of 2017 to the end of 2022. Results

discovered that gold price negatively impacted the index, but CPI and geopolitical risk have a positive impact in the short run. In addition, in the long run, consumer price index has little to none impact on the index while geopolitical risk and economic policy uncertainty have notable impacts.

2.2.6 Crude Oil Price

Pata et al. (2024) aimed to study how gold price and crude oil price interrelate with one another in Turkey. Using a rolling window nonparametric quantile causality test, they uncovered that under normal conditions, crude oil price Granger cause gold price; and crude oil price and gold price affects stock prices more than stock returns. Another article by Kumar et al. (2024) wanted to understand if they can mitigate risk management when using different financial instruments such as WTI ETF, ZKB gold futures, E-mini gold futures, and Brent Oil Futures. Findings showed that their model produces lesser errors.

Shang et al. (2024) discussed how investment spending and business efficiency were affected by crude oil price volatility as well as the underlying mechanisms that underlie these effects. This study shows that while changes in crude oil prices increase the investment efficiency of businesses, they also have a negative effect on investment expenditure. In the micro level, crude oil price volatility had the ability to reduce investment spending and improve business investment efficiency. On the macro level, it mostly relies on lowering the enterprise boom index, entrepreneur confidence index, and macroeconomic boom index.

Zhao et al. (2024) wanted to uncover that political stability and economic growth are significantly influenced by crude oil, and many scholars have dedicated their lives to predicting its price. However, the second multivariate decomposition has rarely been the focus of prior research due to the complexity and diversity of its impacting components. Thus, using weekly WTI oil spot price, their work presents a novel

hybrid model with two-layer multivariate decomposition that uses news about crude oil and financial market elements as forecasts to confirm the suggested model's functionality is proven.

Hashim et al. (2025) wanted to comprehend the relationship between gold price, crude oil price and stock market conditions amidst the Covid-19 pandemic in Malaysia. They uncovered that gold price and stock market fluctuations were largely insignificant. However, crude oil price has a strong and negative correlation with stock market indices, indicating to investors that crude oil price may have a complex role in understanding stock price changes.

2.3 Summary of Empirical Reviews of Developing A Model for Volatility of The Gold Price among the World Gold Producing Countries

Table 2.1 Summary of Empirical Reviews of the Volatility of the Gold Price among the World Gold Producing Countries

No	Author(s) and year	Title	Methodology	Novelty and Findings
Gold Price				
1	Mainal et al. (2023)	Factors influencing the price of gold in Malaysia	Panel data model	GDP is significant in explaining gold price in Malaysia.
2	Yang et al. (2024)	Improved prediction of global gold prices: An innovative Hurst-reconfiguration-based machine learning approach.	Hurst-reconfiguration-based machine learning	They discovered that the US, UK, and Chinese gold markets have diverse multifractal structures.
3	Ali et al. (2024)	Oil prices and gold prices on housing market in China: novel findings from the bootstrap approach	ARDL	Gold price negatively affects housing prices in both the short run and long run.
4	Aqilah & Dini. (2024)	Gold price prediction in Indonesia based on interest rate using distributed lag Almon transformation	Time series data	Almon model can forecast up to one year, and interest rate is not the only factor affecting gold price.

5	Almeida et al. (2024)	Financial assets against inflation: Capturing the hedging properties of gold, housing prices, and equities	Panel data model	Gold is statistically insignificant in their study.
6	Bashir et al. (2024)	Linking gold prices, fossil fuel costs and energy consumption to assess progress towards sustainable development goals in newly industrialized countries	CS-ARDL	Environmental policymaking undergoes significant adjustments as a result of climate change.

No	Author(s) and year	Title	Methodology	Novelty and Findings
Gasoline Price				
1	Du, H., & Zhang, C. (2023b)	Economic policy uncertainty and natural resources commodity prices: A comparative analysis of pre- and post-pandemic quantile trends in China.	Quantile ARDL	There is evidence of quantile analysis when examining economic policy uncertainty and gold and natural gas prices.
2	Hanitha et al. (2024)	Effect of world commodity prices on the movement of the FTSE index on the Indonesia stock exchange 2020-2023	Multiple linear regression	Oil, gas and tin prices have a positive effect while gold and silver are statistically insignificant with the stock market index.
3	Joo and Park (2024a)	Hedging Bitcoin with commodity futures: An analysis with copper, gas, gold, and crude oil futures	DCC and ADCC MGARCH	Gas price is a better inflation hedge tool than Bitcoin.

| 4 | Shear et al. (2024) | Commodity market risk: Examining price co-movements in the Pakistan mercantile exchange | ARDL | Commodity prices have relatively low co-movements with each other in Pakistan. |
| 5 | Dong et al. (2024b) | Impact of oil, gold, and energy prices on resources footprint: Evaluating the role of digital governance and financial development. | CS-ARDL | Crude oil, gasoline, and natural gas prices reduce ecological footprints while gold prices increase ecological footprint. |

No	Author(s) and year	Title	Methodology	Novelty and Findings
Exchange Rate				
1	NDLOVU, T., & NDLOVU, N. M. (2024)	The Dynamic Linkages among Gold Prices, Stock Prices, the Exchange Rate and Interest Rate in South Africa	VAR and Bayesian VAR	Prior to the epidemic, the price of gold and natural gas was negatively impacted by economic policy uncertainties, but not the price of oil.
2	Kulaar and Kaur (2024)	Analysing interrelationship between gold prices in India and US dollar exchange rate	Johansen Cointegration test & Granger causality test	A long-term, unidirectional causal relationship between the US dollar and Indian gold prices has been found, amply demonstrating the US dollar's domination over Indian gold prices.
	Azis et al. (2024)	Currency Exchange Rate Volatility as a Moderating Effect of the Gold and Coal Price Against Fund Age and Mutual Fund in Indonesia	Moderated regression analysis	Exchange rates have a high and positive correlation.

Rastogi et al. (2024)	Volatility integration of crude oil, gold, and interest rates on the exchange rate: DCC GARCH and BEKK GARCH applications	GARCH	Price co-movement has little effect but volatility integration has a greater and longer-lasting effect.
Boateng et al. (2024)	Understanding global commodity price shocks on exchange rates and inflation in emerging economies: ARDL Perspective	ARDL	Commodity prices, inflation, and exchange rates are positively correlated in Ghana.

No	Author(s) and year	Title	Methodology	Novelty and Findings
Inflation Rate				
1	Valadkhani et al. (2022)	When is gold an effective hedge against inflation?	Threshold & piecewise regression models	When inflation is high, gold shows good hedging; when inflation is low, gold is insignificant.
2	Ergül and Karakaş (2024)	Analysis of the relationship of gold prices with inflation and bitcoin in the post-tapering period	ARDL	In the recent past, gold does offer a partial hedge against inflation as an investing tool. Additionally, no statistically meaningful correlation is found between Bitcoin and gold

				prices beginning in the second half of 2016.
3	Changani (2024)	Factors Influencing gold price movements: A Time Series Analysis Perspective	Multivariate time series analysis	Gold prices can also be affected by geopolitical events; investors may gravitate towards safe-haven assets like gold as a result of international conflicts and political unrest.
4	Liu et al. (2024)	International capital flow in a period of high inflation: The case of China	Threshold regression model	Inflation has a significant impact on the role of northbound capital in China's A-share market.
5	Wardani et al. (2024)	The Effect of Inflation Rate and Gold Price on Gold Pawn Financing (Rahn) at PT Bank BSI Indonesia	Multiple linear regression	Gold price and inflation rate significantly affect the Rahn financing.

No	Author(s) and year	Title	Methodology	Novelty and Findings
Consumer Price Index				
1	Ghani et al. (2022)	Forecasting Pakistan stock market volatility: Evidence from economic variables and the uncertainty index	GARCH-MIDAS model	CPI have a certain degree of predictive capabilities to determine stock market prices in Pakistan.

2	Gandhi and Kudare (2023).	Analyzing the dynamics of Nifty 50: Exploring the senstivity to foreign institutional investment, gold prices, consumer price index, and repo rates	Regression analysis & variance inflation factors	Results indicate show that FII investments and CPI of India significantly influence the performance of the Nifty 50.
3	Duc et al. (2023)	Is gold an inflation hedge in Vietnam? Anon-linear approach	NARDL	CPI and gold prices are non-linear and gold can hedge inflation for the short run only in Vietnam.
4	Adnan et al. (2024)	The Consumer Price Index and its Role in Influencing Exports, Food Imports, and the Local Output of the Jordanian Agricultural Sector	Time series data analysis	CPI alone is not enough to meet the needs of the Jordanian economy, and international trade is needed.
5	Darsono et al. (2024)	Unveiling the Nexus of Consumer Price Index, Economic Policy Uncertainty, Geopolitical Risks, and Gold Prices on Indonesian Sustainable Stock Market Performance	ARDL	CPI is significant in the short run but remains negligible in the long run.

No	Author(s) and year	Title	Methodology	Novelty and Findings
Crude Oil price				
1	Pata et al. (2024)	Stock Returns, Crude Oil and Gold Prices in Turkey: Evidence from Rolling Window-Based Nonparametric Quantile Causality Test	Rolling Window-Based Nonparametric Quantile Causality Test	Crude oil price granger cause gold price.
2	Kumar et al. (2024)	Volatility prediction of oil and gold prices using GARCH model	GARCH model	The author's model is more accurate in predicting gold prices.
3	Zhao et al. (2024)	A novel hybrid model with two-layer multivariate decomposition for crude oil price forecasting	Hybrid forecasting model	Crude oil significantly affects political stability and economic growth.
4	Shang et al. (2024)	Unveiling the enigma: Exploring how uncertain crude oil prices shape investment expenditure and efficiency in Chinese enterprises	Panel data model	Crude oil price increases investment efficiency but decreases investment expenditure.

| 5 | Hashim et al. (2025) | The Relationship between the Oil Price, Gold Price, and the Stock Market in Malaysia during the Covid-19 Pandemic | Quantile regression | Crude oil price has a strong and negative correlation with stock market indices. |

2.4 Conclusion

Chapter 2 concludes the study by applying theoretical and empirical reviews into the study to have an overall understanding and comprehension of the variables. First, the study dives into theoretical reviews, where the theories regarding the study have been proved and proved by almost all previous studies. The first theoretical review would be the theory of demand, where price increases, demand will decrease, and vice versa. The total utility and marginal utility theory can provide inside of why demand decreases even though price remains constant. Then, the theory of supply is examined to determine the perspectives of gold producers. Lastly, the theory of equilibrium point of supply and demand is observed. After that, the empirical reviews for each of the variables, including gold price, had been studies extensively.

CHAPTER 3: METHODOLOGY

3.0 Introduction

This chapter introduces the conceptual framework of the study, followed by the model specifications and hypothesis development, data collection and of the study, and the research methodology of the study. Under the research methodology, the study will cover descriptive analysis, correlative analysis, preliminary analysis, as well as the panel data analysis. After conducting the methodology, residual diagnosis tests such as normality tests and heteroskedasticity tests will be. Lastly, criterions for model evaluation such as Mean Absolute Error, Mean Absolute Percentage Error, Root Mean Squared Error, and U-Theil Statistics will be employed before the conclusion of the chapter.

3.1 Conceptual Framework

To form the conceptual framework, the study uses data from the highest gold producing countries, which are Australia, Canada, China, Ghana, and the United States, with time series data spanning 10 years from 2014 to 2023. It is also concluded that gasoline price, exchange rate, inflation rate, consumer price index, and crude oil prices are the important variables for accurately forecasting gold price volatility.

Figure 3.1: Conceptual Framework of The Gold Price among the Gold Producing Countries
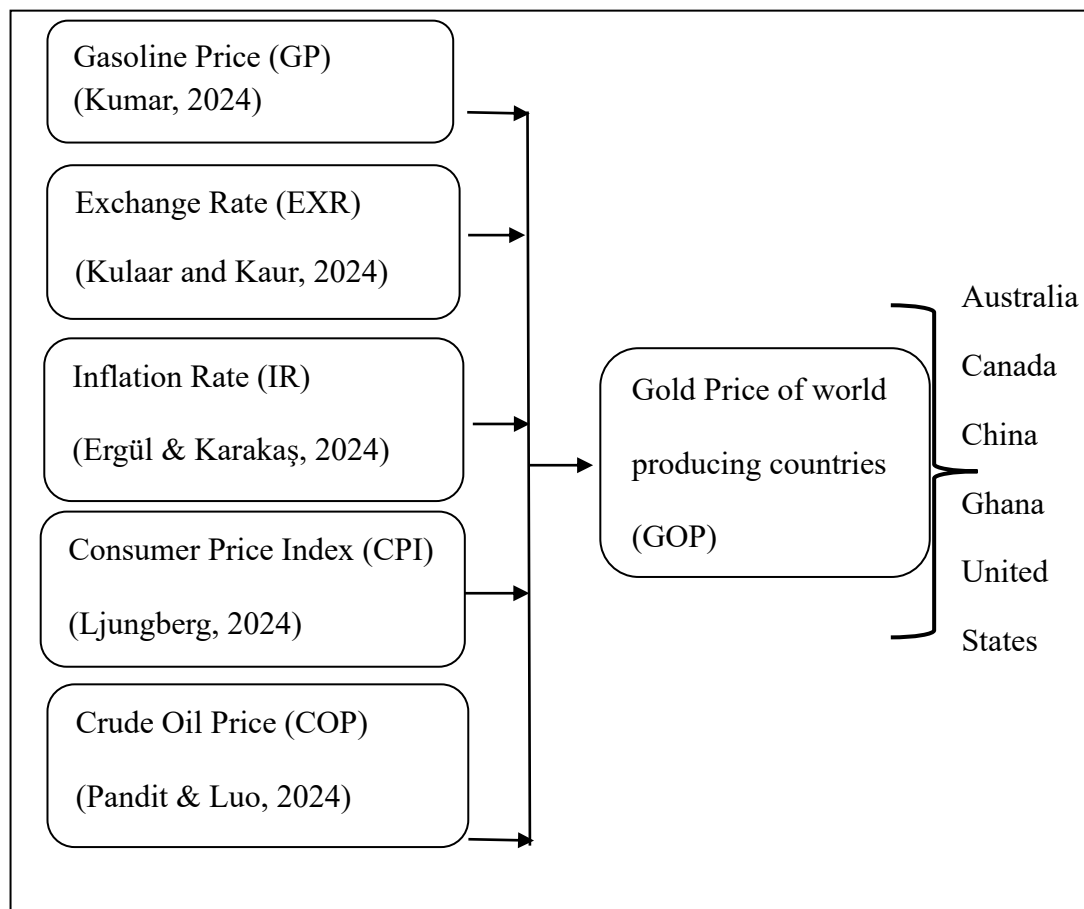
Source: Own Development.

The conceptual framework of the study was conducted based on the world gold producing countries and the factors that may affect the gold price among the world gold producing countries. Referring to Figure 3.1, it explained that gold price could be related with the following variables, gasoline price, exchange rate, inflation rate,

consumer price index, and crude oil price. An article by Kumar (2024) supported this. During the Covid-19 pandemic, gasoline prices and gold prices spiked. In terms of exchange rate, Kulaar and Kaur (2024) supported the interrelationships between exchange rate and gold prices while the article by Ergül & Karakaş (2024) confirmed the existence of inflation rate and gold prices linkages. Finally, Ljungberg (2024) supported the correlations of consumer price index and gold price while Pandit & Luo (2024) supported the interconnections of crude oil price and gold price.

3.2 Model Specifications

$$GOP_{it} = \beta_0 + \beta_1\, GP_{it} + \beta_2 EXR_{it} + \beta_3 IR_{it} + \beta_4 CPI_{it} + \beta_5 COP_{it} + \varepsilon_{it} \qquad (3.1)$$

GOP = Gold Price (USD/ Ounce)

GP= Gasoline Price (USD/ Litre)

EXR= Particular Country's Exchange Rate based on USD

IR= Inflation Rate (%)

CPI= Consumer Price Index (2010=100)

COP= Crude Oil Price (Price per barrel)

β_1 to β_5 = Coefficients of the Independent Variables

β_0= Constant value

ε= Error term

$i=$ World Gold Producing Countries (Australia, Canada, China, Ghana and the United States)

$t=$ Number of Years (2014-2023, 10 years)

$it=$ Panel Data Model (n= 5 X 10 X 6 = 300 observations)

3.3 Hypotheses Developments

H_{01}: There is no relationship between gasoline price and gold price among the world gold producing countries.

H_{A1}: There is a relationship between gasoline price and gold price among the world gold producing countries.

H_{02}: There is no relationship between exchange rate and gold price among the world gold producing countries.

H_{A2}: There is a relationship between exchange rate and gold price among the world gold producing countries.

H_{03}: There is no relationship between inflation rate and gold price among the world gold producing countries.

H_{A3}: There is a relationship between inflation rate and gold price among the world gold producing countries.

H_{04}: There is no relationship between consumer price index and gold price among the world gold producing countries.

H_{A4}: There is a relationship between consumer price index and gold price among the world gold producing countries.

H_{05}: There is no relationship between crude oil price and gold price among the world gold producing countries.

H_{A5}: There is a relationship between crude oil price and gold price among the world gold producing countries.

3.4 Data Collection and Data Sources

The dependent and independent variables data are collected from their respective sources.

Table 3.1 Variables, Description, Source, Unit of Measurement and Definition

Variable	Description	Source	Unit of Measurement	Definition
GOP	Gold Price	Statista	USD per ounce	Price based on the LBMA Gold Price
GP	Gasoline Price	Trading Economics	USD per litre	Price of gasoline based on

				individual countries
EXR	Exchange Rate	Exchange Rates ORG	Home currency/USD	Exchange rate of home currency against USD, if USD is the home currency, then Euro applies
IR	Inflation Rate	World Development Indicators	In %	Increase in the price levels of goods and services
CPI	Consumer Price Index	World Development Indicators	2012= 100	An increase in price of a basket of goods and services
COP	Crude Oil Price	Alberta Economic Dashboard, Worldometer, U.S. Energy Information Administration	Price per barrel	Price per barrel of unrefined crude oil

Source: Own Development.

3.5 Research Methods

Econometrics combines elements of economics and statistical data; even though the measurement of statistical data is vital, econometrics' field of study is much wider (Gujarati & Porter, 2009). Applied econometrics and theoretical econometrics are the two main subcategories of econometrics. One can approach the topic in either the Bayesian or classical traditions within each category. This study will emphasize

on the classical approach. The creation of suitable techniques for quantifying economic interactions as defined by econometric models is the focus of theoretical econometrics. Econometrics mainly relies on mathematical statistics in this regard. The assumptions of this approach, its characteristics, and what results from these characteristics when one or more of the method's assumptions are not met must all be explained in theoretical econometrics (Petropoulos et al., 2022).

Econometrics can not only provide the direction of the change, but also the strength of change by applying a series of observations, or a sample data, and a method to estimate the relationship (Studenmund, 2022). There are many types of regression analysis in econometrics including but not limited to single equation regression models, nonlinear regression models, panel data regression models, dynamic econometric model, etc. There are many diverse types of data too, mainly cross section data, time series data, or a combination of both. A time series is a collection of observations on the values that a variable takes at various points in time. Examples of these include monthly data, such as the consumer price index, daily data, such as weather reports, and annual data, such as government budgets. Examples of time series model may be specified as in equation 3.2.

$$Y_t = \beta_0 + \beta_1 X_t + \beta_2 X_t + \varepsilon \tag{3.2}$$

Whereas in a cross-section dataset, data on one or more variables gathered at the same time, such as the SDG index for each nation, are known as cross-sectional data (Gujarati & Porter, 2009). A panel data on the other hand, provides both cross-section and time series data of an event. For instances, commodity prices in the world market can be a pooled data as different countries will produce different quantities in different years. Hence, not only do econometricians have to worry about stationary issues in the time series data, but also heterogeneity problems from the cross-section data. Examples of cross-section data and panel data can be specified respectively as in equation 3.3 and equation 3.4.

$$Y_i = \beta_0 + \beta_1 X_i + \beta_2 X_i + \varepsilon \tag{3.3}$$

$$Y_{i,t} = \beta_0 + \beta_1 X_{i,t} + \beta_2 X_{i,t} + \varepsilon \tag{3.4}$$

3.5.1 Preliminary Analysis

After collecting data from various sources on the internet, a preliminary analysis must be conducted to determine the descriptive analysis of the data (Gujarati & Porter, 2009). Instances of the descriptive data could be the mean, median, and mode of the data. Examples of a preliminary analysis could be individually plotting the data on a graph, to understand the simple descriptive analysis of the data. However, more complex descriptive analysis would require econometrics software such as EViews, Stata, R, or SPSS. Examples of more complicated descriptive analysis could be the standard deviation, kurtosis, and skewness of the data.

3.5.1.1 Descriptive Analysis

According to Studenmund (2022), before conducting the panel model data study, a descriptive analysis is the stepping stone for the data, not only for this study, but for all existing studies. Descriptive analysis provides researchers and academics with beforehand knowledge of not only how the dataset will react with one another, but also when, why, what, and the degree to which it affects one another.

3.5.1.2 Correlation Analysis

According to Studenmund (2022), one of the most basic assumptions for independent variables in a dataset are adhering to the correlation analysis. Correlation analysis can be defined as a method that statistically computes any two variables to determine the direction and strength of the relationship. The relationship value ranges from -1 to 1, with -1 and 1 indicating a totally same negative or positive relationship, and 0 reflecting no relationship at all. However, it is statistically impossible to have 0 correlation between the variables, no matter how diverse the variables may be (Gujarati & Porter, 2009). Therefore, it is best that the correlation matrix be kept at a minimum to ensure that no correlation issues are present in the study.

3.5.1.3 Panel Unit Root Tests

Before discussing the and resolving potential issues of heteroskedasticity and multicollinearity, unit root tests have to be performed to determine of the panel data model is stationary (Studenmund, 2022). When using a panel data model, the unit root tests are different from conventional tests. Instead, either the Levin-Lin-Chu test will be used for balanced panel model data, or the Fisher test will be used for unbalanced panel data model. The null hypothesis and alternative hypothesis for unit root tests can be specified as follows:

$H_{0=}$ The series are non-stationary.

$H_{A=}$ The series are stationary.

According to Studenmund (2022), when the results show a p-value of more than 0.05, it is concluded that the study does not reject the null hypothesis and that the variables are non-stationary; if the results demonstrate a p-value of less than 0.05, we reject the null hypothesis, and this shows that the variables are stationary. There are many types

of unit root tests, and this study will be using the Levin, Lin & Chu (LLC) unit root test and the Im, Pesaran and Shin (IPS) unit root test (Petropoulos et al., 2022).

3.5.1.3.1 Levin, Lin & Chu Unit Root Test

The LLC unit root test is a panel data econometric test used to determine if a set of time series variables in a panel dataset contains a unit root, indicating non-stationarity (Petropoulos et al., 2022). It extends the Augmented Dickey-Fuller (ADF) test to panel data by pooling information across cross-sectional units, increasing efficiency. The test assumes a common autoregressive coefficient across units but allows for individual-specific intercepts and time trends and requires cross-sectional independence. The LLC test is more powerful than individual unit root tests, especially with moderate time dimensions, t, and large cross-sections, n. However, its assumptions of a common autoregressive coefficient and cross-sectional independence may limit its applicability in some cases.

3.5.1.3.2 Im, Pesaran and Shin Unit Root Test

The IPS unit root test is a panel data econometric test used to determine if a set of time series variables in a panel dataset contains a unit root, indicating non-stationarity (Petropoulos et al., 2022). Unlike the LLC test, the IPS test allows for heterogeneity in autoregressive coefficients across cross-sectional units, making it more flexible. The test averages individual ADF test statistics from each unit, allowing for unit-specific intercepts, time trends, and lag structures. The IPS test is advantageous for datasets with moderate to large time, t, and cross-sectional, n, dimensions, as it accommodates heterogeneity. However, its assumption of cross-

sectional independence may limit its applicability if unobserved common factors are present. Despite this, both unit root tests are widely used in econometrics (Petropoulos et al., 2022).

3.6 Residual Diagnosis Tests

The first test for all data estimations would be the normality test (Studenmund, 2022). The data that is normally distributed often follows a bell-like shape. This test is important especially for parametric tests, where the data assumes that it is normally distributed. If the normality test is not fulfilled, it may lead to inconsistencies in data estimations (Studenmund, 2022). The null hypothesis and alternative hypothesis are listed as follows:

$H_{0=}$ The data is normally distributed

$H_{A=}$ The data is not normally distributed.

When the data is normally distributed, it can streamline the data estimations and results. When the p-value of the data is less than alpha value 0.05, the null hypothesis is rejected and we accept the alternative hypothesis that the distribution is not normally distributed, and vice versa.

The problem that panel data models may encounter are heteroscedasticity (Studenmund, 2022). One of the assumptions in a panel data model is that all error terms have identical error terms. However, reality is always a different case. Heteroscedasticity means that the error terms differ with one another. It can be caused by error learning model, which states that as more hours are put into a specific type of work, the probability of error decreases, or the presence of outliers, which are observations that are very far apart

from the average observations. The null hypothesis and alternative hypothesis for heteroscedasticity can be specified as follows:

$H_{0=}$ Residuals are not co-integrated and there is heteroscedasticity among the residuals.

$H_{A=}$ Residuals are co-integrated and there is no heteroscedasticity among the residuals.

Heteroscedasticity issues are difficult to resolve, as the data cannot be manipulated into the ideal results (Gujarati & Porter, 2009). Nevertheless, when the results illustrate a p-value of more than 0.05, we do not reject the null hypothesis that there is no heteroscedasticity among the residuals; if the p-value is less than 0.05, we reject the null hypothesis and accept that there is heteroscedasticity among the residuals.

The last discrepancy would be multicollinearity issue (Gujarati & Porter, 2009). In theory, all the regressors, the independent variables, have no multicollinearity among one another. However, real life observations tend to have little multicollinearity, no matter how independent the variables are. Hence, the study is to determine how serious is the multicollinearity issue, and to rectify the issue when it arises. Figure 3.2 shows the degree of multicollinearity issues that affect the dependent variable. The null hypothesis and alternative hypothesis for multicollinearity can be specified as follows:

$H_{0=}$ The residuals have no multicollinearity issues.

$H_{A=}$ The residuals have multicollinearity issues.

Gujarati & Porter (2009) mentioned that if the Variance Inflation Factors (VIF) of the variables are more than 10, then the variables have multicollinearity issues. If the VIF values are less than 10, then the model does not suffer from multicollinearity.

Figure 3.2 The Degree of Multicollinearity

(a) No collinearity

(b) Low collinearity

(c) Moderate collinearity

(d) High collinearity

(e) Very high collinearity
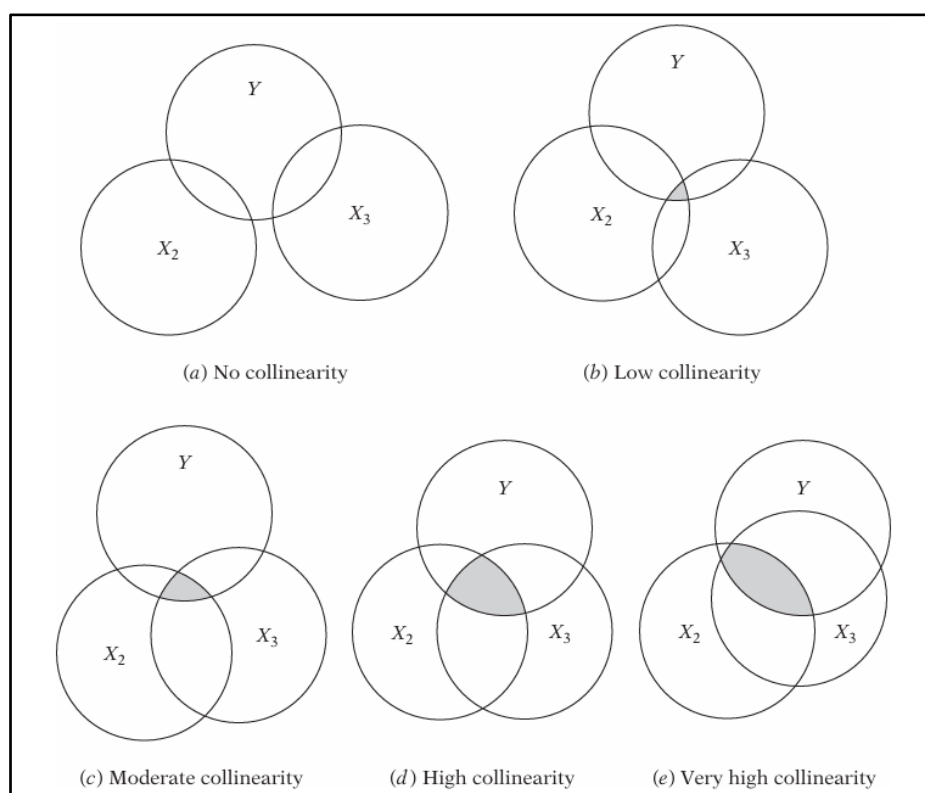
Source: (Gujarati & Porter, 2009)

3.7 Panel Data Model Analysis

There are many names for panel data, such as pooled data, longitudinal data, micropanel data, event history analysis, cohort analysis, and combination of time series and cross-section data (Gujarati & Porter, 2009). There are advantages of

utilising a panel data rather than a cross-section data or time series data. Panel data provides more variability, less collinearity across variables, more degrees of freedom, greater efficiency, and more meaningful information by integrating time series of cross-section observations; also, effects that are just impossible to see in pure cross-sectional or pure time series data can be more accurately detected and measured using panel data. Hence, the study will use a balanced panel data instead of an unbalanced panel data, where some of the observations are absent.

Furthermore, there are 3 options to opt for a balanced panel data, which are the fixed effect model (FEM), the random effect model (REM), and the pooled OLS model (POLS) (Gujarati & Porter, 2009). Gujarati & Porter (2021) claimed that in order to determine which model is the preferred model, a series of test is carried out, namely, the redundant fixed effect test, the Lagrange Multiplier test, and the Hausman Test.

For the redundant fixed effect test, the panel data will test whether the POLS is the preferred model, or the FEM is the preferred model. In the redundant fixed effect test, if the null hypothesis is rejected with a p-value of less than 0.05, then the alternative hypothesis of FEM is the preferred model will be adopted; if the p-value is larger than 0.05, then the null hypothesis is adopted. The null hypothesis and alternative hypothesis for the redundant fixed effect model are as follows:

$H_{0=}$ POLS is the preferred model.

$H_{A=}$ FEM is the preferred model.

Next, we will also be comparing the panel data to determine if the POLS model or REM model is the preferred model through the Lagrange Multiplier test. In the Lagrange Multiplier test, if the null hypothesis is rejected with a p-value of less than 0.05, the alternative hypothesis is accepted and the alternative hypothesis of REM is the preferred model is adopted; otherwise, do not reject the null hypothesis and the POLS model is adopted. The null hypothesis and alternative hypothesis for the Lagrange Multiplier tests are as follows:

$H_{0=}$ POLS is the preferred model.

$H_{A=}$ REM is the preferred model.

Lastly, we will be making a comparison on whether the FEM model or the REM model is the preferred model through the Hausman test. In the Hausman test, the null hypothesis states that the FEM model is the preferred model whereas the alternative hypothesis states that the REM model is the preferred model. If the p-value is less than 0.05, then the alternative hypothesis of REM being the preferred model is agreed upon; if the p-value is more than 0.05, then the FEM model is agreed upon. The null hypothesis and alternative hypothesis for the Hausman test are as follows:

$H_{0=}$ FEM is the preferred model.

$H_{A=}$ REM is the preferred model.

3.8 Panel Cointegration Analysis

Panel cointegration analysis is a statistical method used to examine long-term equilibrium relationships between variables across multiple cross-sectional units such as countries, firms, or regions over time (Petropoulos et al., 2022). It extends traditional cointegration techniques, which analyse time series data, to panel data settings, allowing for the investigation of whether non-stationary variables move together in the long run despite short-term fluctuations. This approach is particularly useful in economics and finance to test theories involving relationships like purchasing power parity, economic growth, or energy consumption. By pooling data across units, panel cointegration increases the power of statistical tests and accounts for heterogeneity and cross-sectional dependencies, providing more robust insights into persistent relationships in multivariate systems.

3.9 Granger Causality Analysis

The Granger Causality Analysis is a statistical measurement for research. Granger Causality analysis is defined as a time series analysis to determine whether one variable affects the other variable. When a variable "Granger Causes" another variable, it implies that the lagged value of a variable has predictive capability in determining another variable (Studenmund, 2022). The null hypothesis and alternative hypothesis are as follows:

$H_{0=}$ The variables are not cointegrated.

$H_{A=}$ The variables are cointegrated.

When the p-value of the study is less than 0.05, we reject the null hypothesis and accept the alternative hypothesis that the variables are cointegrated and have a long run relationship.

3.10 Model Evaluation

Lastly, the model evaluation will be utilised to analyse any short run or long run relationships between the variables (Gujarati & Porter, 2009). Model evaluation means forecasting the model to determine if the model can be used consistently to forecast the dependent variable. One of the best ways to do that is to determine the mean of the percentage errors (in absolute value) using a technique known as the mean absolute percentage error (MAPE) method. The root mean square error criteria (RMSE), which is determined by squaring the forecasting error for each time period, averaging these

squared amounts, and then taking the square root of this average, is also one of the most widely used alternative technique of assessing prediction accuracy.

3.10.1 Mean Absolute Error

One statistic frequently employed in sentiment analysis tasks based on regression is the mean absolute error, or MAE for short. It calculates the mean absolute disparity in the sentiment values that were anticipated and those that were actually observed. On a continuous scale, MAE gives an indication of how well the model predicts sentiment.

Figure 3.3 Mean Absolute Error of Consumption of Chicken
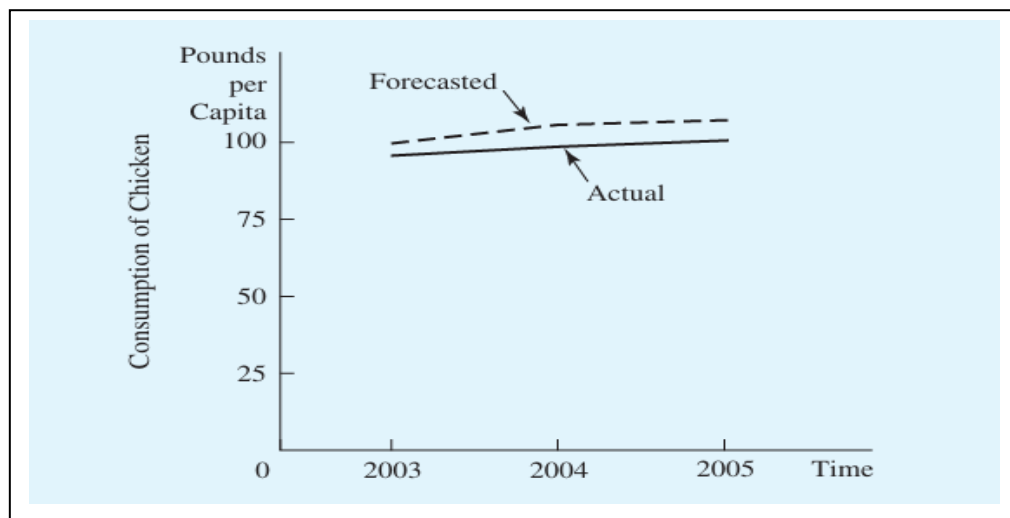
Source: (Studenmund, 2022)

Figure 3.3 illustrates the forecasted consumption of chicken and the actual consumption of chicken. The difference between the forecasted consumption and the actual consumption is known as the MAE.

3.10.2 Mean Absolute Percentage Error

Another type of forecast is gauged by its mean absolute percentage error (MAPE), also known as its mean absolute percentage deviation (MAPD) (Studenmund, 2022). Calculated as the mean absolute percent inaccuracy for each time period minus real values divided by the actual values, it expresses this degree of precision as a percentage. The equation of the MAPE is mentioned in equation is mentioned in equation (3.5).

$$\text{MAPE} = \frac{\Sigma \frac{(A-F)}{A} X\ 100}{N} \qquad (3.5)$$

Equation (3.5) uses the sum of the actual values minus the sum of the forecasted values, divided by the actual values and multiplied by 100 to turn the values into a percentage; then the value is divided by the number of observations.

3.10.3 Root Mean Squared Error

The variability of the residuals, or prediction mistakes, is known as the Root Mean Square Error, or RMSE (Studenmund, 2022). The distance between the data points and the regression line is indicated by residuals, and the degree of dispersion of these residuals is indicated by RMSE. Stated differently, it indicates the degree of concentration of the data around the line of the most optimal fit. Regression analysis, climatology, and forecasting frequently use RMSE to validate experimental findings. The advantage of the RMSE is that it squares the error, giving more weightage to larger errors, while also giving lesser weightage to smaller errors. This

can help improve the forecast model. The equation for the RMSE is listed in equation (3.6).

$$RMSE = \sqrt{\frac{\Sigma(y-\hat{y})^{\wedge}2}{n}}$$ (3.6)

Equation (3.6) sums the difference of the actual values squared and the forecasted values squared and divides it with the number of observations. Lastly, the value is square root to determine the RMSE.

3.10.4 Theil U Statistic

A measure of relative accuracy called Theil's U statistic contrasts the predicted outcomes with those of predicting with little historical data. Additionally, it squares the variations in order to magnify and give greater weight to significant errors, which can aid in the removal of procedures with high errors. Equation (3.7) demonstrates the formula for Theil U Statistic.

$$Theil\ U = \sqrt{\frac{\Sigma[\frac{(\hat{y}-y)}{y}]^{\wedge}2}{\Sigma[\frac{(y-y)}{y}]^{\wedge}2}}$$ (3.7)

3.11 Model Estimation Procedure

Figure 3.4: Model Estimation Procedure of the Study
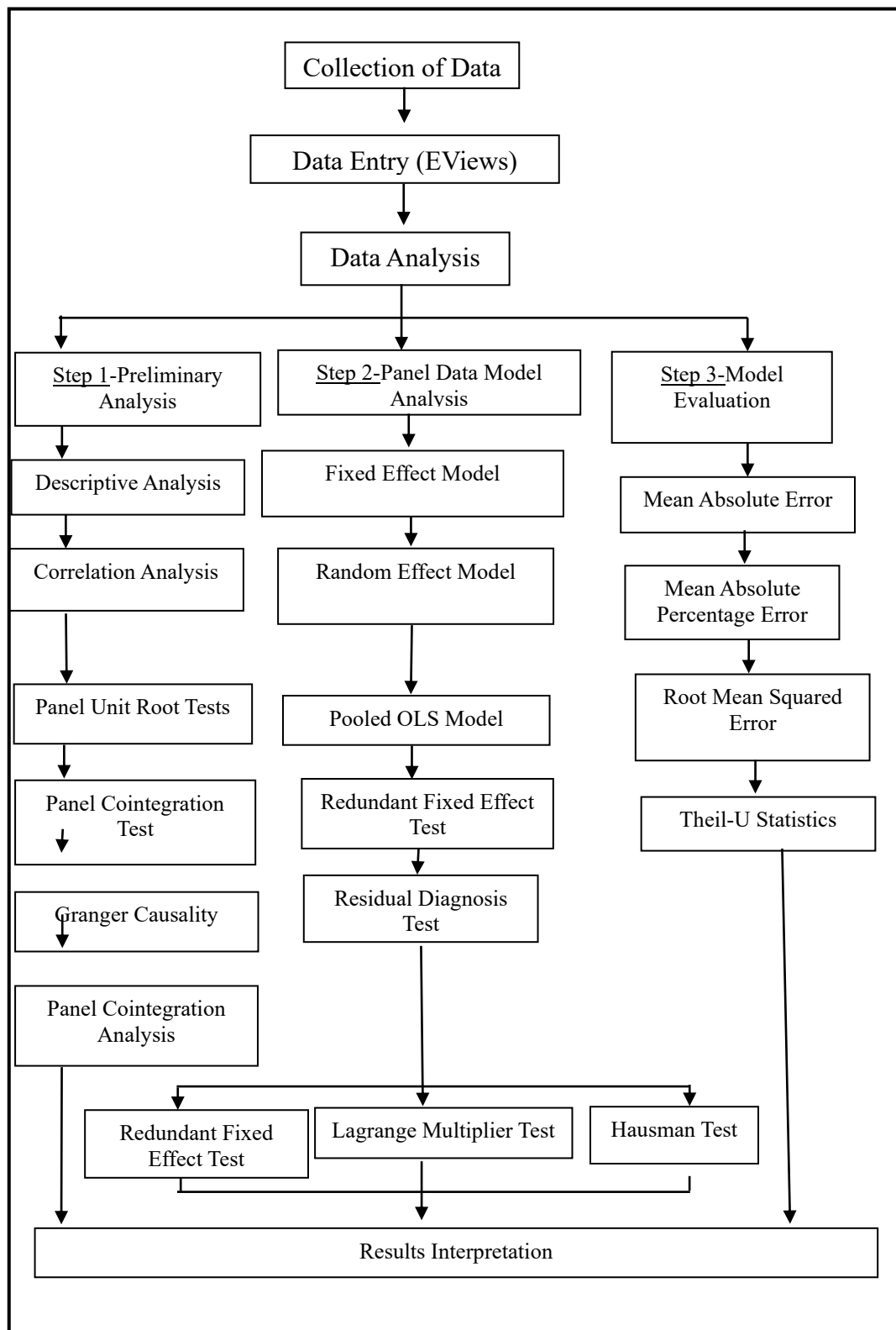
Firstly, the study collects data from reputable sources from the internet. Then, the collected data is inserted into an econometrics software, which in this case is EViews. Next, analysis of the data is conducted. The analysis is divided into three steps, which is step 1 preliminary analysis, Step 2 panel model data analysis, and Step 3 model evaluation.

In Step 1 preliminary analysis, the study conducts the descriptive analysis and the correlation analysis. In Step 2 panel data model analysis, the study tests panel model unit root tests, and determine whether the fixed effect model, random effect model, or the Pooled OLS model is the most suitable model for the study. Next, the Redundant Fixed Effect test is carried out along with the Granger Causality test. In Step 3 model evaluation, the study will be testing the Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), Root Mean Squared Error (RMSE), and the U-Theil statistics. After conducting all three steps, then the results would be interpreted.

3.12 Conclusion

This chapter concludes the methodology used in the study. First, a conceptual framework is formed followed by the contributions of the respective authors. Then, the model specifications, hypotheses developments, and data collection are also supervised. Next, the research methods, which cover the preliminary analysis and the residual diagnosis tests are covered, followed by selecting a panel model data analysis to aid in the study. Lastly, the model evaluation is carried out before the conclusion of the chapter is made.

CHAPTER 4: DATA ANALYSIS

4.0 Introduction

Chapter 4 covers the descriptive analysis and the correlation analysis of the study, the panel unit root tests, which consists of the Levin, Lin and Chu unit root tests and the Im, Pesaran and Shin unit root test, and the residual diagnosis tests of the study. Furthermore, the study conducts the panel model data analysis, which is further differentiated into the Redundant Fixed Effect Model (FEM), the Omitted Random Effects Lagrange Multiplier, and the Hausman Test. Then, a Granger Causality analysis is carried out to determine any long-term trends between the variables, and a model evaluation is conducted.

4.1 Descriptive Statistics

Table 4.1: Descriptive Statistics of The Study

Description	GOP	GP	EXR	IR	CPI	COP
Mean	1519.28	0.90	3.04	5.37	156.58	56.35
Median	1416.89	0.89	1.35	2.10	121.20	54.23
Maximum	2070.97	1.41	11.69	33.10	610.00	101.57
Minimum	1060.70	0.54	0.14	0.40	107.50	5.97
Std. Dev.	347.60	0.20	2.90	7.02	94.21	17.75
Observations	50.00	50.00	50.00	50.00	50.00	50.00

Source: Own Development.

Table 4.1 shows the description of the mean, median, maximum and minimum values, and the standard deviation with a balanced observation of 50. The mean value of GOP is USD 1519.28 per ounce with a standard deviation of ±347.60. The maximum value of GOP is USD 2070.97 per ounce while the minimum value for GOP is USD 1060.70 an ounce, and other variables are accordingly. Researchers analyse descriptive statistics to summarize and understand the basic features of the data collected in a study. By examining these statistics, researchers can identify patterns, detect outliers, and gain insights into the characteristics of the sample population. Descriptive statistics serve as a foundation for further inferential analysis, enabling researchers to make informed decisions about the appropriate statistical tests to use and to interpret the results accurately. Ultimately, this step is crucial for ensuring the validity and reliability of the study's findings.

4.2 Correlation Analysis

Table 4.2: Correlation Analysis of The Study

Description	GOP	GP	EXR	IR	CPI	COP
GOP	1.000	0.345	0.156	0.186	0.294	0.535
GP	0.345	1.000	0.132	0.478	0.367	0.382
EXR	0.156	0.132	1.000	0.488	0.627	0.343
IR	0.186	0.478	0.488	1.000	0.850	0.375
CPI	0.294	0.367	0.627	0.850	1.000	0.367
COP	0.535	0.382	0.343	0.375	0.367	1.000

Source: Own Development.

Table 4.2 shows the correlation analysis between the variables. Researchers analyse correlation statistics to examine the strength and direction of relationships between two or more variables in a study. This analysis helps determine whether variables change together and to what extent, providing insights into potential associations or

dependencies. Hence, understanding these relationships is essential for identifying patterns, generating hypotheses, and guiding further research.

4.3 Panel Unit Root Tests

Table 4.3: Panel Unit Root Tests for Original Data

Variables	Levin, Lin & Chu Tests		Im, Pesaran and Shin Tests	
	Level	1st Difference	Level	1st Difference
GOP	0.9213	-7.3396***	2.7233	-2.7141***
GP	-2.4596***	-8.2207***	-1.0940	-5.0454***
EXR	-2.1801**	-4.9815***	-0.9085	-2.4947***
IR	-2.9691***	-5.7940***	-1.0559	-2.8801***
CPI	4.48318	1.0792	6.4255	0.3937
COP	-2.9654***	-7.6841***	-0.5316	0.0000

Source: Own Development.

Note: *** Represents statistical significance at 0.01 level.

** Represents statistical significance at 0.05 level.

* Represents statistical significance at 0.10 level.

Table 4.3 showcases the Levin, Lin and Chu (LLC) panel unit root test and the Im, Pesaran and Shin (IPS) unit root test. The LLC panel unit root test and the IPS unit root test are statistical tests to determine whether the variables are stationary or non-stationary. In the LLC panel unit root test, except for GOP and CPI, other variables are stationary; in first difference, all variables except CPI are stationary. In the IPS

panel unit root test, all variables are non-stationary when level, and only CPI and COP are non-stationary.

4.4 Panel Cointegration Test

Table 4.4: Panel Cointegration Test

Test Methods			
Pedroni's Residual Cointegration Test	Panel Cointegration Statistics		
		Individual Intercept	
	Test Statistics	t-statistics	p-value
	Panel PP-Statistic	1.4067	0.9202
	Panel ADF-Statistic	2.0733	0.9809
Kao's Residual Cointegration Test	Null Hypothesis	t-statistics	p-value
	No Cointegration	-3.028185	**0.0012***
	Residual variance	32382.04	
	HAC variance	31910.16	

Source: Own Development.

Note: ***   Represents statistical significance at 0.01 level.

      **   Represents statistical significance at 0.05 level.

      *   Represents statistical significance at 0.10 level.

Table 4.4 displays the panel cointegration tests of the study. Using Pedroni's Residual Cointegration Test, it was discovered that all the variables do not cointegrate with GOP. The p-values of the variables are above the alpha value of

0.05. According to the null hypothesis of the cointegration test, a p-value above the alpha value of 0.05 is not rejected. Hence, the study also used Kao Residual Cointegration Test to determine if the variables are cointegrated. Using the Kao Residual Cointegration Test, the p-value is lesser than alpha value 0.05. Therefore, we reject the null hypothesis that the variables are not cointegrated and accept the alternative hypothesis that the variables are cointegrated. In conclusion, the Pedroni Residual Cointegration Test showed no evidence of cointegration, but the Kao Residual Cointegration Test showed evidence of the variables being cointegrated.

4.5 Panel Model Selection

4.5.1 Results for Redundant Fixed Effect Test

Table 4.5: The Results for Redundant Fixed Effect Test

Redundant Fixed Effects Tests

Equation: EQ01

Test cross-section and period fixed effects

Effects Test	Statistic	d.f.	Prob.
Cross-section F	1.407302	(4,31)	0.2547
Cross-section Chi-square	8.342936	4	0.0798
Period F	1306.584226	(9,31)	**0.0000 *****
Period Chi-square	297.052084	9	0.0000

Cross-Section/Period F	1221.564059	(13,31)	**0.0000 *****
Cross-Section/Period Chi-square	312.039984	13	0.0000

Source: Own Development.

Note: ***   Represents statistical significance at 0.01 level.

   **   Represents statistical significance at 0.05 level.

   *   Represents statistical significance at 0.10 level.

According to Table 4.5, using the Fixed Effect Model (FEM), the study showed that the Fixed Effect Model is the preferred model. The null hypothesis that Pooled Ordinary Least Square (POLS) model is the preferred model is mostly rejected because the p-values are less than the alpha value 0.05 except for the Cross Section probability. The p-values of the Period and the Cross Section/Period probabilities are close to zero, which is lesser than the alpha value 0.05. Therefore, we reject the null hypothesis and accept the alternative hypothesis that the FEM is the preferred model.

4.5.2 Results for Lagrange Multiplier Test

Table 4.6: The Results for Lagrange Multiplier Test for Random Effects

Null hypotheses: No effects

Alternative hypotheses: Two-sided (Breusch-Pagan) and one-sided

(all others) alternatives

	Test Hypothesis		
	Cross-section	Time	Both
Breusch-Pagan	0.497485	44.84968	45.34717
	(0.4806)	(0.0000)	**(0.0000) *****
Honda	0.705326	6.696991	5.234229
	(0.2403)	(0.0000)	**(0.0000) *****
King-Wu	0.705326	6.696991	4.301689
	(0.2403)	(0.0000)	**(0.0000) *****
Standardized Honda	4.146788	7.115049	4.333623
	(0.0000)	(0.0000)	**(0.0000) *****
Standardized King-Wu	4.146788	7.115049	4.012721
	(0.0000)	(0.0000)	**(0.0000) *****
Gourieroux, et al.	--	--	45.34717
			(0.0) ***

Source: Own Development.

Note: *** Represents statistical significance at 0.01 level.

    ** Represents statistical significance at 0.05 level.

    * Represents statistical significance at 0.10 level.

Table 4.6 shows the Random Effect Model (REM) for the study. According to the all the tests, the REM model is the preferred model because all the p-values are

close to zero and less than the alpha value of 0.05. The null hypothesis of POLS model is the preferred model is rejected, and the alternative hypothesis of the REM model is the preferred model is accepted.

4.5.3 Results for Hausman Test

Table 4.7: Results for Hausman Test

Correlated Random Effects - Hausman Test

Equation: EQ02

Test period random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Period random	27.6631	5	**0.0000 *****

Source: Own Development

Note: ***   Represents statistical significance at 0.01 level.

   **   Represents statistical significance at 0.05 level.

   *   Represents statistical significance at 0.10 level.

According to Table 4.7, the study shows that the FEM is the better model selection compared to the REM model. According to the null hypothesis of the Hausman Test, if the p-value of the test is more than alpha value 0.05, the null hypothesis of REM

model is accepted; if the p-value is lower than 0.05, the null hypothesis is rejected. The Hausman Test of the study revealed that the REM model is rejected, and the FEM model is accepted as the better model. Thus, the study uses a Cross Section Period Fixed Effect Model.

Table 4.8: Summary of the Panel Model Selection

Tests	Hypotheses	P-values	Conclusion
Redundant Fixed Effect Test	H_0 = POLS is the preferred model. H_A = FEM is the preferred model.	0.0000 < α value =0.05	Reject H_0. FEM is the preferred model.
Lagrange Multiplier Test for Random Effect Test	H_0 = POLS is the preferred model. H_A = REM is the preferred model.	0.0000 < α value =0.05	Reject H_0. REM is the preferred model.
Hausman Test	H_0 = REM is the preferred model. H_A = FEM is the preferred model.	0.0000 < α value =0.05	Reject H_0. FEM is the preferred model. (**Cross-Section and Period Fixed Effect Model**)

Source: Own Development.

4.6 Gold Price Cross-Section and Period Fixed Effect Model

$$GOP_{it} = 510.3159 + 377.4191GP_{it} - 16.7600EXR_{it} - 24.2435IR_{it}$$

$$t = \qquad [1.5010] \qquad [-0.8875] \qquad [-2.0407**]$$

$$+1.9971CPI_{it} + 9.5382COP_{it}$$

$t =$ [2.1322**]   [3.5781***]

R-squared= 0.3807

Adjusted R-squared= 0.3103

Note: ***   Represents statistical significance at 0.01 level.

        **   Represents statistical significance at 0.05 level.

        *   Represents statistical significance at 0.10 level.

For the variables affecting GOP, out of five independent variables, only three variables are significant in explaining GOP. Based on the estimations, GP and EXR show no evidence of significant relationships between GOP. GP and EXR have p-values of 0.1405 and 0.3796 respectively, which is higher than the alpha value of 0.05. The decision rule states that when the p-value of a variable is lesser than the alpha value, the null hypothesis of not significant relationship is rejected, and vice versa. The p-values of IR, CPI, and COP are less than alpha value 0.05 and hence, the null hypothesis of insignificant relationship is rejected, accepting the alternative hypothesis that the variables are significant. Therefore, not all variables that are selected for the study are significant in explaining GOP. The R-squared value of the study is 0.3807

4.7 Gold Price Model Evaluation

Figure 4.1: Model Evaluation for the Random Effect Model
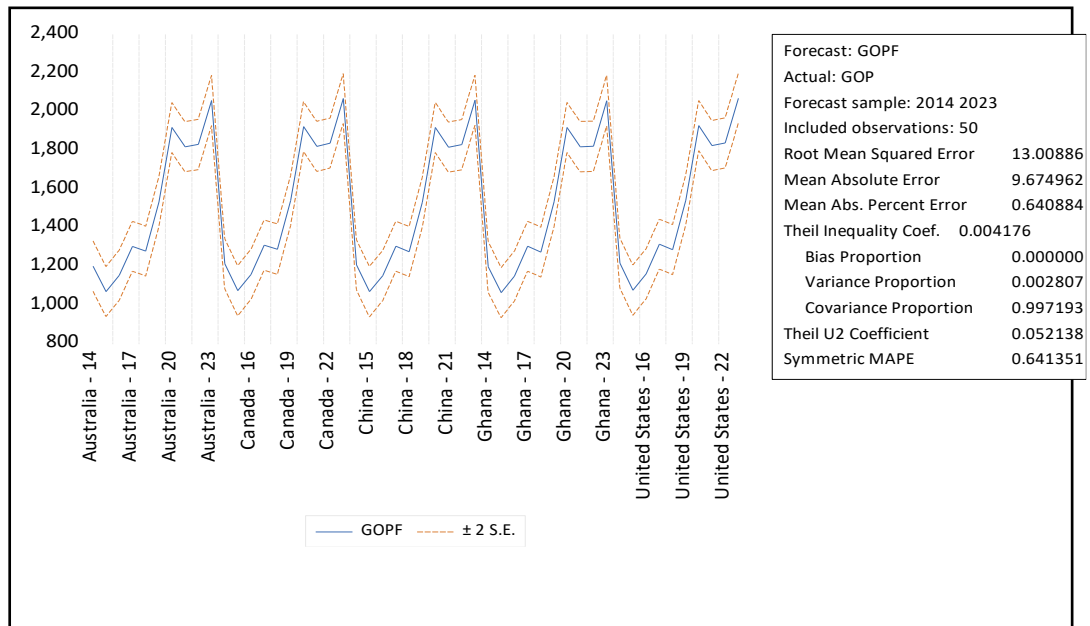
Source: Own Development.

Figure 4.2: Model Evaluation for the Fixed Effect Model
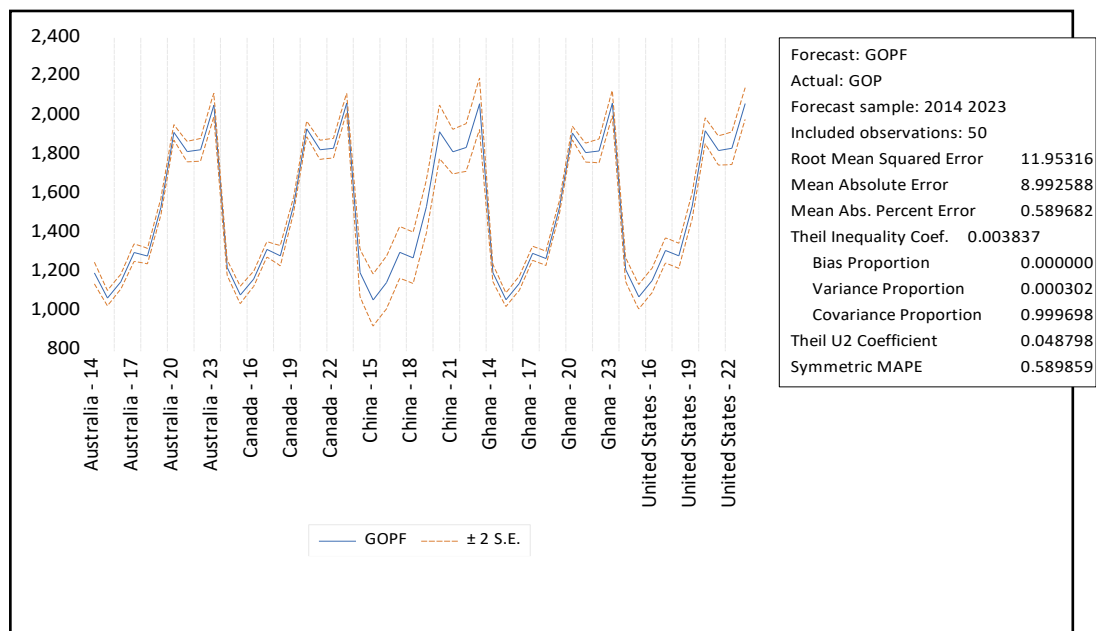
Source: Own Development.

Figures 4.1 and 4.2 show the forecast values of GOP using REM model and FEM model. Comparing the two model evaluations, FEM is the better model. Based on the MAE, MAPE, RMSE, and Theil-U statistics, the values in the FEM model are all lower than the REM model. Thus, the model evaluation also proves that the FEM model is the preferred model.

4.8 Gold Price Model Simulation

The data range for the study is from 2014 to 2023, with 5 countries, Australia, Canada, China, Ghana, and the United States. For the baseline data, the study uses the entire data range of 10 years; for the ex-post forecast, the study uses the latest 5 years to conduct the forecast. The tables below show the ex-post forecast of the countries from 2019 to 2023.

Figure 4.3: 5 Year Ex-post Forecast of Australia

Ex-post Forecast of Australia
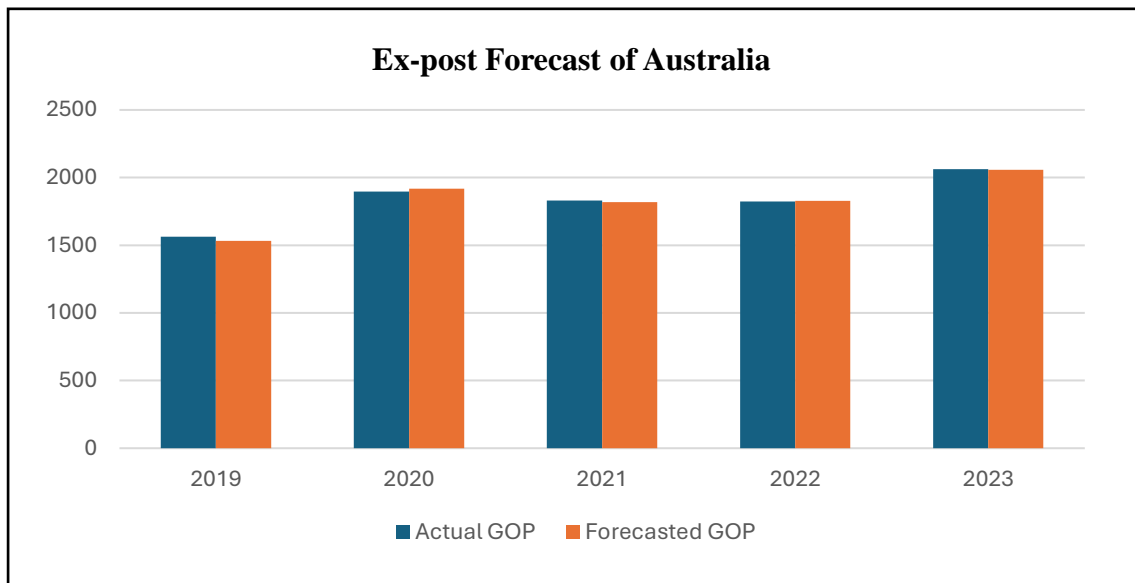
Source: Own Development.

Figure 4.4: 5 Year Ex-post Forecast of Canada

Ex-post Forecast of Canada
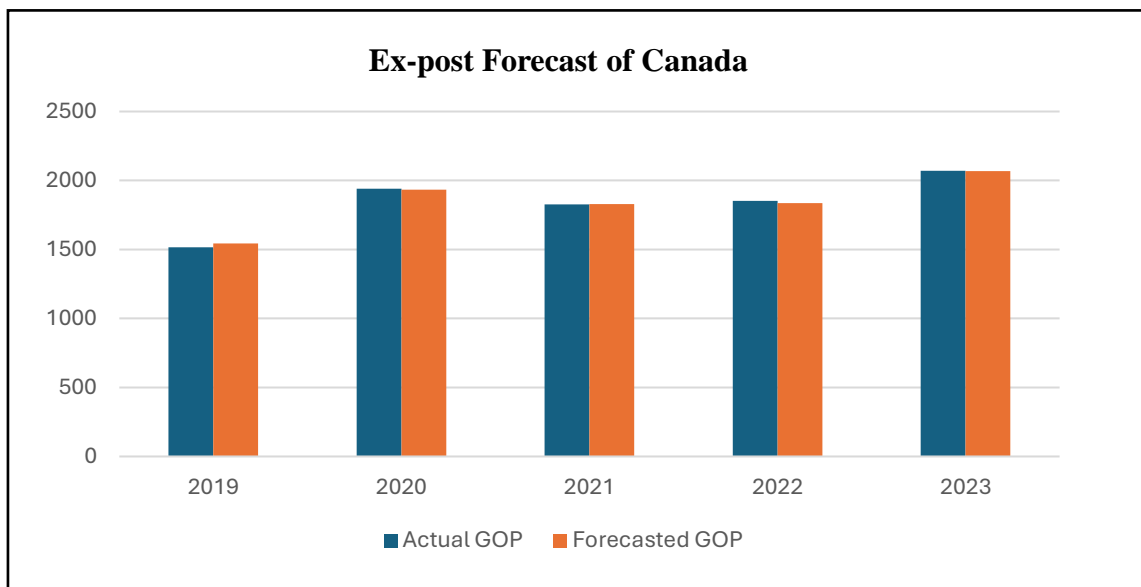
Source: Own Development.

Figure 4.5: 5 Year Ex-post Forecast of China

Ex-post Forecast of China
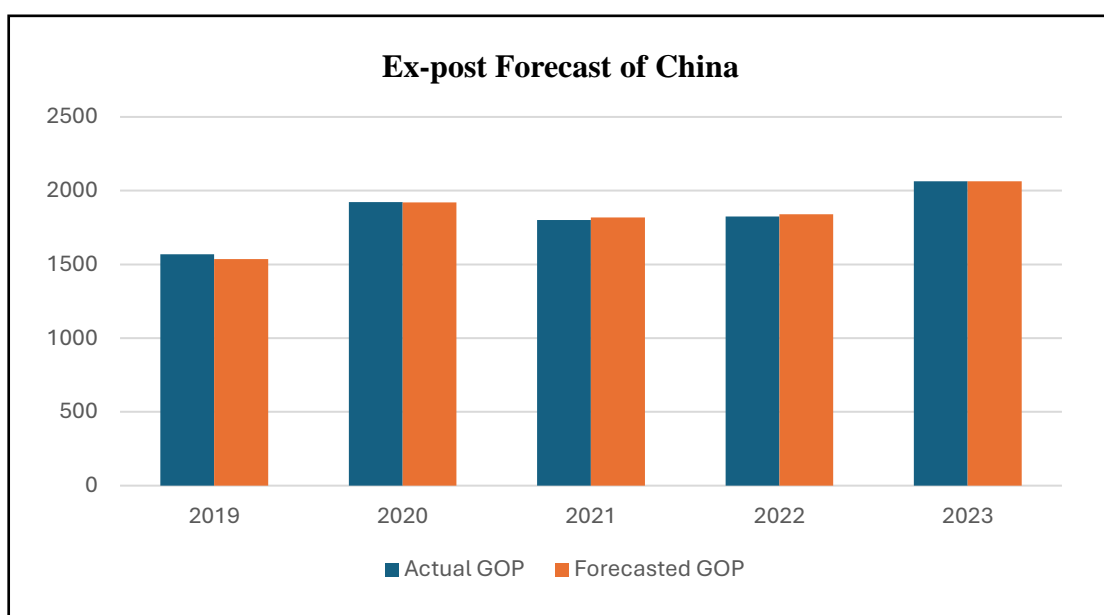
Source: Own Development.

Figure 4.6: 5 Year Ex-post Forecast of Ghana

Ex-post Forecast of Ghana
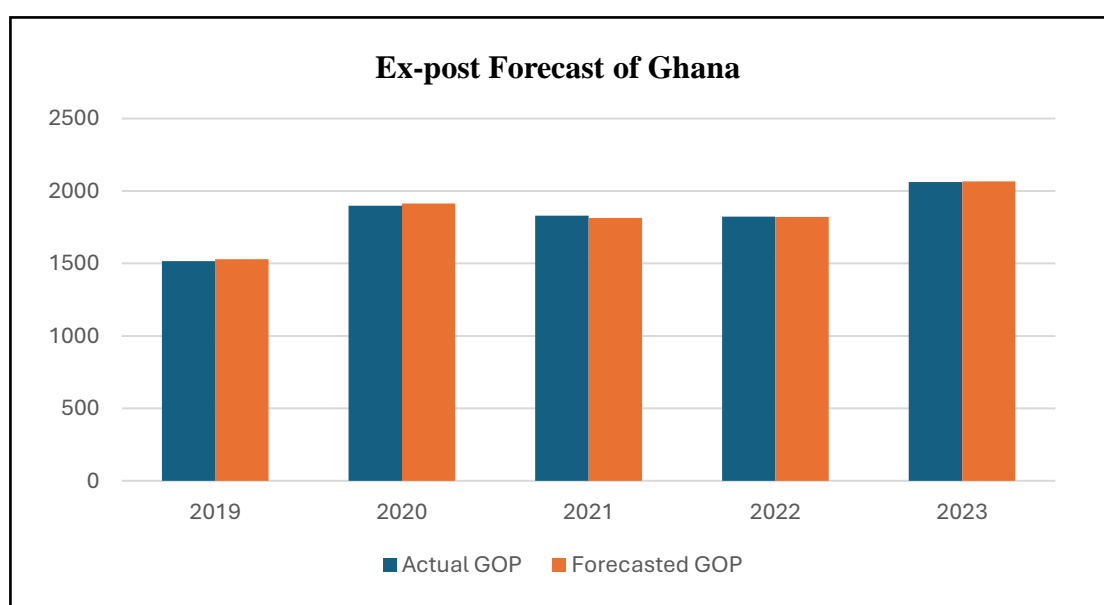
Source: Own Development.

Figure 4.7: 5 Year Ex-post Forecast of the United States

Ex-post Forecast of the United States
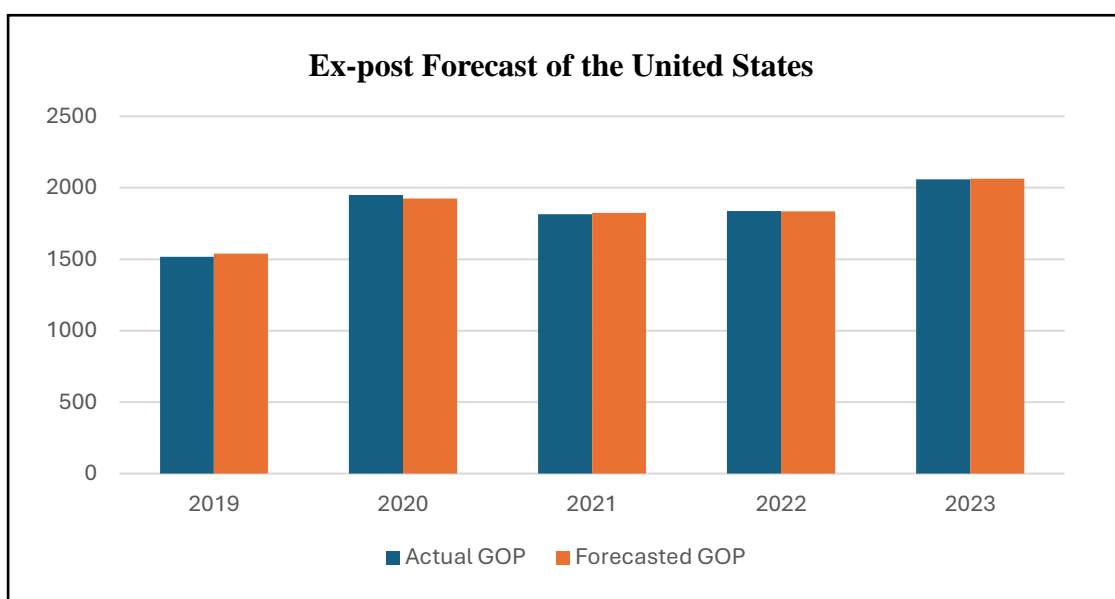
Source: Own Development.

Table 4.9: Actual and Fitted Observation for Australia, Canada, China, Ghana, and

United States

Year	Actual Data	Ex-post Forecast
	Australia	
2019	1562.82	1532.51
2020	1897.77	1916.90
2021	1830.12	1818.35
2022	1822.63	1827.90
2023	2062.20	2056.49
	Canada	
2019	1515.27	1543.87
2020	1940.94	1934.37
2021	1825.73	1827.96
2022	1852.19	1836.04
2023	2070.97	2066.98
	China	
2019	1568.34	1537.02
2020	1923.02	1919.53
2021	1801.79	1818.03
2022	1824.41	1840.07
2023	2063.40	2063.02
	Ghana	

2019	1516.91	1529.08
2020	1898.68	1913.62
2021	1829.09	1813.46
2022	1823.84	1821.68
2023	2062.76	2066.60
United States		
2019	1517.84	1538.70
2020	1949.56	1925.55
2021	1815.26	1824.18
2022	1838.22	1835.60
2023	2058.28	2064.52

Source: Own Development.

Figures (4.3) to (4.7) and Table 4.9 show the Ex-post forecast of Australia, Canada, China, Ghana, and the United States. It was revealed that in 2020, both the actual GOP and forecasted GOP are higher before sliding down in 2021. In 2023, all 5 countries show the highest actual GOP and forecasted GOP. These figures indicate that gold prices are facing an upward trend in all 5 countries.

4.9 Residual Diagnosis Test

The residual diagnosis tests consist of the normality test, the heteroskedasticity test and the multicollinearity test.

4.9.1 Normality Test

Figure 4.8: Normality Test of the Study
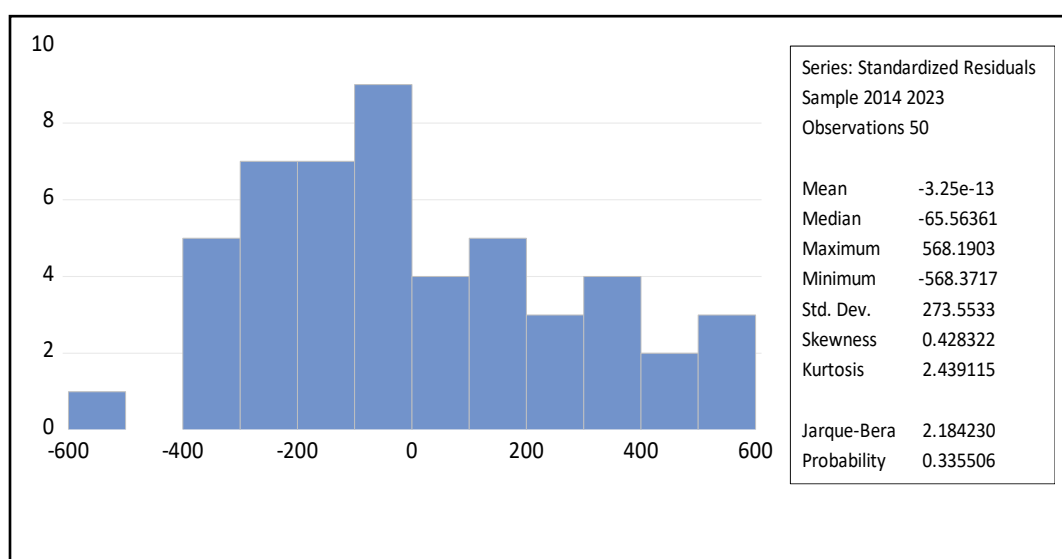
Source: Own Development.

Figure 4.3 shows the normality test of the study. The null hypothesis claims that the distribution is normally distributed while the alternative hypothesis rejects this claim. The p-value of the normal distribution is 0.3355, which is more than the alpha value of 0.05. Therefore, we do not reject the null hypothesis that states that the error terms are normally distributed.

4.9.2 Heteroskedasticity Test

Table 4.10: Heteroskedasticity Test

Kao Residual Cointegration Test

Series: GOP GP EXR IR CPI COP

Date: 03/23/25   Time: 22:08

Sample: 2014 2023

Included observations: 50

Null Hypothesis: No cointegration

Trend assumption: No deterministic trend

Automatic lag length selection based on AIC with a max lag of 1

Newey-West automatic bandwidth selection and Bartlett kernel

	t-Statistic	Prob.
ADF	-3.028185	**0.0012*****

Source: Own Development.

Note: *******   Represents statistical significance at 0.01 level.

      **   Represents statistical significance at 0.05 level.

      *   Represents statistical significance at 0.10 level.

Table 4.4 shows whether the variables are homoscedastic, or heteroskedastic. Using the Kao Cointegration Test, it is determined that the p-value of the ADF test is 0.0012, which is less than 0.05.

H_0 = The residuals have no cointegration and have heteroskedasticity.

H_A = The residuals have cointegration and have no heteroskedasticity.

According to the null hypothesis of the Kao Residual Cointegration Test, when the p-value is less than 0.05, we reject the null hypothesis that there is no cointegration and there is heteroskedasticity among the variables. Therefore, there is no heteroskedasticity among the residuals.

4.9.3 Multicollinearity Test

Table 4.11: Multicollinearity of the Variables

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(RESID)

Method: Least Squares

Date: 03/23/25   Time: 22:08

Sample (adjusted): 2015 2023

Included observations: 45 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID(-1)	-0.742426	0.141991	-5.228670	0.0000
R-squared	**0.365927**	Mean dependent var		45.79086
Adjusted R-squared	0.365927	S.D. dependent var		276.5059
S.E. of regression	220.1781	Akaike info criterion		13.64872
Sum squared resid	2133049.	Schwarz criterion		13.68887
Log likelihood	-306.0962	Hannan-Quinn criter.		13.66369
Durbin-Watson stat	2.103837			

Source: Own Development.

Table 4.5 shows the Variance Inflation Factors of the variables. Based on the R-square value of the Kao Cointegration Test, the study will be using 0.3659. The hypothesis is as follows:

$H_{0=}$ The residuals have no multicollinearity issues.

$H_{A=}$ The residuals have multicollinearity issues.

The VIF would be

$$VIF = \frac{1}{1-R^2}$$

$$= \frac{1}{1-0.3670}$$

$$= 1.5798$$

When the VIF value is more than 5, it shows signs of multicollinearity among the variables, and vice versa. In the estimation, the VIF value is 1.5798, which is less than the threshold value of 5. Therefore, there is no multicollinearity among the variables.

4.10 Granger Causality Analysis

Table 4.12: Results of Granger Causality Analysis

Pairwise Granger Causality Tests

Date: 03/30/25   Time: 13:54

Sample: 2014-2023 (Lags: 3)

Null Hypothesis:	Obs	F-Statistic	Prob.
GP does not Granger Cause GOP	35	0.57825	0.6341
GOP does not Granger Cause GP		7.75211	**0.0006***
EXR does not Granger Cause GOP	35	0.37059	0.7748
GOP does not Granger Cause EXR		3.53020	**0.0275**
IR does not Granger Cause GOP	35	0.37899	0.7689
GOP does not Granger Cause IR		2.45147	**0.0842***
CPI does not Granger Cause GOP	35	0.59995	0.6204
GOP does not Granger Cause CPI		1.39714	0.2643
COP does not Granger Cause GOP	35	2.86493	**0.0544***
GOP does not Granger Cause COP		2.71882	**0.0634***

Source: Own Development.

Table 4.12 shows the Granger Causality analysis of the study. According to the table, the independent variable COP Granger Cause GOP. Surprisingly, the dependent variable GOP Granger Cause four out of five variables. The null hypothesis of Granger Causality claims that if the p-value is bigger than alpha value 0.05, there is no Granger Causality; if the p-value is less than 0.05, the alternative hypothesis that there is Granger Causality among the variables is accepted. Thus, there are three unidirectional Granger Causality and 1 bidirectional Granger Causality in the study. Below is the graphical illustration of the Granger Causality of Gold Price.

Figure 4.9: Illustration of Gold Price Granger Causality
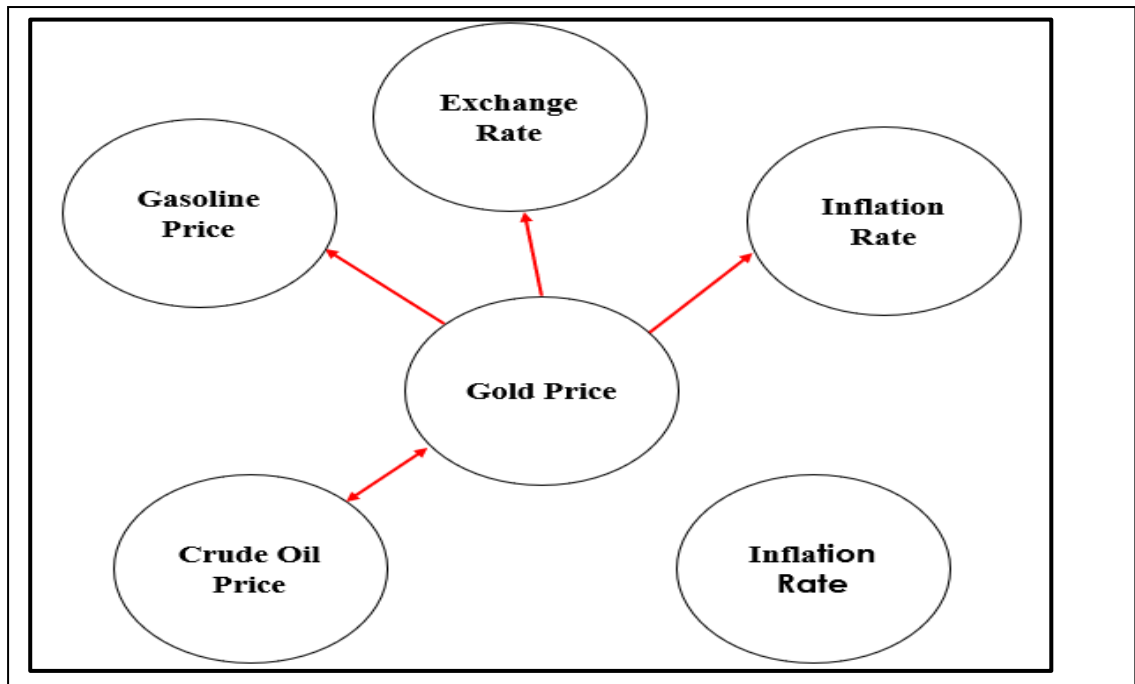
Source: Own Development.

4.11 Hypothesis Testing

Table 4.13 shows a summary of the description of the hypothesis testing of the variables, the p-values of the variables, the decision rule, and the conclusion of the hypothesis.

Table 4.13: Hypothesis Testing for The Study

Description	P-value Significant (P<0.05)	Decision	Conclusion
H_{A1}: There is a relationship between GP and GOP.	P-value = 0.1405 < α 0.05. Not Significant	Rejected	Therefore, there is no significant relationship between **GP and GOP**.

H_{A2}: There is a relationship between EXR and GOP.	P-value = 0.3796 < α 0.05. Not Significant	Rejected	Therefore, there is no significant relationship between **EXR and GOP.**
H_{A3}: There is a relationship between IR and GOP.	P-value = 0.0473** < α 0.05. Significant	Supported	Therefore, there is a significant relationship between **IR and GOP** at 5% significance level. A one unit increase in IR decreases GOP by 24.2435 units.
H_{A4}: There is a relationship between CPI and GOP.	P-value = 0.0386** < α 0.05. Significant	Supported	Therefore, there is a significant relationship between **CPI and GOP** at 5% significance level. A one unit increase in CPI increases GOP by 1.9971 units.
H_{A5}: There is a relationship between COP and GOP.	P-value = 0.0009*** < α 0.01. Significant	Supported	Therefore, there is a significant relationship between **COP and GOP** at 1% significance level. A one unit increase in CPI increases GOP by 9.5382 units.

Source: Own Development.

Note: ***   Represents statistical significance at 0.01 level.

      **   Represents statistical significance at 0.05 level.

      *   Represents statistical significance at 0.10 level.

According to Table (4.12), the summary shows that except for GP and EXR, other variables are significant in explaining GOP, with IR and CPI at 5% significance level and COP at 1% significance level. Both GP and EXR showed a p-value of 01405 and 0.3796 respectively, proving that the p-value cannot be rejected.

4.12 Conclusion

Chapter 4 concludes the data collection and interpretation of the study. First, the descriptive statistics and correlation analysis are studied. Next, panel unit root tests of LLC and IPS are conducted to determine if the variables are stationary. Then, a panel cointegration test is carried out to determine if the variables had any long run relationships continued by the model selection, which consists of the Redundant Fixed Effect Test, the Lagrange Multiplier Test, and the Hausman Test. After choosing the best selection, the Gold Price Panel Model, the Gold Price Model Evaluation and the Gold Price Panel Simulation are further conducted for robustness of the result. Then, the residual diagnosis tests, which are normality test, heteroskedasticity test, and multicollinearity test. Lastly, a Granger Causality Analysis is conducted followed by the hypothesis testing of the variables.

CHAPTER 5: CONCLUSION AND IMPLICATIONS

5.0 Introduction

Chapter 5 introduces the summary of results of the data analysis, which consists of the panel unit root test, the cointegration test, the most suitable panel model selection, the R-squared value of the study and the residual diagnosis tests. The study also introduces the discussion of the major findings, the contributions of the study, the limitations of the study, the recommendations for future research, and the conclusion of the study.

5.1 Summary of Results for the Data Analysis

Based on Chapter 4, the study conducted panel unit root tests and determined that the LLC level unit root test is a suitable model prior to conducting the first different tests. Then, the panel cointegration test is conducted, in which it was discovered that the Pedroni Residual Cointegration Test is not significant in explaining the variables. On the other hand, when conducting the Kao Residual Cointegration Test, the cointegration test is significant in the long run.

Next, the panel model selection is run to analyze which model is the best model. It was revealed that the cross section and period fixed effect test equation was the most appropriate model. According to the fixed effect test equation, the variables IR, CPI, and COP showed significant effects at the alpha value of 0.05, 0.05, and

0.01 levels, respectively. The R-squared value of the study is also considered appropriate with a value of 0.3807.

Furthermore, the residual diagnosis tests for the study are the normality test, heteroskedasticity test, and the multicollinearity test. The normality test was conducted, and it showed normal distribution with a value of 0.3355. Next, the heteroskedasticity test used the p-value of the Kao Residual Cointegration Test, and it showed a value of 0.0012, proving that there is no heteroskedasticity in the study; then, the multicollinearity test showed a VIF value of 1.5798, which is less than VIF value of 5.

Next, after careful selection of the model, the study uses a Cross-Section and Period Fixed Effect Model. The four criteria, the RMSE, MAE, MAPE and U-Theil Coefficient have the lowest values. Hence, using the estimation, Crude Oil Price is the most significant variable in the study. Inflation Rate and Consumer Price Index are also significant in explaining the study.

Next, the study also conducts a Granger Causality analysis to determine if the variables have Granger Causality analysis with gold price or not. Based on the long run Granger Causality analysis, gold price has three unidirectional analysis and one bidirectional analysis with Crude Oil Price.

According to the actual data and ex-post forecast data of the gold producing countries, the actual data shows an increase in gold price from 2014 to 2023, with the ex-post forecast data also demonstrating an increasing trend from 2014 to 2023.

Lastly, the hypothesis tests are conducted, and the hypothesis tests determine if we should support or reject the hypothesis of the variables.

5.2 Hypothesis Testing

According to the results of the Hausman Test, the study concludes that a Fixed Effect Model is the most appropriate model. Thus, the study uses a Cross-Section and Period Fixed Effect Model to conduct the model. The study exhibited that IR, CPI, and COP are significant with GOP whilst GP and EXR exhibit insignificant relationships with GOP.

Table 4.13 shows the hypothesis testing of the study.

H_{A1}: There is a significant relationship between gasoline prices and gold prices.

The p-value for gasoline prices is 0.1405, which is more than alpha value 0.05. Hence, gasoline prices are not significant in the study and the alternative hypothesis is rejected; and it is concluded that there are no significant relationships between gasoline prices and gold prices. This study supports the findings by Shear et al. (2024) where commodities are not highly correlated with one another. In the article by Shear et al. (2024), the Pakistan market had low commodities correlated with one another, and the study is also similar when examining and observing multiple countries. Hence, we reject the alternative hypothesis that there is a significant relationship between gasoline price and gold price.

H_{A2}: There is a significant relationship between the exchange rate and gold price.

The p-value for exchange rate in this study is 0.3796, which is more than the alpha value 0.05. Thus, EXR is not significant in explaining the gold price in the study. This study challenges most of the articles, where their studies show consistency in that exchange rates have a certain degree of relationship with gold prices. This article acknowledges that it is different from most of the other studies conducted by previous researchers because this study uses panel model data, whereas other studies use only data from one country. Therefore, we reject the alternative hypothesis that there is statistical significance between exchange rate and gold price.

H_{A3}: There is a significant relationship between inflation rate and gold price.

The p-value for inflation rate is 0.0473, which is less than the alpha value 0.05. However, instead of the traditional positive correlation of inflation rate and gold price as claimed by Valadkhani et al. (2022), this study shows that the inflation rate shows

a significant negative relationship with gold price. Another article by Ergül and Karakaş (2024) claimed that gold has no statistical significance when observed during the entire period of their study and has a positive statistical significance in a specific period of their study. However, our study indicated otherwise. It indicated that as inflation increases, gold price decreases. This may challenge the traditional institutional perception that gold prices increase when inflation rate increase because investors would turn their assets into gold to hedge from inflation risks. Thus, we support the alternative hypothesis that there is a strong negative relationship between inflation rate and gold price.

H_{A4}: There is a significant relationship between consumer price index and gold price.

The p-value for CPI is 0.0386, which is lower than alpha value 0.05. Hence, consumer price index positively correlates with gold prices. This study provides a new approach on how the consumer price index affects gold price. In the study by Duc et al. (2023), consumer price index affects gold price only in the long run and not in the short run. The article also focuses on one country, which is Vietnam, a non-gold producing country. In our study, it used a panel model instead of NARDL approach, and the countries utilised are all gold developing countries, showing that consumer price index has influence on gold prices in the long run. So, this study provides novel insights by demonstrating a positive relationship between consumer price index and gold price.

H_{A5}: There is a significant relationship between crude oil price and gold price.

The p-value of crude oil price is 0.0009, which is less than alpha value 0.01, indicating a 1% significance level. This proves that crude oil price has sufficient and significant evidence that it positively affects gold price. This supports the article by Pata et al. (2024), where they provided evidence that crude oil price Granger cause gold price. Therefore, this study aligns with the article by Pata et al. (2024) where crude oil prices have relationships with gold prices.

Furthermore, the actual data and the ex-post forecast data of gold price shows an increasing trend in recent years as supported by Grobys (2024b). For Australia, Canada, China, Ghana, and the United States, gold price increase from just below USD 1600 per ounce in 2019 to well above USD 2000 an ounce in 2023. Thus, this

study aligned with Grobys (2024b) that gold price has been experiencing an upward trend.

5.3 Contributions of the Study

5.3.1 Theoretical Contributions

Based on the study, the study revisits how volatile gold price is when examining a specific commodity in the global market, using five gold-producing countries. Although the supply of gold remained relatively stable and did not change much, the demand for gold can fluctuate uncontrollably due to various reasons. On the demand side, prices of related goods can influence the price of gold (Landsburg, 2023); expectations can also play a role in determining how high gold prices can be (Landsburg, 2023). For example, when the US dollar is seen as unstable compared to other safe-haven assets, the demand for gold will increase, because the USD is relatively volatile compared to gold. Also, if investors and central banks expect that the expected return of gold is higher, demand for gold would also increase (Landsburg, 2023).

On the supply side, many factors come into play. Input prices can be a pivotal factor in determining how much an ounce of gold can be sold (Mankiw, 2023). Although some form of gold is mined through river panning, most of the gold extraction uses machinery to extract gold deep in the Earth's crust, and this process uses crude oil to power up the machinery. In addition, the level of technology can play a part in determining gold prices (Mankiw, 2023). When technology becomes more efficient in extracting and refining gold, the process would be more efficient. However, due to the scarcity of gold as a precious metal, the price would not fluctuate as much.

Lastly, the equilibrium point that intersects between the supply and demand curve will be the ideal equilibrium price and quantity (Mankiw, 2023). All goods and services market that have the demand and supply largely follows this mechanic where surpluses would decrease demand, and shortages would increase demand. Valuable commodity prices are also influenced by external factors such as geopolitical events. Thus, the gold market also somewhat aligns with the theory of supply, demand, and equilibrium price.

5.3.2 Empirical Contributions

Based on Chapter 1 and 2 of the study, the empirical contributions may not be as profound or significant as first intended. According to Mainal et al. (2023), they claimed that interest rate, unemployment rate, and exchange rate have a significant relationship with gold price. In their article, they used only Malaysia as a cross-section data while using a quarterly time series data from 2005 to 2021. In our study, we used a panel data model with exchange rates as one of the variables. However, our study revealed that exchange rate is insignificant with gold price. According to Ali et al., (2024), they used China as their country of interest to determine does gold price influence housing prices. They revealed that gold price is negatively related to housing prices, meaning that as gold price increases, housing price will decrease; when housing price increases, gold price will decrease. This claim can be supported by Hanif et al. (2023) that real estate investment trusts (REIT) can be used as a hedge against shocks.

The next variable is gasoline price. When gasoline price increases, gold price will also increase because gasoline powers machinery and transportation needed for gold production. Hence, gasoline price is thought to be important as what Kumar (2021) claimed. In the study, it was revealed that gasoline prices negatively affect gold price, because their country of interest, India, used gasoline as a hedge or an investment tool more than an input for gold. Zhou and Liang (2025) also proved

this when examining the gas price of Russia. In their study, they wanted to determine if geopolitical uncertainty affects gold price in different nations. In the context of Russia, when there are geopolitical tensions, gasoline prices fall whereas gold price remains unchanged.

Both variables show insignificant results; therefore, for policymakers, this implies that changes aimed at managing gasoline prices or maintaining a stable exchange rate may have limited direct effect on gold price. Consequently, monetary authorities might not prioritise these variables in the context of gold price regulation or forecasting. This may also mean that gold prices are more likely influenced by other factors such as interest rates, inflation expectations, or geopolitical uncertainty like the Russia-Ukraine war or the most recent tariff trade war, warranting a focal point on broader macroeconomic stability rather than targeted interventions in currency market or energy markets. Furthermore, for investors and central banks using gold as a hedge, reliance on exchange rate or fuel price trends may be misleading, underscoring the need for diversified analytical models that account for more relevant variables.

On the other hand, inflation rate, consumer price index, and crude oil price have significant relationships with gold price. In the article by Valadkhani et al. (2022), they argued that as inflation reaches a certain threshold, gold can be a good inflation hedge, which would increase the price of gold. Other researchers like Liu et al. (2024) argue that as inflation rate increases, housing prices in China would increase Hanif et al. (2023). Since the Chinese population thinks that housing estates are also a safe-haven asset, and gold is a substitute for housing, gold price would decrease. This study has China as one of its countries, and hence, gold price may be negatively affected by it.

Moreover, consumer price index has a positive and significant relationship with gold price. According to Gandhi and Kudare (2023), when the CPI of India increases, the stock price of the Nifty 50 would also be affected, as supported by Oosterlinck et al. (2023). Stocks can be seen as a good substitute of US stocks and good diversifier for European stocks. Thus, when the inflation rate increases, stocks can be bought, increasing the price of stocks, as well as gold price.

In addition, crude oil price also positively affects gold price. Pata et al. (2024) concluded that crude oil price Granger causes gold price in their study. This finding aligns with our study that crude oil price Granger causes gold price. In Pata et al.'s (2024) study, they only used Turkiye as their country of interest. It is safe to assume that the study also expands to other nations like Australia, Canada, China, Ghana, and the United States, where crude oil price has a Granger Causality analysis with gold price.

To summarise, policymakers and investors should prioritise more on inflation rate, consumer price indices and crude oil price. For policymakers, the positive relationship between these macroeconomic indicators and gold prices provides valuable insight into how inflationary pressures and commodity market volatility influence investor behaviour and capital flows.

A rising inflation rate and elevated CPI typically leads to increased demand for gold as a hedge against loss of purchasing power (Wee et al., 2024). Understanding these interactions enable policymakers, particularly central banks and finance ministries, to anticipate shifts in public sentiment and adjust monetary policy tools like interest rates or inflation targeting frameworks to better predict gold price. Gold can also be an attractive tool for investors to mitigate inflation risks, diversifying portfolios, and preserving capital flows (Erb & Harvey, 2024).

5.4 Limitations of the Study

This study acknowledges that it does not encapsulate the entirety of the gold price volatility because of the uncertainty of the real-world economy and conditions of the market. One of the reasons that cannot be predicted is geopolitical tensions around the world. This study only takes macroeconomic and commodity prices into consideration and does not take geopolitical events into account. Hence, it is not known how gold prices would react when geopolitical events arise around the world.

Furthermore, there may be irregularities in the data as well. Most of the countries have suppression of news and media to a certain extent. For example, countries like Vietnam, Cuba, and China suppresses news and data collection. Thus, getting data from those countries would prove to be a challenge. Nevertheless, this study manages to collect data from popular and reliable sources like LSEG.

In addition, the software for processing the data may be limited too. In many instances, the EViews software is unable to process the data because of multiple reasons, such as the data not being considered a large sample size or the independent variables are more than the observed cross section observations. Therefore, the software may not provide data that is accurate and true. It is hoped that governments and firms can be more transparent in their approach of revealing data to streamline current and future studies.

Next, black swan events may cause unpredictable shocks to the world market. For example, the Covid-19 pandemic, the Russia-Ukraine war, and the Israel-Gaza war are considered black swan events that complicates the issue of accurately predicting gold prices or any prices in that manner because of how big these economies are in terms of specific resources.

5.5 Recommendations for Future Studies

There are a few recommendations to be suggested to further improve the overall gold price volatility of the study. One of the recommendations is to observe more countries and more periods. This study used five countries as cross-sectional data and 10 years as time-series data. Hence, this does mean that the study model follows exactly according to real world situations. Some important countries may be left out, resulting in inconsistencies when estimating the results of the study.

Another recommendation to be suggested is to utilize machine learning tools to aid in commodity modelling. This study used a historical data approach, which can be difficult to predict as commodity prices can now be quite unpredictable to forecast.

Through machine learning approaches, it is able to better capture nonlinear or complicated gold price dynamics.

The third recommendation could be to incorporate geopolitical events into the estimations of the study. This study uses macroeconomic and commodity prices to estimate the results. However, gold price, an asset for safe haven, also relies heavily on how good or bad the geopolitical tensions are. By adding geopolitical events into the equation, it may provide better test results and a better fit of equation modelling.

Furthermore, there may be unobserved seasonal factors that affect gold prices. For example, seasonal celebrations like Chinese New Year may increase the gold price compared to a few months ago. Also, central bank regulations and policies and mining regulations may hinder gold prices to a certain extent.

Moreover, spillover effects can affect gold prices in all countries. Since gold is an internationally traded commodity, a shock in one country can lead to global spillover effects. For example, a reduced supply of gold in China can significantly increase the price of gold due to a shortage of the commodity. This may have a misleading effect on the study.

5.6 Conclusion

Chapter 1 starts off with the concept of what the study is researching. The title for the study is "Exploring a Model for Volatility of the Gold Price among the World Gold Producing Countries". Then, the current situation of all the variables is determined. Next, the research questions, research objectives, and the significance of study are explored. Lastly, the chapter layout is used as a guide for later chapters.

Chapter 2 starts with the theoretical and empirical reviews of the study. Since gold is an internationally traded commodity, the theory of demand, theory of supply, and

equilibrium point between supply and demand is used for theoretical reviews. Then, for each of the variables of the study, at least 5 research articles ranging from 2021 to 2025 were used to verify the results.

Chapter 3 introduces the methodology of the study. The study uses the data of the five gold producing countries, which are Australia, Canada, China, Ghana, and the United States. The research methodology covered the collection and processing of data, the unit root tests, panel model selection, Granger causality analysis, cointegration analysis, residual diagnosis tests, and model evaluation and simulation.

Chapter 4 starts by descriptive analysis and the correlation analysis of the study, the panel unit root tests, which consists of the Levin, Lin and Chu unit root tests and the Im, Pesaran and Shin unit root test, and the residual diagnosis tests of the study. Furthermore, the study conducts the panel model data analysis, which is further differentiated into the Redundant Fixed Effect Model (FEM), the Omitted Random Effects Lagrange Multiplier, and the Hausman Test. Then, a Granger Causality analysis is carried out to determine any long-term trends between the variables, and a model evaluation is conducted.

Chapter 5 concludes by first summarizing the major findings of the study, including panel unit root tests, residual cointegration equations, which is the most appropriate model selection, and R-squared value. Residual diagnosis tests are also conducted to ensure that the observations are robust. Next, the hypothesis testing is also carried out, which shows that three of the five variables are significant in explaining the dependent variable. Then, the theoretical and empirical contributions are proposed for researchers to validate or refute theories that are relevant in the commodity sector. It also improves the critical thinking skills of inexperienced and experienced researchers alike. After that, the chapter also provides the limitations of the study as well as the recommendations for future research. Lastly, the conclusion is written for the entire study.

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