The role of gold as a safe haven against economic policy uncertainty in major economies

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Abstract

This research sought to understand the role of gold as a safe haven against economic policy uncertainty in the United States, Europe, China and Japan.

In 2008 the world stared into the abyss of credit fuelled economic ruin. The outcome of that crisis was further financial engineering on a massive scale. How long before the solutions to the previous disaster become the next disaster? In the face of this, does gold still play the role as a safe haven against EPU?

Extant literature has used the nascent economic policy uncertainty index (EPUI) to model the effect of United States (US) and European EPU on gold priced in US dollars, using multivariate linear regression (Jones and Sackley, 2016). The effect of EPU in China, Europe and Japan has not been tested, nor has a more advanced approach than linear regression been applied. This research set out to examine the role of gold as a safe haven in major economies: US, China, Europe and Japan. It did so expanding the multivariate linear regression approach of previous work with additional variables, and by estimating models using the ARIMAX methodology.

The study found evidence that gold was used as a safe haven against EPU in Europe, but not in the US or Japan. Further, evidence suggested that the Chinese economy dominates the gold price. The findings of this research have implications for gold mining companies, and investors and speculators, through the contribution to the understanding of drivers of the gold price. Moreover, this study highlighted the need for further research into the supply and demand dynamics of gold in China.

Keywords: Gold, Economic policy uncertainty, Safe havens, ARIMAX

Declaration

I declare that this research project is my own work. It is submitted in partial fulfilment of the requirements of the degree of Master of Business Administration at the Gordon Institute of Business Science, University of Pretoria. It has not been submitted before for any degree or examination at any other University. I further declare that I have obtained the necessary authorisation and consent to carry out this research.

David Nightingale

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Glossary

ACF	-	Autocorrelation function
ARCH	-	Autoregressive conditional heteroscedasticity
ARIMA	-	Autoregressive integrated moving average
ARIMAX	-	Autoregressive moving average with exogenous variables
CCF	-	Cross-correlation function
CCVF	-	Cross-covariance function
CHF	-	Swiss Franc
CNY	-	Chinese renminbi
CPI	-	Consumer price index
EMH	-	Efficient market hypothesis
EPU	-	Economic Policy Uncertainty
EPUI	-	Economic Policy Uncertainty Index
EPWB	-	Euro and British pound weighted basket
ETF	-	Exchange traded fund
EU	-	European Union
EUR	-	Euro
GARCH	-	Generalised autoregressive conditional heteroscedasticity
GBP	-	British pound
GFCF	-	Gross fixed capital formation
GOFO	-	Gold forward offer rate

IMF	-	International monetary fund
JPY	-	Japanese yen
LBMA	-	London Bullion Market Association
LIBOR	-	London interbank offered rate
MAE	-	Mean absolute error
MAPE	-	Mean absolute percentage error
MGARCH	-	Multivariate generalised autoregressive heteroscedasticity
MLR	-	Multivariate linear regression
PACF	-	Partial autocorrelation function
RLR	-	Recursive linear regression
RMSE	-	Root mean squared error, being the standard deviations of residuals from a regression
SwLR	-	Stepwise multivariate linear regression
UIRP	-	Uncovered interest rate parity
UK	-	United Kingdom
US	-	United States of America
USD	-	United States Dollar
VECM	-	Vector error correction model
VIF	-	Variance inflation factor
VIX	-	Chicago Board Options Exchange volatility index

CHAPTER 1 Introduction to the Research Problem

1.1 Research Title

The role of gold as a safe haven against economic policy uncertainty in major economies.

1.2 Introduction

Gold's fungibility, immutability, liquidity and scarcity are such that throughout history, it has held the status as a safe haven asset in the face of political and economic uncertainty. This status is critically relevant in the current global context where global markets operate in a finely balanced equilibrium between greed and fear. If the global financial crisis of 2008 has taught us anything, it is that the global economy persistently teeters at the edge of a debt-fuelled Armageddon. Rather than learn from the mistakes that led to the calamity wrought by unsustainable lending in the United States (US) housing market, developed economies reduced interest rates to levels near zero and flooded their financial systems with cheap money. Quantitative easing, as this technique was known, was reminiscent of the aftermath of the Chernobyl disaster in 1986. In the same way that the Soviet authorities hastily erected a flimsy concrete sarcophagus over the nightmare that their efforts to keep pace with the west had wrought, western governments hastily erected a flimsy veneer of stability around the global credit system following the meltdown of the US housing market of 2008.

Ever since the great depression which followed the 1929 stock market crash, the developed world's solutions to their financial crises have sown the seeds of their next crisis. The very people who we task to manage our economies seem remarkably incapable of doing so.

How can the conscientious investment manager preserve his clients' capital in the face of such uncertainty? What of the pensioners who wish to preserve the fruits of their labour? One would be hard pressed to consider the question of preservation in the face of calamity without reference to the role of gold as a safe haven (Baur & McDermott, 2010).

1.3 Gold as a safe haven

Safe haven assets have been defined as those which are negatively correlated to other assets in times of crisis (Baur & Lucey, 2010; Baur & McDermott, 2010). Safe havens can be distinguished from hedges, which have been viewed as assets with a negative correlation to other assets in non-crisis times, but which are positively correlated in times of crisis (Baur & Lucey, 2010).

As recently as fifty years ago, major economies such as the United States and those in Europe linked their currencies to gold under the Bretton Woods system (Eichengreen, 1996), and to this day gold still remains a key reserve asset of central banks. In the past twenty years China, now the world's second largest economy, has emerged as the nexus of global gold demand (World Gold Council, 2017a).

Gold remains a key source of safety in uncertain economic environments (World Gold Council, 2016), and the function that gold plays as a safe haven against economic uncertainty has been the subject of ongoing research (Bernanke, 1983; Levin & Wright, 2006). Such research has however faced the challenge of quantifying economic uncertainty in an effective manner. To meet this challenge, Baker, Bloom and Davis (2016) have developed an index of economic policy uncertainty (EPU) which has provided an empirical quantitative measure of EPU. The index views EPU through the lens of monetary policy uncertainty, fiscal policy uncertainty, and perceived uncertainty surrounding taxation and government spending. Baker, Bloom and Davis' (2016) study, and the index developed by the authors has already been of interest to those seeking to model the relationship between gold and uncertainty pursuant to understanding gold's role as a safe haven (Jones & Sackley, 2016).

This research seeks to make a methodological contribution to the body of knowledge by developing on previous work conducted on gold spot prices and US EPU (Jones & Sackley, 2016). The development undertakes to improve on the explanatory power of Jones and Sackley's (2016) models, by modelling the effect of EPU on gold futures (specifically the 3-month NYMEX gold future contract) and incorporating EPU volatility as an independent variable.

This research goes further to expand the geographical scope of the understanding of gold's use as a safe haven by modelling the relationship between gold spot prices and EPU in China, the European Union (EU) and Japan. And finally, it seeks to expand on the explanatory power of the regression approach used by Jones and Sackley (2016) by estimating an autoregressive integrated moving average (ARIMA) based multivariate forecasting model for the price of gold using EPU as a key predictor variable.

In 2017 dominant economic narratives in major economies included Brexit and the potential for other nationalist movements across Europe to force secession of their countries from the EU (Sampson, 2017; Seal & Pakiam, 2017). The forthcoming fiscal reforms in the US (Seal & Pakiam, 2017), and the looming debt crisis in China (Cuestas & Regis, 2018) also featured in the global narrative. Any of the contemporaneous tensions could result in another global economic crisis with disastrous consequences. In this environment, research into gold's potential as a safe haven can have critical benefits for the effective preservation of capital.

1.4 A historical perspective of gold as money

For centuries gold has played a role in monetary systems (Barro & Misra, 2016), not only as a store of value and a universal medium of exchange, but also as a means of underpinning the value of government issued money (Farhi & Maggiori, 2016).

During the 18th century, currencies such as the British pound (GBP) which were exchangeable for gold at a fixed rate, had a sense of intrinsic value (Eichengreen, 1996; Morys, 2014), which derived from gold's fungibility, immutability, liquidity and scarcity. Money, exchangeable for gold at a fixed rate, meant that central banks could only print and issue an amount of money equal to the amount of gold in their vaults multiplied by the fixed rate that the bank determined (Eichengreen, 1996).

It is worth noting that despite the apparent adherence to the gold standard in the 19th and early 20th centuries, fractional reserve banking was very much in evidence. As a lender of last resort, central banks were expected to supply additional liquidity beyond the amount of gold held in their vaults (Eichengreen, 1996).

The outbreak of World War I resulted in the collapse of the international gold standard which had existed since the 1870's (Eichengreen, 1996), although the Bank of England only officially ended sterling-to-gold convertibility in 1931 (O'Connor, Lucey, Batten, & Baur, 2015). Through the interwar years, and under the Bretton Woods system after World War II, major countries strove to reintroduce gold-backed money. These attempts ultimately failed and following the closure of the gold window (as the event when US President Nixon's administration began refusing to redeem US dollars (USD) for gold was known) in the early 1970's, the world's economy operated almost exclusively with fiat money.

Fiat money is currency that is issued under the authority of governments and central banks and is not backed by a commodity (Friedman, 2008). With money no longer backed by gold, its value is underpinned by the market's confidence in the issuing authority (Y. S. Kim & Lee, 2017). The confidence in the issuing authority in turn is determined by factors such as fiscal and monetary policy, politics, greed, and fear (Y. S. Kim & Lee, 2017).

The result of the decline of the gold standard through the 20th century and the eventual implementation of fiat currency has seen the rise of monetary policy primarily as an instrument of moderating inflation (Eichengreen, 1996). Money no longer represented debt held by citizens, against a central bank, settleable in gold. The implication of fiat money for central banks with the best intentions was that they were able to issue as much money as they saw fit to stimulate growth in their economies. Moreover, they could dictate the cost of that money to borrowers through their role as a lender of last resort to their banking systems (Friedman, 1968).

Despite Friedman's (1968) best intentions, governments and central banks with a flagrant disregard for their economic stability were able to finance their deficits through reckless seigniorage (as the excessive printing of money to fund government expenditure is known (Miles, Scott, & Breedon, 2012)) to the point where their currencies were completely valueless. Zimbabwe in the 2000's (Hanke & Kwok, 2009) and Venezuela at the time of writing (Smith, 2017) are the most recent case studies that demonstrate the degree to which hyperinflation resulting from seigniorage can devastate an economy.

Gold has the potential to provide a safe haven in the face of both short- and long-term monetary uncertainty. Monetary policy announcements have been found to be the subject of significant information asymmetries which introduce uncertainty into currency markets (Mueller, Tahbaz-Salehi, & Vedolin, 2017). Market participants with lower appetites for risk may wish to seek a hedge, or safe haven, against such monetary policy uncertainty. Furthermore, ordinary people may wish to protect their savings and their pensions against inflation-fuelled decimation as seen in Zimbabwe and Venezuela.

This research does not argue in favour of the reintroduction of a global gold standard, as the researcher is well aware of the severe limitations of the gold standard system exemplified by the failures of both the pre-war gold standard and the Bretton Woods system. The gold standard that was introduced following the Napoleonic Wars was exposed when central banks held gold in excess of the levels that would ensure the automatic functioning of the system (Cassel, 1966). During the international gold standard period from the 1870's to 1914, central banks needed to set rates and control money supply (Cassel, 1966). The Bretton Woods system proved to be equally difficult to effectively implement.

1.4.1 The Bretton Woods System: A final encore for the gold standard

Following World War II, the US was the last country to equate their currency to gold, and many major currencies' exchange rates were fixed to the USD under the Bretton Woods system (Eichengreen, 1996; Mikesell, 1994). Participants in the Bretton Woods system included the majority of the world's major economies including the Soviet Union, Japan, China and those of Europe. The effect of this was that the bulk of the world's economy was adhering to a de facto gold standard.

This arrangement became increasingly difficult to maintain in the 1960's due to the US's chronic balance of payments deficit (Fukumoto, 2011). Further pressure was constantly placed on the system by countries testing the effectiveness of the capital controls set out in the Bretton Woods agreement (Eichengreen, 1996).

The system finally collapsed in 1971, when the US was no longer willing (or indeed able) to settle foreign debt with gold, an event known as the closing of the gold window (Fukumoto, 2011). Subsequent to these events real exchange rates were ultimately allowed to float freely, and the currencies and their underlying economies became exposed to both aggregate demand shocks (Valcarcel, 2013) and monetary policy shocks (Mueller et al., 2017; Valcarcel, 2013).

The collapse of the Bretton Woods fixed exchange rate system introduced an element of uncertainty, greed, and fear into the global macroeconomic landscape. With gold no longer backing currency but still freely available, it took on the role that has become familiar today: that of a safe haven against uncertainty, shocks and turmoil.

1.4.2 Arguments against gold as an investment

The view that gold is an investment is not universally held. By the standards of value investing, gold amounts to a speculative asset. Value investing favours exploiting information asymmetries to obtain cheap assets that yield excellent operational cash flows (Marks, 2011). Gold yields no free cash flow. Indeed, much of gold's attraction as an investment is based on its response to fear (Wasik, 2016). According to Warren Buffet:

> *"Gold is a way of going long on fear, and it has been a pretty good way of going long on fear from time to time. But you really have to hope people become more afraid in a year or two years than they are now. And if they become more afraid you make money, if they become less afraid you lose money, but the gold itself doesn't produce anything."* (as cited in Cline, 2015, p. 203).

Both Wasik (2016) and Buffet (as cited in Cline, 2015, p. 203), undermined gold's role as an investment, but suggested that its use as a safe haven when fear dominates the political and economic narrative persists. Buffet alluded to an element of irrationality in holding gold in the long term as a means of building wealth, and this view is supported by empirical quantitative research by Bauer and McDermott (2010) who found that gold is subject to short-term panic buying in the face of specific crises, but that its actual effectiveness in hedging against losses in the face of global systemic crises is limited.

The question then remains: is fear the basis of developing an effective short-term trading strategy in gold, thus taking advantage of the safe haven seeking behaviour of a market panicked by uncertainty shocks?

1.5 Research motivation and problem

In the long term, gold is found to have a rate of return close to the US risk free rate and has no significant covariance with changes in macroeconomic consumption (Barro & Misra, 2016). This confirms its long run suitability as a hedge against inflation and recessions. The work of Valcarcel (2013) found a link between aggregate demand shocks and currency shocks and this, coupled with the view from Barro and Misra (2016) that gold is uncorrelated to these shocks, would appear to support the view that gold is a suitable safe haven, and remains to many the ultimate store of value.

What is less well known is gold's suitability as a safe haven against economic shocks in the short run. A negative correlation has been shown to exist between gold and the USD (Reboredo, 2013), the implication of which is that when the USD declines against other currencies, gold enjoys increased demand, implying a move of US investors into a safe haven. Nevertheless, gold still attracts much attention in times of crisis (CNBC, 2017; Fortune, 2017; Seal & Pakiam, 2017), and the short term effects of geo-political shocks, combined with economic policy shocks provide an opportunity for speculators to profit from trading in gold and gold derivatives.

With China now representing 13% of gross world product (World Bank, 2017), and the same share of global exports (Reuters, 2016), the Chinese renminbi (CNY) presents an increasing threat to the dominance of the USD as the global currency of trade and reserve. As China continues to attempt to exert control over global trade with their introduction in 2017 of gold backed oil futures contracts (Jegarajah, 2017). Should trade in the "Petro-Yuan" gain traction, this would amount to a gold-buy/dollar-sell. Such a shift in the trade in the world's largest commodity market (the annual oil market amounted to $1.75 trillion, in 2016, larger than all metals markets combined (Desjardins, 2016)) would reduce the importance of the USD in the global economy thus exposing it to shocks stemming from reckless monetary policy.

The decline in US dominance is concerning for a sovereign entity carrying $20 trillion in debt (Cox, 2017) (this represents over 100% of US GDP (World Bank, 2017)). Moreover, US sovereign debt is projected to grow by 25% to over $25 trillion by 2022 (Statistica, 2018), and may lead to severe instability in the US economy. While interest on US debt currently accounts for 6.8% of the US budget compared to 16% in the 1990's (DeSilver, 2017), this comparatively low level must be viewed against the backdrop of negligible interest rates that have accompanied the quantitative easing that followed the global financial crisis. Should US interest rates begin to rise, the federal deficit could widen substantially, resulting in a spiral of credit downgrades and higher rates which would be transmitted to the private sector, thus reducing growth and increasing risk.

The US economy is a finely balanced machine with millions of different moving parts which are extensively integrated with the global economic system. One can but speculate as to the effect that US President Donald Trump's administration's dramatic tax cuts announced late in 2017 (Hirschfeld Davis & Rappeport, 2017) may have on the US economy. The Trump administration may expect the massive stimulus package to drive growth the likes of which the US economy has not seen since the Clinton era between 1992 and 2000, which peaked at 5% (Mankiw, 2001).

One must question what effect the Trump administration's tax reforms may have on the fiscal health of the US. President Trump conveniently forgets how cutting taxes in the 1980's led to a substantial widening of the fiscal deficit (from approximately $70 billion up to 1981, to $221 billion in 1986 (U.S. Office of Management and Budget, 2018)). The misunderstanding of the expansionary effect of tax cuts on the broader economy plunged the US into an era of persistent fiscal deficits (Abell, 1990) which has resulted in US sovereign debt reaching $20 trillion by 2017 (Cox, 2017). What effect then will these developments have on US sovereign debt?

The next US debt crisis is likely to have a spill over to the global financial system as was seen in the 2008 global financial crisis (Ozkan & Unsal, 2012). With a possible cause of such a crisis being a general move away from the USD and towards Chinese gold backed instruments, the prospects for gold are positive under such circumstances, and it may provide an effective safe haven for investors: a golden chair for when the music of the global credit system stops.

With US treasury securities being so widely held globally, including by many other US government departments (DeSilver, 2017), the US only needs to default once for a calamity to rip through the global financial system. But the US probably will not default, since using fiat currency affords the federal reserve the power to simply finance debt by printing money. The US can avert such an acute catastrophe, and in so doing they would destroy the world's confidence in the dollar, thus ending its role as the global reserve currency.

In the absence of a move back to the gold standard, those who seek the stability and safety of a gold backed currency can easily take positions in gold itself or in many easily accessible derivative forms: exchange traded funds (ETF's) (Ivanov, 2013), gold futures (Brooks, Rew, & Ritson, 2001), or gold options. Thus, movements in the price of gold could provide evidence of such safe haven-seeking by investors.

Levin and Wright (2006) sought to build a forecasting model for gold which incorporated measures of political uncertainty on a global scale with the inclusion of binary variables to indicate economic policy shocks. Studies involving economic policy uncertainty (EPU) were given a quantitative tool with the development by Baker, Bloom and Davis (2016) of an EPU index, which is published by the authors at http://www.policyuncertainty.com. The EPU index provided a new avenue of research for Jones and Sackley (2016), who modelled the effect of short term economic policy uncertainty shocks on the price of gold.

Jones and Sackley (2016) used Baker et al.'s (2016) Economic Policy Uncertainty Index (EPUI) for the US and the European Union (EU) to extend Levin and Wright's (2006) model. Jones and Sackley (2016) showed that gold does respond to economic policy uncertainty, and this resulted in a model with an R^2= .208. Jones and Sackley (2016) concentrated their research on the US and the EU, however they did not find a relationship between EU EPU and gold. Jones and Sackley (2016) highlighted as a need for further research, testing EU EPU's effect on the euro (EUR) price of gold.

Levin and Wright (2006) as well as Jones and Sackley (2016) concentrated their studies on US shocks and EPU, and this provides a further avenue of new research into the effect of other major economies EPU on their respective local currencies gold price. The fourth research objective of this study (outlined in section 1.8) seeks to determine the extent of the relationship between EPU in China, Europe and Japan(which, together with the US, account for 65% of the world's economy (The World Bank, 2017)), and the price of gold in local currencies in those countries or regions.

Finally, Jones and Sackley's (2016) analysis concentrated on gold spot prices as a dependent variable. Gold futures on the other hand are exposed to other variables besides the price of their underlying asset (Pindyck, 2001). In futures markets, spreads from the underlying spot price are known as backwardation in cases where futures prices are below their underlying asset spot price, and contango in cases where the futures price exceeds the underlying spot price (Kolb & Overdahl, 2006). It is the purpose of the second and third objectives of this research to determine the extent of the relationship between gold futures and US EPU. It is critical to our understanding of gold’s role as a safe haven to know if investors and speculators readily move positions into gold and gold backed securities such as futures in response to events of economic policy uncertainty.

1.6 Motivation of this research in the South African context

Ever since an outcrop of gold bearing rock was discovered on a windy “koppie” in 1886, in what was at the time the Transvaal colony (City of Johannesburg, 2017), South Africa and the Witwatersrand have been synonymous with gold. This ubiquity is illustrated by Johannesburg’s isiZulu name, Egoli – City of Gold. This association is not without good reason: Over 62,000 tonnes of gold have been extracted from the Witwatersrand basin (Chamber of Mines South Africa, 2017b), which amounts to approximately one third of the estimated 187,000 tonnes of gold mined throughout recorded history (World Gold Council, 2018b). Given the importance of gold to the South African economy, its role as a safe haven in the global context is of critical importance to the country. This section elaborates on the current state of South African gold mining to illustrate how this research will be of importance.

It could be argued that South African gold mining is a shadow of its former self. From being the world’s largest gold producer in 1995 by a comfortable margin, having produced 522 of the 2174 tonnes mined globally that year (World Bank Group, 2017), South Africa’s production has averaged 152 tonnes since 2012 (World Bank Group, 2017).

A range of factors have been cited for this decline in the country’s status as the world’s gold supplier: HIV/AIDS impact on the mining workforce (Engineering & Mining Journal News, 2010), the unreliable supply of electricity (Engineering & Mining Journal News, 2010), political and economic uncertainty in South Africa (Cropley & Flak, 2011), orebody exhaustion (Engineering & Mining Journal News, 2010), and historic tensions between communities and mines (Cropley & Flak, 2011). Gold mining in South Africa has seen minimal investment in new infrastructure, with the only new project in the past decade being Gold Fields’ South Deep operation (Engineering & Mining Journal News, 2010). Indeed, the investment narrative around South African mines’ boardroom tables lately has been around decisions to curtail, rather than to expand (Engineering & Mining Journal News, 2010).

These challenges are deepened by the standoff between the South African Department of Mineral Resources and the mining industry over the 2017 Mining Charter. Some argue that the radical changes that the charter seeks to implement to mine ownership and profit sharing would completely throttle investment in the industry (Chamber of Mines South Africa, 2018b).

Yet, some facts about gold production in South Africa must be noted:

- The Witwatersrand is still home to the world's largest gold deposit (Chamber of Mines South Africa, 2017b);
- Gold producers paid R1.6bn in taxes in 2014 (Chamber of Mines South Africa, 2017b);
- Employees of gold mining companies in South Africa were paid R23.4 billion in 2014 (Chamber of Mines South Africa, 2017b). The personal income tax collected on this is not disclosed however if all this was paid to workers who earn the minimum level of R13,435 per month (Chamber of Mines South Africa, 2017b) it exceeds R2 billion based on a rudimentary calculation. The reality is that many in the mining industry earn far more than this (van Niekerk, 2015), and it is reasonable to infer that highly paid executives in the mining industry swell this tax contribution substantially.

Based on these points, while its importance to the gold market on a global scale has declined, gold remains a crucial component of South Africa's economy. Indeed mining as a whole in South Africa is a crucial component of the economy, employing close to half a million people each of whom support up to nine dependants (Chamber of Mines South Africa, 2018a). Further, it is reasonable to argue that the mining sector aside from gold is thriving, despite the challenges facing the industry: Gross fixed capital formation (GFCF) attributable to mining rose from R40 billion in 2007 to R93 billion in 2016 (Chamber of Mines South Africa, 2017a). The level of importance of this investment is clearer when viewed against South Africa's overall private sector GFCF between these two periods: R307 billion in 2007, and R519 billion in 2016. Despite the time of crisis for the industry, mining has grown its total contribution to South Africa's annual private sector GFCF from 12.6% in 2007 to 17.9% in 2016.

Decisions to invest in projects are driven by economics. Business leaders must constantly ask themselves: does the value of a project's future cash flows exceed the amount of money invested to produce those cash flows (Koller, Goedhart, & Wessels, 2015)?

Future cash flows at their most basic level are a function of the price an entity can realise for its product, the amount of product it can deliver, and the cost of delivering that product (Koller et al., 2015). The price a mining operation can achieve for its product is dictated by the market, and the amount of product that is available to be sold, in accounting terms, is dictated by accounting standards (the International Financial Reporting Standards in South Africa's case (Graham & Winfield, 2010)) as the amount of the commodity that can be extracted profitably at the contemporaneous price (Graham & Winfield, 2010). The size of the investment required to establish new deep-level gold mining operations is also of grave importance with payback estimates ranging from 10 to 50 years depending on ore grades, and gold prices (Neingo & Tholana, 2016). Given the huge investment required to exploit gold in the Witwatersrand basin, and the role of price in the calculation of proven reserves, it is argued that a critical input variable to the investment decision-making process, for both current and future mining projects, is a reliable forecast of future prices.

Unfortunately, this research does not undertake to alleviate HIV/AIDS' effect on productivity, or political uncertainty in South Africa. It does not seek to develop a new way to bring workers and mine bosses together in harmonious industrial relationships. Nor does it seek to convince mining companies and their investors of the long-term benefit of working with communities in a meaningful way. And it does not express a view on whether gold mining in South Africa should continue or be curtailed permanently.

This research has, as its central purpose, an elevated understanding of the role of gold as a safe haven in major economies, with the goal of providing the foundation for an improved forecasting model to better drive investment decisions involving scarce capital. To be clear, these investment decisions may seek to allocate capital to new gold projects, or to existing projects (for the purpose of sustaining them though periods of losses). Alternatively, the decisions may relate to shutting down operations permanently and allocating capital to more profitable undertakings which mine other commodities, and which may be of greater benefit to South Africa.

Given the arguments made in this research concerning US and Chinese debt, and the fine balance of credit markets that are constantly on the brink of crisis, South Africa's gold reserves provide a unique long-term opportunity for the country. Even continuing to mine unprofitable gold deposits now may amount to a strategic investment in the future. Subsidised or nationalised gold mining for the purpose of establishing strategic gold reserves may be prudent if models suggest that uncertainty and safe haven seeking in the global economy could drive the value of gold held by the South African reserve bank to stratospheric levels.

In short, it is one of the motivations of this research to provide analytical tools for decision-makers, whose decisions may include investments to tap South Africa's still-massive gold resources.

1.7 Research purpose

The purpose of this quantitative research paper is to investigate the role played by gold as a safe haven against economic policy uncertainty by adopting a positivist paradigm. The intent of the study is to make a methodological contribution to previous work by Jones and Sackley (2016).

These contributions will be achieved in the following manner:

- By expanding the set of variables used: EPU volatility will be added as an independent variable to the study, while gold futures prices will be investigated in addition to gold spot prices.
- By expanding the geographical scope: The geographical scope of the study will be expanded from the US only, to include China, Europe, and Japan.
- By using a more sophisticated analytical technique: This study will adopt the same multivariate linear regression analysis used by Jones and Sackley (2016), however it will also use an autoregressive integrated moving average model with exogenous variables (ARIMAX) estimation approach to add a greater level of precision pursuant to developing a forecasting model for gold prices.

A forecasting model developed from the outcome of this study may be of use to analysts, speculative traders, developers of high frequency trading algorithms, and long-term investors (including gold mining firms in South Africa and abroad), whose profits can be improved with a better understanding of the market.

1.8 Research objectives

The purpose of this paper is to develop a better understanding of the use of gold and gold futures as a safe haven in the event of economic policy shocks by using Jones and Sackley's (2016) model as a term of reference.

In support of this purpose the following objectives were set:

1. Determine whether the addition of EPUI Volatility to the multivariate regression model developed by Jones and Sackley (2016) described the relationship between EPU and gold spot prices, and thus the use of gold as an EPU safe haven asset, better than the original model (the subject of hypothesis 1, outlined in Chapter 3).

2. Determine whether estimating Jones and Sackley's (2016) model with its original set of variables against gold futures produces a better multivariate regression model, thus indicating that gold futures are a better safe haven against EPU (the subject of hypothesis 2, outlined in Chapter 3).

3. Determine whether the addition of EPUI Volatility to the multivariate regression model estimated by Jones and Sackley (2016) describes the relationship between EPU and the price of gold futures as a dependent variable, and thus the use of gold as an EPU safe haven asset, better than the original model does by using the spot price of gold as a dependent variable (the subject of hypothesis 3, outlined in Chapter 3).

4. Pursuant to the avenues for further research in Jones and Sackley (2016), EPUI was modelled against gold spot prices in domestic currency, using multivariate regression, in Europe, China and Japan, which together constitute over 60% of the world's GDP (World Bank, 2017). These tests were performed to determine whether or not a statistically significant relationship existed between EPU in major economies outside the US and the price of gold (the subject of hypothesis 4, outlined in Chapter 3).

5. In an effort to develop a more robust understanding of the nature of the relationship between EPU and the price of gold, an ARIMAX (Andrews, Dean, Swain, & Cole, 2013; Ďurka & Silvia, 2012) was estimated using the best fitting set of variables from the previous four hypotheses (Andrews et al., 2013). This test was performed to determine whether or not a methodology incorporating autoregressive (AR) and moving average (MA) terms could produce a more statistically significant model, or one with better explanatory power, than those estimated with multivariate linear regression (the subject of hypothesis 5, outlined in Chapter 3).

Exploring these research objectives may contribute to a better understanding of economic policy uncertainty's role in the price of gold and gold futures. In so doing, this contribution, it is proposed, will fulfil the purpose of this research by deepening the understanding of gold's use as a safe haven against EPU.

Moreover, the estimation of a model with greater explanatory power than those developed by Levin and Wright (2006) and Jones and Sackley (2016) may provide a better means of forecasting future gold prices.

1.9 Scope of the research

This study will focus on the US, the European Union (EU), China, and Japan, which, as at 2016 collectively account for 62% of the world's GDP (World Bank, 2017), two thirds of gold reserves (World Gold Council, 2017a), and the bulk of global gold demand (World Gold Council, 2017a).

Monthly EPUI's are published for India, Brazil, Canada, South Korea, Russia and Australia, allowing the study to round out the top 10 largest economies in the world (given that the EU is treated as one economy). Extending this study to these countries would account for a further 13% of gross world product, however obtaining certain control variables for some of these economies may prove to be problematic. In addition to the availability of control variables, the limited timeframe to execute this study (from November 2017 to February 2018) led to the decision to focus only on the US, China, Europe and Japan.

The time scale for the study shall encapsulate 20 years beginning January 1997 and ending December 2016. The starting date of 1997 was chosen to align the study with the prior work of Jones and Sackley (2016). The end date of 2016 was chosen to allow out-of-sample tests to be performed with 2017 data. The research is constrained on the following principle, *ceteris paribus*, whereby the laws of economics transposes human nature in application and execution.

1.10 The data: An introduction

This section seeks to introduce the recent history of the gold price and the EPU indices in order to tie together the interaction between EPU and movements in the price of gold. The section focuses on the timeframe following the collapse of the Bretton Woods system in the early 1970's (Reinhart & Rogoff, 2009) and it carries through to 2016. The discussion encapsulates the period when major economies' currencies began to move independently of gold as a result of monetary policy and economic shocks and serves to provide a background to the price history of gold, and the scaling and movements of the EPU indices for the US, EU, China and Japan. Sub-Section 1.10.3 seeks to provide some background between the coincidences of economic policy uncertainty and rising gold prices.

1.10.1 The gold price since 1970

Through much of the period after the end of World War II up until 1970, gold traded at $35 per ounce, thanks to the Bretton Woods system, under which the USD was linked to the value of gold (Abrams & Butkiewicz, 2017; Cogley & Sargent, 2015). Following the events of the early 1970's when Nixon's administration closed the gold window, exchange rates of major countries were allowed to float freely, and inflation became a persistent feature in the global economy.

Figure 1 *Gold Prices, 1970 to Present with specific high prices indicated*

Data Source: US Federal Reserve

Thus, *Figure 1* details the price of gold, both in nominal and inflation adjusted USD, from 1970 to the present day. The gold price has experienced two periods of rapid growth since 1970, one which culminated in a price of $843 on 21 January 1980, and another culminating in a price of $1 869.50 on 5 September 2011. It is worth noting the effect of US inflation on the gold price. Discounting the gold price for the effects of US inflation has a profound effect on the real gold price, with the high of 2011 being slightly lower than that of 1980 in real terms. This is consistent with Barro and Misra's (2016) finding that gold is a long run hedge against inflation. Notwithstanding this, the fact remains that over the period from 1970 to 2017, gold has provided positive returns after discounting inflation.

The drive to the record high of January 1980 was driven by a combination of factors including double-digit inflation in most large economies through the 1970's (Davig & Doh, 2014), Soviet involvement in Afghanistan, and relatively high oil prices. Oil throughout the 1970's was dominated by manoeuvrings by OPEC including the 1973 oil embargo (Baumeister & Kilian, 2016), while the Soviet-Afghan conflict resulted in major geopolitical uncertainty, at the height of the cold war.

The high of 2011 was in large part due to the boom in demand from an increasingly wealthy China (Hewitt, Street, Gopaul, & Cheng, 2014), which rose from relative economic obscurity in 1980 to the world's second largest economy by 2016. The World Gold Council reports that the China Gold Association estimate of demand in that country has risen from under 500 tonnes per annum in 2009 to close to 800 tonnes in 2011 (Hewitt et al., 2014).

That said, this research paper specifically deals with short term shocks. The necessity for a controlled study into the interaction between these shocks and the price of gold will be introduced in section 1.10.3, before receiving extensive quantitative analysis as outlined in the purpose and objectives of the study.

1.10.2 Economic policy uncertainty

This research seeks to model the relationship between gold prices and EPU using the measures developed by Baker, Bloom and Davis (2016), for the US, China, Japan and the EU for the purpose of investigating the role of gold as a safe haven. The EPU indices are constructed by mining keywords from news articles in major publications in the respective regions (Baker et al., 2016).

1.10.2.1 Economic Policy Uncertainty in the United States

The US EPU Index (EPUI) is produced daily using over 1000 newspapers and these range from large national to smaller local publications (Economic Policy Uncertainty, 2012d).

Figure 2 details the US Daily EPUI for the period of this study, from 1997 to 2016. The index has a mean of 99.39, which is roughly equivalent to the baseline of 100 when the index was established. Index values are not normally distributed and a Box-Cox transformation (Box & Cox, 1964; Sakia, 1992) with $\lambda=0$ was performed to produce a normal distribution for the purposes of determining which EPUI values lie above a 99% confidence level. Values that lie above the 99% confidence interval are marked on *Figure 2*. Eleven specific instances are described in the remainder of this section.

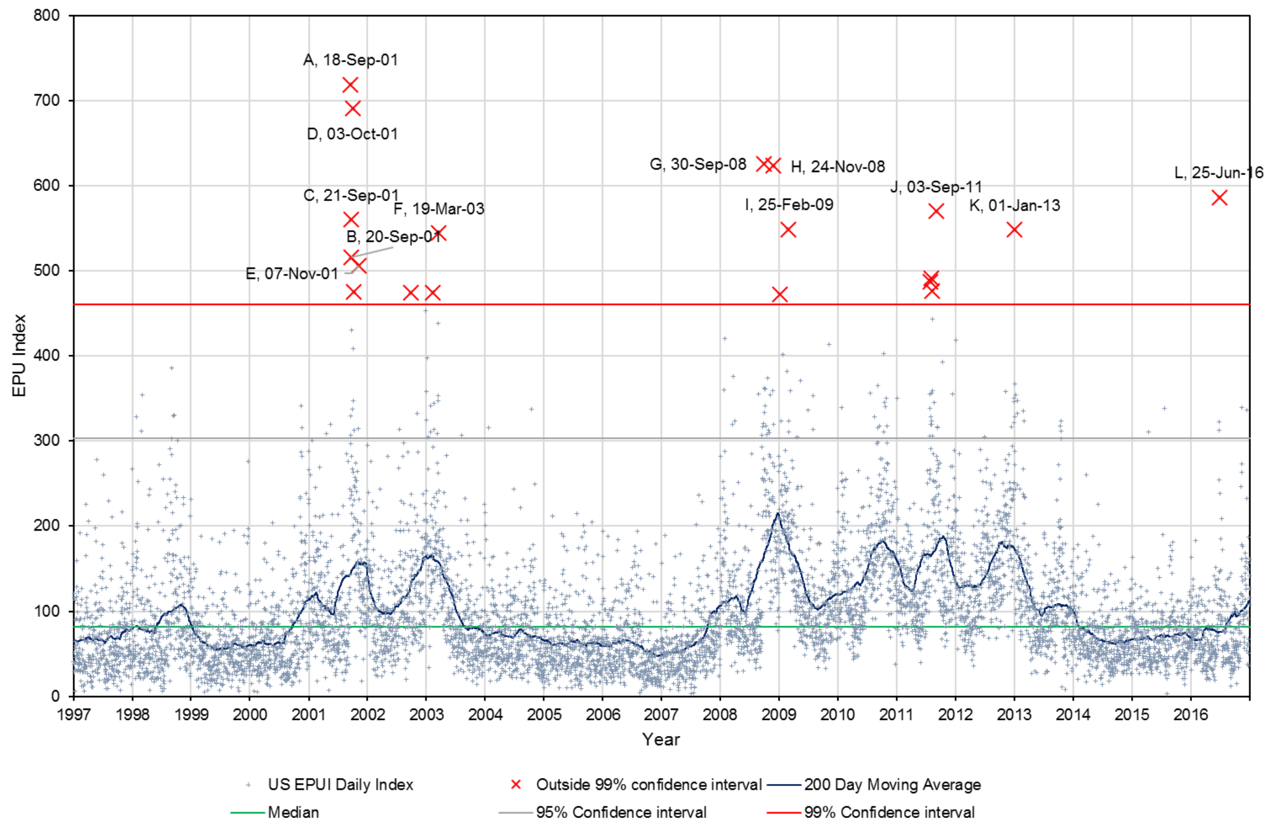


Figure 2 *US Daily economic policy uncertainty index, 1997 to 2016. Specific instances of high EPU are indicated*

Source: http://www.policyuncertainty.com/us_daily.html

The cluster of outliers in late 2001, marked as A through E, closely align with the aftermath of the 9/11 terror attack. The attack, and the US' response, took place in the midst of a recession caused in part by the collapse of US technology stock prices in March 2000 which resulted in a global equities selloff (Griffin, Harris, Shu, & Topaloglu, 2011). The US' response to 9/11 included engaging in a progressive increase in foreign military deployment (starting with Afghanistan in early October 2001), as well as policies such as the hastily implemented Patriot Act (Mugarura, 2016). The wide-ranging provisions of the Patriot Act, the purpose of which was ostensibly to protect the US from future terror attacks on home soil (Whitehead & Aden, 2002), have been found by Mugarura (2016) to have contributed to an increase in uncertainty and suspicion of interference in individual freedoms in the US.

Point F on *Figure 2* corresponds with the US invasion of Iraq on 20 March 2003 (Fox, 2009). Fox (2009) studied the effect of the Iraq war on the approval rating of US President G.W. Bush and found that Bush's public approval declined in part due to the US' declining economic performance. Is it possible that the declaration of war was seen by the public at large as an event of economic uncertainty? A further factor in any military action in the Persian Gulf is the effect on the supply and price of crude oil (Lu, Hong, Wang, Lai, & Liu, 2014) and its resulting negatively correlated effect on energy costs and US economic output (Lippi & Nobili, 2012).

Point G took place on 30 September 2008 amid the chaos that followed the collapse of Lehman Brothers Holdings Inc. Lehmans' bankruptcy filing was (and remains at the time of this research) the largest in US history. The widespread liquidity crisis that ensued necessitated many developed market governments intervention in their banking systems, either by nationalising distressed banks, or providing cash bailouts, or in many cases, both (Guillén, 2009).

Point H took place on 24 November 2008, amid widespread speculation (later confirmed the following day) that the US would cut interest rates to near zero levels and buy back bonds en-masse to provide liquidity to banks and to bolster a stalling economy, in a technique known as quantitative easing (Guillén, 2009). Quantitative easing had the effect of inflating central bank balance sheets in the US and Europe (Guillén, 2009). Some argued that the excess of liquidity and cheap money could lead to reckless financial behaviour (The Economist, 2015).

Point I, in late February 2009, aligns with continued declines in global equities markets following the turmoil of the previous quarter and the height of the global financial crisis of 2008. The crisis culminated in the worst start to any year for US stocks in history. The S&P500 dropped over 18% at the beginning of 2009 (Standard & Poors, Dow Jones, 2017) while US banks lost close to 40% of their market capitalisation in the same period.

The points marked J and K correspond to uncertainty surrounding the US government debt ceiling crises in 2011 (Fanning, 2016) and 2013 (Nippani & Smith, 2014), where US borrowing had approached its congressionally approved limit known as the debt ceiling. While policy was set by the administration of the Democratic Party's US President Barak Obama, the Republican controlled House of Representatives held the government's purse strings, leading to substantial economic uncertainty in the US (Fanning, 2016; Nippani & Smith, 2014).

Finally, point L on 25 June 2016 follows directly after the unexpected result of the United Kingdom (UK) referendum to leave the European Union (EU), known colloquially as Brexit. The event serves to illustrate the extent to which local events can have economic policy impacts on a global scale. Contagion from Brexit is speculated in include an impact on US stocks (Gensler, 2016) and cross-border trade agreements (Obstfeld, 2016).

Modelling the effect of US EPU on the gold price is the subject of research objectives 1, 2 and 3 set out in section 1.8. Understanding the role of gold as a safe haven against EPU in the US is important because of the scale of that economy and the heterogenous views that exist in the US's rich political and economic landscape.

1.10.2.2 Economic Policy Uncertainty in the European Union

The European measure of EPU developed by Baker, Bloom and Davis which is published at http://www.policyuncertainty.com/ is constructed using two large newspapers from each of Europe's largest five economies by GDP (Economic Policy Uncertainty, 2012b), being Germany, the UK, France, Italy and Spain (World Bank, 2017). With reference to the components of the European EPU index, the UK public had voted in a referendum to leave the EU on 23 June 2016 and the UK government subsequently filed an Article 50 (as the statutory procedure to commence the exit process of a country from the EU is known). However, at the time of writing and for the scope of the research the UK remains part of the EU, and thus, it remains a subject of this research.

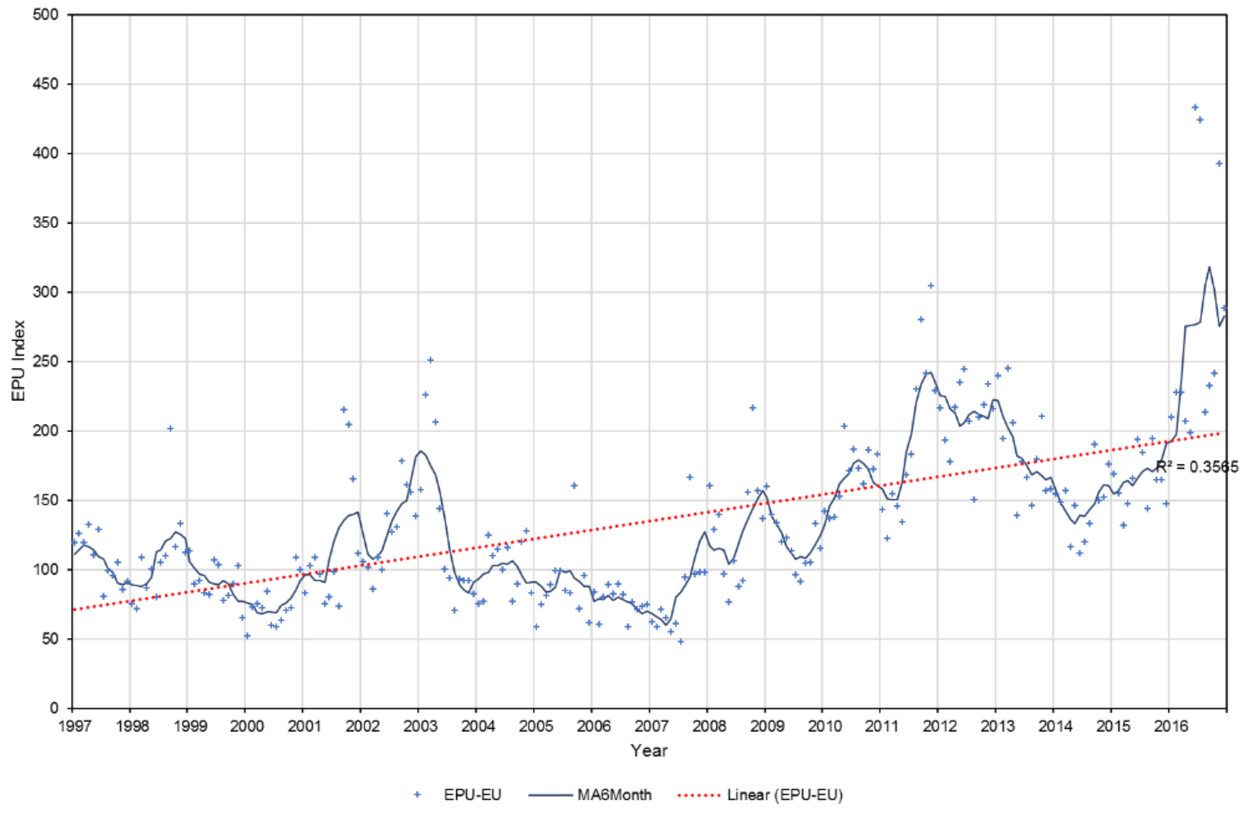


Figure 3 *EU economic policy uncertainty index, 1997 to 2016*

Source: http://www.policyuncertainty.com/europe_monthly.html

Given the relatively small size of the news sample for the EU (10, as opposed to over 1000 for the US) the EU EPUI is published monthly. Unlike the US EPUI described above, the EU EPUI displays an upward trend, as illustrated in *Figure 3*.

To highlight outliers in the data, the index has been converted to log returns to remove the trend. This transformation resulted in a series that was found to be stationary beyond a 95% confidence level. *Figure 4* illustrates EU EPUI Log returns with seven key events highlighted, and these are discussed in the remainder of this section.

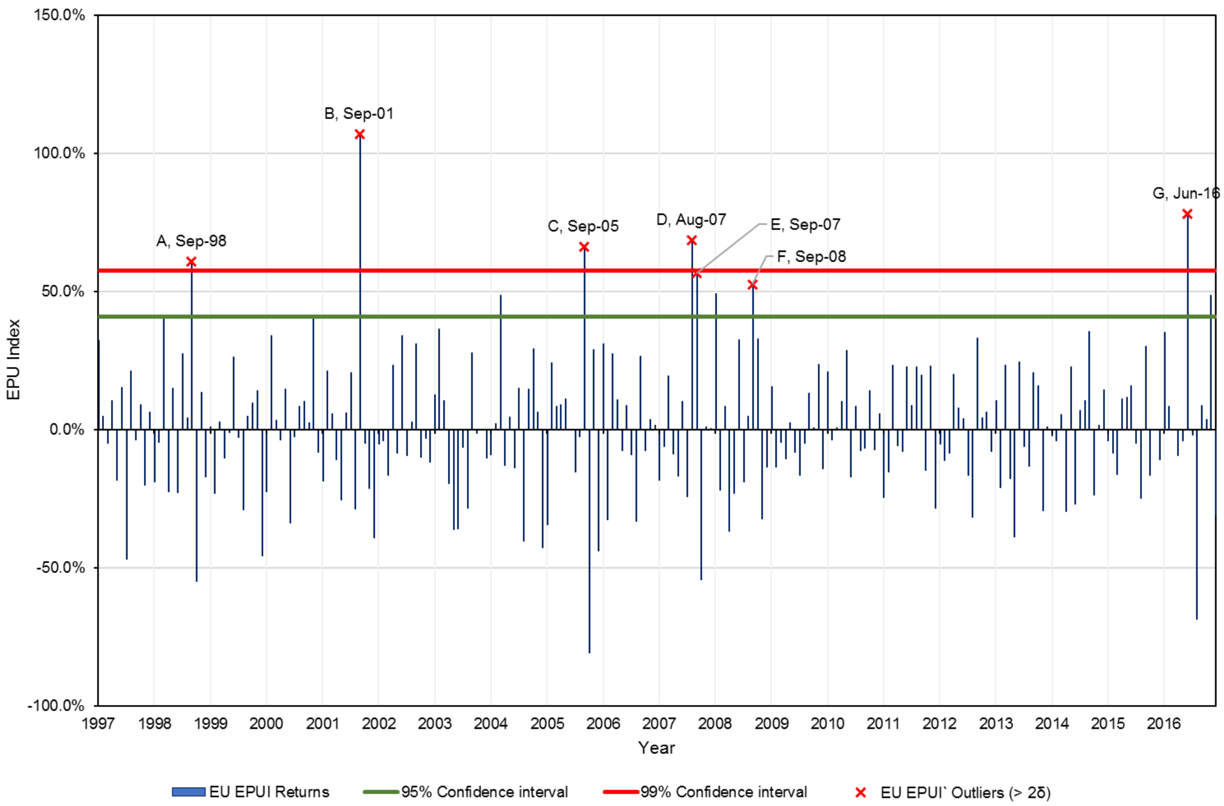


Figure 4 *EU economic policy uncertainty index log returns, 1997 to 2016. Noteworthy instances of EPU innovations are marked.*

Source: http://www.policyuncertainty.com/europe_monthly.html

Point A coincides with the 1998 German elections in which the left wing returned to power, with the victory of the Social Democratic Party's Gerhard Schröder (Drozdiak, 1998). The ramifications of this event for the rest of Europe were considerable. European monetary unification had been planned since the early 1990's (Bordo, Duca, & Koch, 2016), and official unification was set to take place on 1 January 2000, prior to adoption of the EUR in 2003. Germany was considered to be the low-inflation anchor currency in the Euro system (Hein & Truger, 2005). Concerns regarding expansion of debt under a liberal, left wing, Social Democrat government may have contributed to a pan-European rise in economic policy uncertainty.

Point B coincides with the climate of geopolitical uncertainty following the 9/11 World Trade Centre attacks, which were discussed in the US context in section 1.10.2.1. Points D and E, in August and September of 2007 respectively, align with events that presaged the 2008 global financial crisis. Liquidity concerns were raised when French investment bank BNP Paribas S.A.

advised clients of valuation problems with two of its funds (European Central Bank, 2009), while the European central bank responded by pushing close to €200 billion into the European Banking system over the following weeks (European Central Bank, 2009; Guha, Milne, & Tett, 2007). At the same time the US Federal Reserve and Bank of Japan also sought to intervene in a similar manner (Guillén, 2009). In August 2007 economic uncertainty in Europe was further fuelled by the near collapse and ultimate rescue of German retail bank Sachsen Landesbank who had seen subprime mortgage backed assets evaporate (Guillén, 2009). Losses due to contagion from the US subprime mortgage market continued to mount in September 2007 when German bank IKB, took a $1 billion loss (Guillén, 2009; Reuters, 2017), and UK lender Northern Rock was granted emergency funding following the largest run on any bank in UK History (Guillén, 2009; Larsen & Giles, 2007).

The global financial crisis continued to worsen over the following year until the failure of Lehman Brothers Inc. in September 2008 (Guillén, 2009), which aligns with Point F. From September 2007 until beyond September 2008, EPU continued to climb in Europe, as subprime losses began to mount and these directly impacted on Europe's central banks via their efforts to support their banking system.

The final point on *Figure 4*, in June 2016, follows the Brexit vote, and the aftermath of this shock, which essentially meant that one of the EU's largest economies would leave the European free trade block. The result of the vote was unexpected and had vast economic ramifications for the whole of Europe (Sampson, 2017). Arguably the most remarkable aspect of Brexit was the lack of certainty about how the process would proceed, and how the post-Brexit relationship between Britain and the EU would coalesce. The events of late June 2016 understandably coincide with the highest ever level of the European EPUI.

Determining the effect of EU EPU on the gold price is the subject of the fourth research objective set out in section 1.8. Collectively Europe and the UK form a larger economic bloc than China, and a greater understanding of gold's role as a safe haven in this vast economy can contribute to fulfilling the purpose of this research.

1.10.2.3 Economic Policy Uncertainty in China

The Chinese EPUI is constructed by flagging keywords in the South China Morning Post (Economic Policy Uncertainty, 2012a). While publishers find a high level of accuracy in the index, some concerns are found relating to its utility for this study. As with the EU EPUI, the Chinese EPUI displays a clear positive trend as illustrated in *Figure 5*.

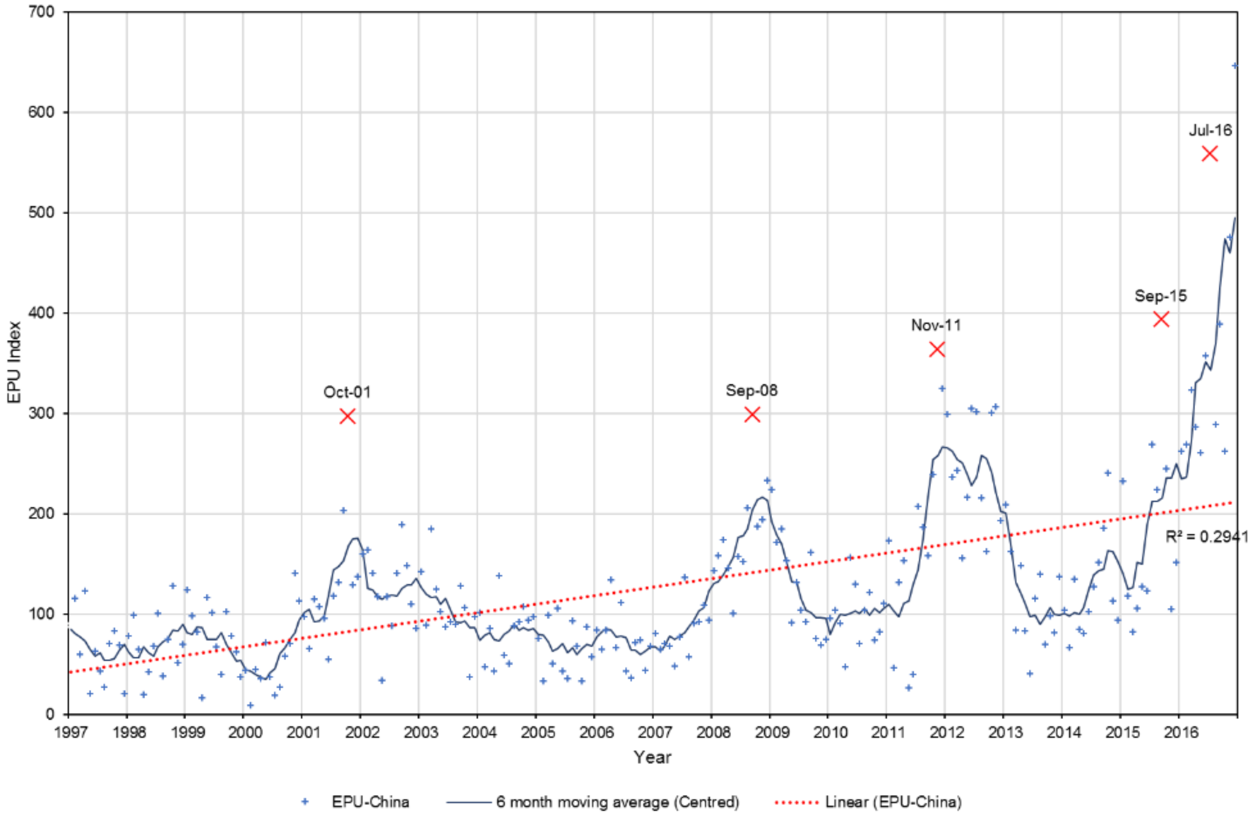


Figure 5 *China economic policy uncertainty index, 1997 to 2016. Noteworthy instances of EPU innovations are indicated.*

Source: http://www.policyuncertainty.com/china_monthly.html

The index displays a substantial rise in EPU in China in general, with a rapid increase from late 2015. Some notable peaks are evident: in October 2001, September 2008, November 2011, September 2015, and July 2016. These peaks will be discussed in this section, following a discussion of the index returns.

Chinese EPUI returns are indicated in *Figure 6*. An issue that raises concern is the fact that the large outliers on the positive side are simply mean reversions from large outliers on the negative side (indicated by points A through F on *Figure 6*.) The reason for this is unclear, however it is possible to speculate that this pattern represents a limitation in the manner in which the index is constructed.

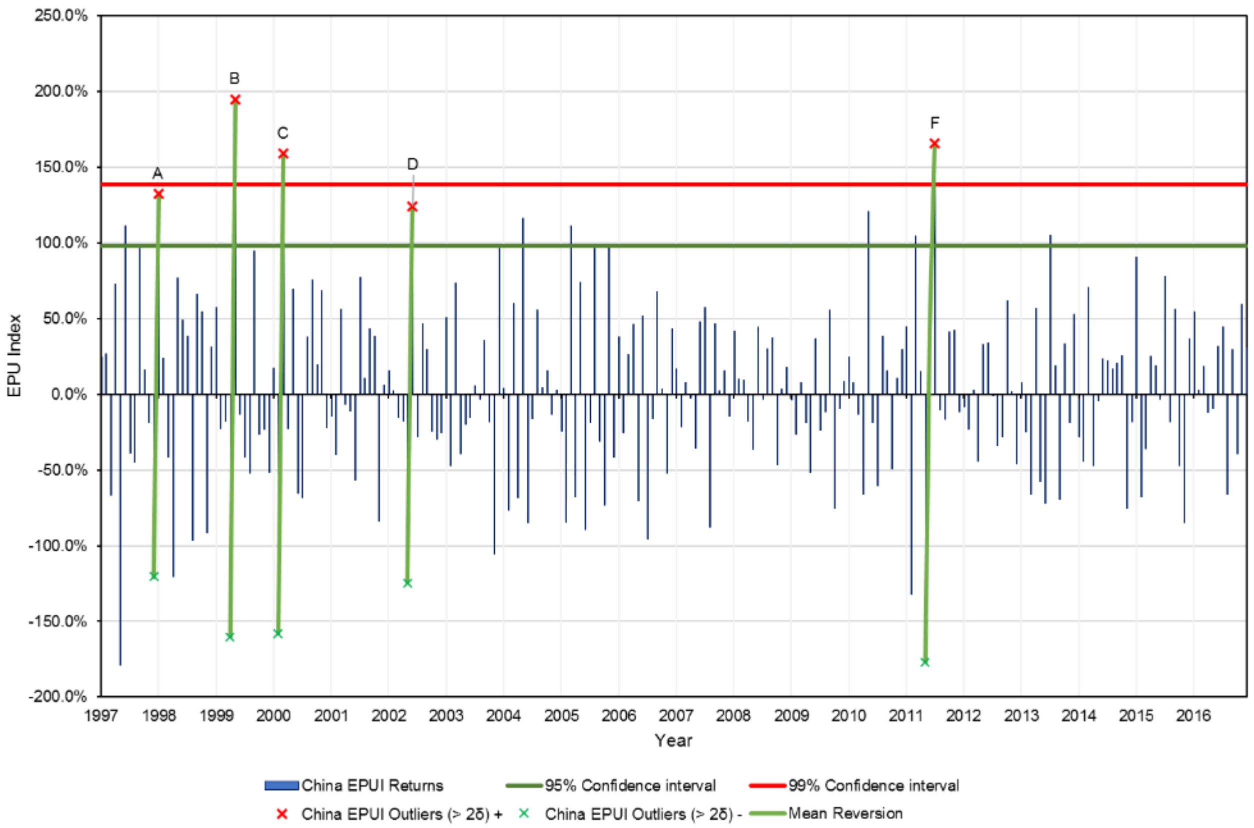


Figure 6 *China monthly economic policy uncertainty log returns, 1997 to 2016.*

Source: http://www.policyuncertainty.com/china_monthly.html

The upward trend in the Chinese EPUI in recent times illustrated in *Figure 5* is of interest, as are the peaks, which coincide with previously explored events in the US EPUI: The 9/11 Terror attack, the global financial crisis of 2008, the US debt ceiling crises of 2011 and 2013, and the Brexit vote of June 2016.

When considering this trend, it is worth noting the dramatic and continuing growth of Chinese exports since the 1990's, as illustrated in *Figure 7*. While China's exports as a proportion of their GDP has declined since 2006, it is argued that this decline is due to the continued growth of the Chinese economy rather than a contraction in exports. Moreover, while domestic consumption as a proportion of GDP has grown as China grows wealthier, that wealth is unquestionably underpinned by exports of manufactured goods. It is also noteworthy that the October 2008 spike in Chinese EPU precedes a year of sharp decline in exports. It is therefore argued that EPU in China is driven largely by offshore factors.

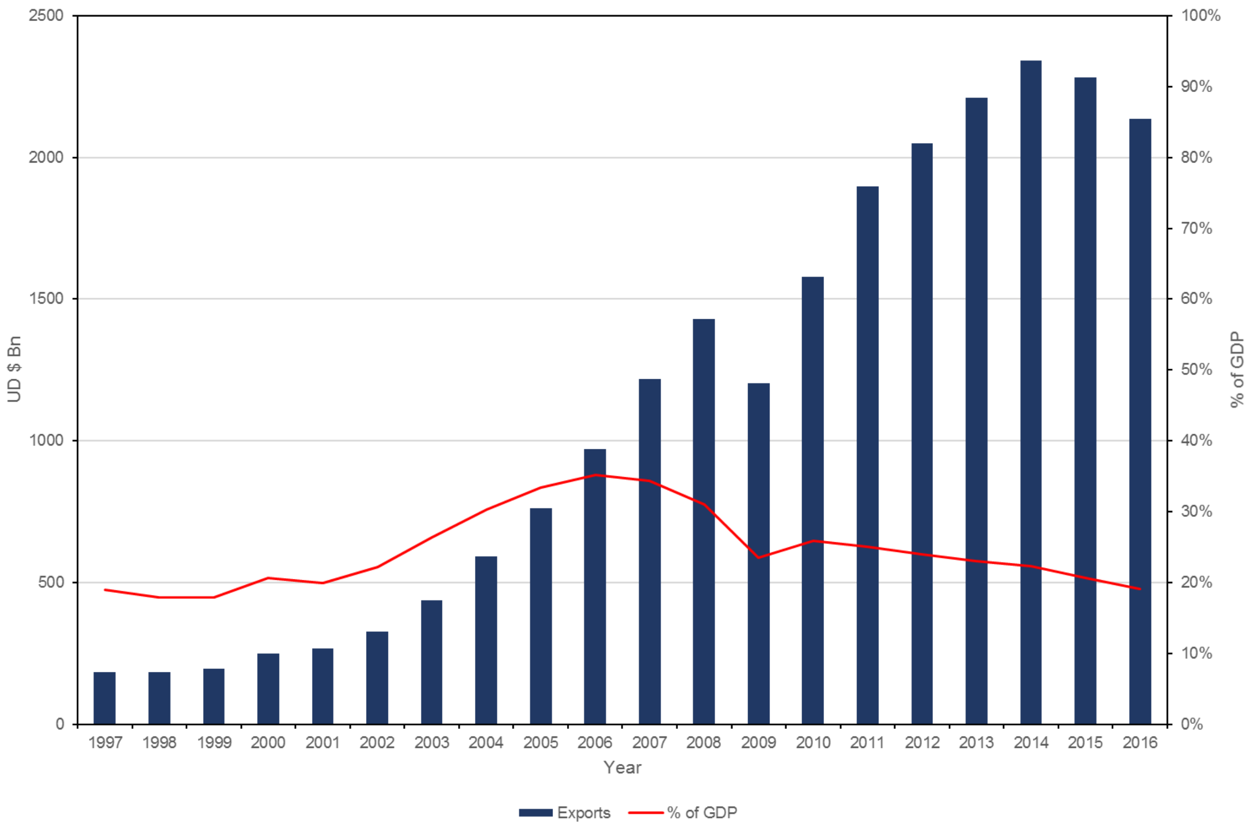


Figure 7 *Chinese exports in US$, with exports as a percentage of GDP indicated*

Source: China exports: Federal Reserve Bank of St Louis (2017), Gross world product: World Bank (2017)

Determining the effect of EPU in China on the gold price is the subject of the fourth research objective set out in section 1.8. China is currently the world's second largest single economy, and it is growing at a rate that may see it overtake the US in terms of GDP in the next 20 years. A greater understanding of gold's role as a safe haven in this dynamic economy can contribute to fulfilling the purpose of this research.

1.10.2.4 Economic Policy Uncertainty in Japan

The Japanese EPUI is generated by Elif C. Arbatli, Steven J. Davis, Arata Ito, Naoko Miake and Ikuo Saito and is hosted at http://www.policyuncertainty.com/japan_monthly.html. The index is constructed from four major Japanese newspapers, and was normalised at a value of 100 when it commenced in 1987 (Economic Policy Uncertainty, 2012c).

The index for the period of the scope of this study is illustrated in *Figure 8*. To highlight outliers in the data, the index was converted to log returns to remove the trend. *Figure 9* illustrates Japan's EPUI log returns with five key events highlighted. These instances of interest are indicated, and marked A through E. They are discussed in the remainder of this section.

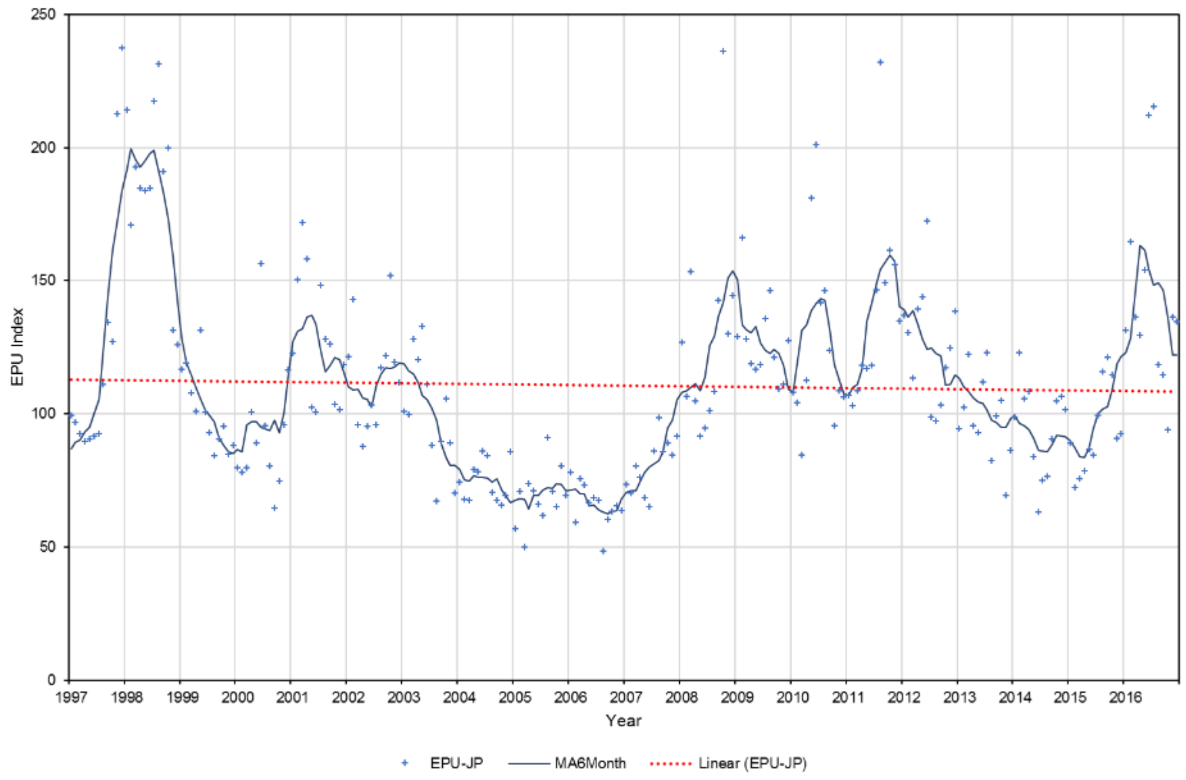


Figure 8 *Japan monthly economic policy uncertainty index, 1997 to 2016*

Source: Economic Policy Uncertainty (2012c)

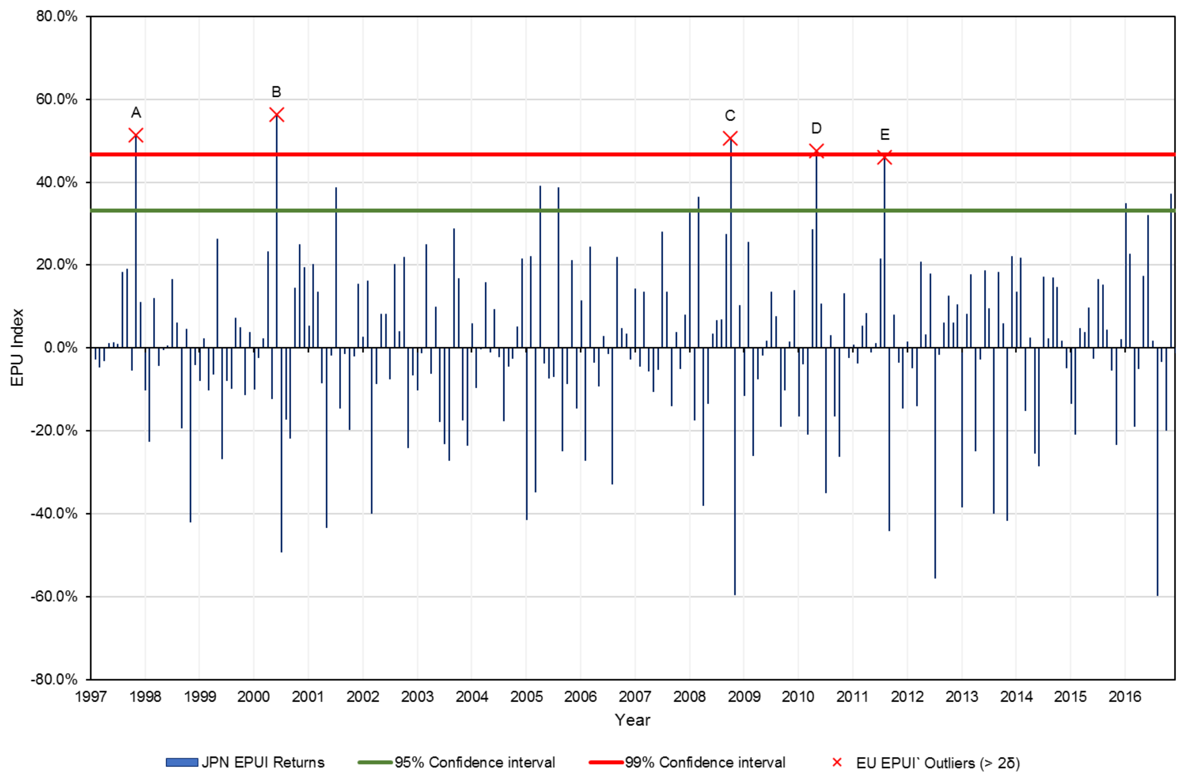


Figure 9 *Japan monthly economic policy uncertainty index log returns, 1997 to 2016*

Source: Economic Policy Uncertainty (2012)

Point A aligns with the Asian financial crisis of 1997 which started with the devaluation of the Thai Bhat in early July of that year (Maroney, Naka, & Wansi, 2004). The Asian crisis had lasting ramifications for economies across the region including Japan, where uncertainty about the economic future was well founded: in the wake of the crisis the Japanese economy experienced declines in certain key industries such as machinery and electronic equipment, while many large firms began shifting production from Japan to China (Banasick & Hanham, 2008)

Point B takes place in June 2000 following the parliamentary election in Japan where Yoshiro Mori's Liberal Democrats lost significant ground (Tolbert, 2000). This event also took place against the backdrop of uncertainty created by the recession following the collapse of US technology stocks in March 2000 (Griffin et al., 2011), and which was previously discussed relating to high contemporaneous levels of uncertainty in the US. Point C coincides with the global financial crisis of 2008 and 2009 (Guillén, 2009), which has also been a feature of EPU in the US, the EU and China.

May 2010, and point D, saw the onset of the Greek Sovereign debt crisis, which ultimately led the EU and the International Monetary Fund (IMF) to advance over €1 Trillion in guarantees to Greece's ailing economy (Reuters, 2010). May 2010 was also the height of the lead up to Japan's parliamentary elections and a hotly contested topic between the Liberal Democrats and the Democratic Party of Japan was taxes, which is a key component of economic policy. Point E may illustrate how large economies are intertwined, for it coincides with the US Debt Ceiling Crisis of 2010 (Fanning, 2016), although causal relationships were not investigated in the course of this discussion.

Determining the effect of EPU in Japan on the gold price is the subject of the fourth research objective set out in section 1.8. The previous section dealt with world events and how they coincide with large increases in EPU as measured by the EPU indices. The following section seeks to motivate the research by illustrating the difficulty in taking a prima facia view of the variables.

1.10.3 Short term policy shocks and gold

As will be discussed in section 2.2.2, the price of gold is the outcome of a complex interaction between supply on one hand, and demand consisting of variables including inflation, bond yields, opportunity cost relating to the yields foregone on other assets, fear, greed, and dose of irrationality, on the other. *Figure 10* below is a combined plot of gold prices and the EPUI's of the US and EU. The complexity of the movement of the two prices makes assessing the price interactions visually an impossible task.

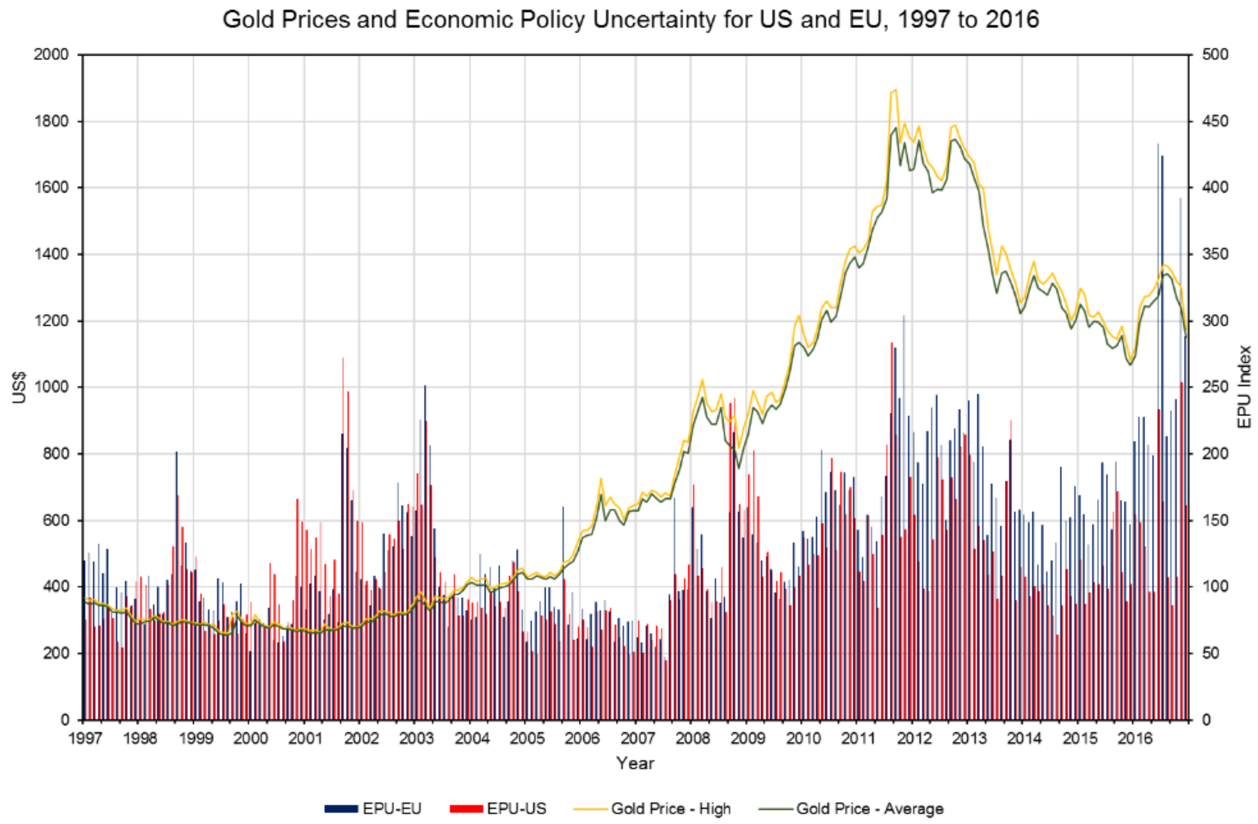


Figure 10 *Gold Prices and Economic Policy Uncertainty for US and EU, 1997 to 2016*

Sources - European EPUI: Economic Policy Uncertainty (2012b). US EPUI: Economic Policy Uncertainty (2012e). Gold prices: World Gold Council (2017a)

This study is important because one cannot base a view that gold is unaffected by economic policy uncertainty without conducting a controlled study. The work of Jones and Sackley (2016) provides a basis for this study, by modelling the interaction between Baker, Bloom and Davis' (2016) EPUI and the spot price of gold, together with a range of control variables. These control variables include real exchange rate, inflation, default risk, and covariance with the US stock market. Jones and Sackley (2016) also provided a departure point in terms of how their study may be improved. This research aims to affect such an improvement to the Jones and Sackley's (2016) model, and as such it aims to make a methodological contribution to the body of knowledge.

1.11 Overview of the report

The remainder of the document is organised as follows:

- Chapter 2 reviews recent and seminal literature relating to gold as a safe haven, the study of economic policy uncertainty, pricing of commodity futures, and seeks to explain the background of the research objectives;

- Chapter 3 builds hypotheses based on the research objectives outlined in this chapter, and expanded on in chapter 2;
- Chapter 4 outlines the methodology to be followed to test the hypotheses built in chapter 3;
- Chapter 5 details the results of the analyses outlined in chapter 4;
- Chapter 6 discusses the results detailed in chapter 5;
- Chapter 7 summarises the discussion in chapter 6 and concludes the study, while setting the scene for future research.

CHAPTER 2 Literature review

2.1 Introduction

The purpose of this literature review is to explain the academic foundation of the theories underpinning this research, while explaining the background of the independent variable, being the EPUI. It concludes by developing a theoretical framework for the research.

2.2 Theoretical framework

The following section discusses the theoretical work on economic policy uncertainty, and the determinants of the price of gold. It concludes with a discussion of safe haven assets and currencies.

2.2.1 Economic policy uncertainty

Uncertainty as a contextual variable in economic models received attention from former Federal Reserve chairperson Ben Bernanke (1983) as a contributor to decision-making in irreversible capacity investment. Without a specific index for uncertainty, Bernanke (1983) modelled investment decisions with the potential for negative macroeconomic conditions. An example is given of the choice to replace an old production facility with a new one, the investment in which may be subject to the renewal of a tax credit regime. If there is an a priori belief that the renewal is definitely not being discussed by tax authorities, the decision is easy and the business would definitely invest, however if the tax credit is up for discussion this introduces an option value (Bernanke, 1983). The investment would then be deferred until such time as a new tax credit regime is implemented, however without a means of quantifying uncertainty surrounding the tax system, quantifying these investment decisions was difficult (Bernanke, 1983).

In response to concerns over economic policy uncertainty following the 2008-2009 global financial crisis, and with superior data than that which was available to Bernanke (1983), Baker et al. (2016) sought to develop an index to measure economic policy uncertainty, which builds on earlier work for the National Bureau of Economic Research by Bloom (Bloom, 2009).

Other work on quantifying EPU was undertaken by Jurado, Ludvigson and Ng (2015) and built on Bloom (2009) and Basu, Susanto, and Bundick's preliminary work since 2009 (which culminated in publication as Basu and Bundick (2017)). The Chicago Board Options Exchange Volatility Index (VIX) was specifically used as a means of quantifying uncertainty, however while there has been shown to be a close correlation to monetary policy (Bekaert, Hoerova, & Lo Duca, 2013), VIX does not in itself measure uncertainty in monetary policy (Bekaert et al., 2013) and has strong stock market connections (Baker et al., 2016). Moreover VIX had been found to be problematic as a measure of EPU since it was found to lag events of monetary policy uncertainty rather than lead them (Bekaert et al., 2013).

The 2016 paper, ‘Measuring Economic Policy uncertainty’ described a methodology of mining keywords from newspapers (Baker et al., 2016) (a far easier task in 2016, with digital publishing than in Bernanke’s time where most news archives were stored on microfiche) and applying statistical methods to develop an index of uncertainty. The work was originally centred on US economic policy uncertainty but has since been expanded to incorporate the world’s 10 largest economies, with the EU incorporated into one block. The method of mining data relating to sentiment around uncertainty had the distinct advantage of focussing on the root cause of uncertainty as opposed to the outcome (Baker et al., 2016). By adopting an interpretivist approach and focussing on measuring the underlying cause of EPU, Baker, Bloom and Davis’ (2016) EPUI was viewed as an explanatory measure of EPU, where VIX was seen as an outcome of EPU.

Baker et al. (2016) sought to validate their findings (and by implication validate the EPU index as a reliable economic indicator) with three tests: First, the EPU index was compared to other uncertainty measures including implied stock volatility, and a strong relationship was found; second, a strong relationship was demonstrated between the Federal Reserve’s references to monetary policy uncertainty in their publications and the EPUI; and finally the authors recalculated the index against news reports in both right and left leaning newspapers, and found that the publishers’ political orientation did not distort the index significantly (Baker et al., 2016).

2.2.1.1 Utility of economic policy uncertainty in economic analysis

Baker, Bloom and David’s (2016) ‘Measuring Economic Policy Uncertainty’ has contributed to a body of further work since its publication in 2016.

Uncertainty shocks, as evidenced by economic policy uncertainty, were shown to cause a contraction in overall spending, and while given that labour supply was sticky, and capital stock was fixed (Basu & Bundick, 2017), this resulted in an increase in investment, specifically in inventories (Basu & Bundick, 2017). Furthermore, research specifically relating to the 2008-2009 global financial crisis showed that near zero interest rates limit monetary policy authorities’ ability to implement stimulus (Basu & Bundick, 2017).

In speculative currency trading strategies where positions are taken based on the Federal Reserve Open Market Committee, EPU had been found to be a proxy measure when measuring monetary policy uncertainty (Mueller et al., 2017). Linked to the notion of exchange rates was the correlation between EPU and uncertainty about inflation, determined by way of inflation expectations (Binder, 2017).

The concept of uncovered interest rate parity (UIRP) was a contentious one in large part because it had been empirically disproved, particularly in the short run (Ismailov & Rossi, 2017). The EPUI provided some explanation for this, for Ismailov and Rossi (2017) found that uncovered interest rate parity did indeed hold while EPU is low, and this had important implications because UIRP underpins many macroeconomic models (Ismailov & Rossi, 2017). And finally, Jens (2017) used EPUI as a control variable to calibrate a model intended to test the specific effect of political uncertainty on oil prices.

Recent studies using the EPUI as a dependent variable have shown the utility of the index for the purpose of this research. The following section seeks to outline current academic research dealing with determinants of the gold price.

2.2.2 Determinants of Gold prices

The gold price was central to this study, since those who seek a safe haven in gold do so in the hope that it will hold its price in the face of a collapse in the price of other assets. Gold's use in jewellery and as an investment and reserve asset was well known and these uses together account for 90% of the gold mined throughout history (Tully & Lucey, 2007), while a significantly smaller portion was held in industrial applications (Tully & Lucey, 2007).

The market for gold is extremely liquid and the entire global stock of gold typically passes through the London Metals Exchange in less than one week (Hillier, Draper, & Faff, 2006). The relative stability of gold prices under the Bretton Woods regime came to an end in 1971 (Sjaastad, 2008). Since then the USD had long been held to have a significant negative correlation to gold. This was once again confirmed by Tully and Lucey's (2007) asymmetric power generalised autoregressive heteroscedasticity (APGARCH) analysis from 1983 to 2003 of the determinants of the price of gold, while they found an insignificant relationship between the gold price and US interest rates and inflation.

Interestingly, while Tully and Lucey's (2007) overall 1983-2003 analysis of both the gold spot price and gold futures showed a significant negative relationship to the USD, when the analyses were restricted to two periods of crisis, being the 1987 stock market crash, and the 2001 events surrounding the World Trade Centre attack, they found a substantially weaker inverse relationship between gold and the USD. It was also noted that consistently stronger relationships, in Tully and Lucey's (2007) crisis analyses, were found for gold futures than for gold spot price.

The view that the primary determinant of the price of gold was the USD real exchange rate, and the price was independent of US inflation was also held by Jones and Sackley (2016). It must be noted however that their regression analysis, with the inclusion of US Economic Policy Uncertainty, only had an $R^2 = .153$ with domestic US variables and $R^2 = .208$ with international control variables included. Jones and Sackley's (2016) work is discussed in detail in section 2.3, as it formed a significant departure point for this research.

Given Baur and Lucey's (2010) definition of a hedge as being any asset which was either inversely correlated or uncorrelated to another asset, there was evidence to suggest that gold was a hedge to the USD (being negatively correlated), and US inflation, to which it is uncorrelated.

A final counterpoint to Bauer and Lucey (2010) and Jones and Sackley (2016) was provided by Sjaastad and Scacciavillani (1996) who found that it was not the USD that was the primary determinant of gold's USD price, but it was the relative exchange rates of the Eurozone countries, at least in the period from 1982 to 1990. It is also necessary to note that Bauer & Lucey (2010) found a degradation of their model in 1987 (the year of a significant market crash), which may contribute in some way to Sjaastad and Scacciavillani's (1996) findings. The remainder of section 2.2.2 deals with a range of possible drivers of the gold price, as these drivers may also be included as control variables in this study.

2.2.2.1 Gold supply considerations

The body of knowledge relating to gold supply resided with institutions including the World Gold Council and financial institutions which analyse the market. This body of knowledge was the subject of O'Connor et al.'s (2015) meta study of the economics of gold. Key findings are listed in this subsection.

Annual gold production has remained relatively stable since the late 1990's, and in the past 20 years production amounted to roughly 1% of global stocks, with total mine production in the region of 4000 tonnes (O'Connor et al., 2015). Since 1980 gold production had shifted substantially and become increasingly geographically dispersed. South Africa produced two thirds of the world's gold in 1980, while in 2014 China, the world's largest producer, only accounted for 450 tonnes of the 4000 tonnes produced in that year (O'Connor et al., 2015).

While gold is fungible, and through history it has rarely been the subject of permanent loss, its use in electronics had resulted in a small permanent leakage from above-ground stocks (O'Connor et al., 2015). It was argued that the cause of this loss was that quantities used in certain electronic applications were too small to be recycled economically (O'Connor et al., 2015).

2.2.2.2 Gold demand considerations

Gold demand was found to be chiefly driven by investment and jewellery requirements (O'Connor et al., 2015), with the majority of jewellery demand originating in Asia, with over 70% of all gold being used in the Asian jewellery trade (O'Connor et al., 2015). While demand for gold in China traditionally served the need for artefacts for many centuries, recently the demand for coinage and bars for investment had been found to have risen substantially (Zhang, Pian, Santosh, & Zhang, 2015). Investment demand in China was substantial and it was estimated that government and private stocks in 2014 amounted to 30,000 tonnes and 21,000 tonnes respectively (Zhang et al., 2015).

The rise of demand for gold in China was matched by that in other emerging markets (J. Liu, 2016). That said, the link to higher disposable incomes was not found to be homogenous, and gold demand per marginal Gross National Income (GNI) was positively correlated in Vietnam, China and Thailand (meaning that gold demand increases at a higher rate than GNI as GNI rises). This phenomenon was not observed in Indonesia, Turkey and Egypt, where demand was negatively correlated to GNI (J. Liu, 2016).

A significant development in the gold market since 2003 was the advent of exchange traded funds (ETF's) which provide an easy way to gain exposure to gold for retail investors (O'Connor et al., 2015), through financial instruments which have been demonstrated to have negligible price variation from underlying assets (Ivanov, 2013). Despite the general rise of ETF's globally, gold ETF's saw a decline of approximately 15% through 2013 (O'Connor et al., 2015) and this may have contributed to lower than expected gold prices during this time.

2.2.2.3 Gold and inflation

The relationship between gold and inflation is one of much debate and has been the subject of extensive study (Jones & Sackley, 2016; O'Connor et al., 2015). Arguments that inflation is an important driver of gold prices are as prevalent as those to the contrary (Jones & Sackley, 2016).

The average annual price movement of gold over the last 180 years closely matches US inflation (Barro & Misra, 2016). This suggests gold's suitability as a hedge against inflation, and this view derives from gold's inelastic supply in the short run, when compared to fiat money (O'Connor et al., 2015). Levin and Wright (2006) proposed that in the long term inflation was the main driver of the gold price, however this view was not universally held with other researchers finding the link to gold did not extend to future inflation expectations (Blose, 2010).

While many studies focussed on US inflation, gold had been found to be negligibly affected by global inflation (Sjaastad, 2008). That said, to treat the rest of the world as one globular inflation zone would be incorrect, and there was evidence to suggest that gold was also an inflation hedge against the GBP (Hoang, Lahiani, & Heller, 2016), however this this was not the case in Japan and the eurozone (Beckmann & Czudaj, 2013). Moreover gold has been shown to not be an inflation hedge in India (Hoang et al., 2016). The relationship between gold and inflation has also been suggested to be regime-dependent (Beckmann & Czudaj, 2013), and align with periods of crises (Białkowski, Bohl, Stephan, & Wisniewski, 2015) with consideration to the oil crises of the 1970's and early 1980's, as well as the European sovereign debt crisis (Białkowski et al., 2015). The debate surrounding gold and inflation remains unresolved, and it was found to be prudent to retain a measure of inflation in this research, as was the case in Jones and Sackley's (2016) study.

2.2.2.4 Gold and currencies

Given that inflation was argued to be a monetary phenomenon (Johnson, 1971), it would follow that the debate surrounding gold and currency strength should be closely linked to the gold-inflation debate. The question for this study was whether to include the USD relative strength as a control variable in non-US studies, or to use those economies' currencies' relative strength.

Empirical evidence showed that since the closure of the gold window, apart from occasional departures, not only the USD, but also the GBP, Japanese yen (JPY), and EUR real exchange rates show an inverse relationship with the price of gold in those currencies (Pukthuanthong & Roll, 2011). Recent research suggested that these relationships vary significantly with time, with the strength of the relationship being minimal from the mid 1980's to the mid 1990's for the USD and EUR, while strong relationships existed from 1970 to 1985, and following 1995 (Baur, Beckmann, & Czudaj, 2016).

Research which argued in favour of USD relative strength having a substantial effect on the price of gold cited the fact that gold is priced on global markets in USD (O'Connor et al., 2015). The view that gold was a hedge against USD depreciation was supported by Reboredo (2013) in a study which sought to determine gold's role in currency risk management, and found that strengthened gold prices were associated with USD depreciation against a range of currencies.

Reboredo (2013) argued that these findings indicated gold’s suitability as a hedge against USD depreciation. The study also found evidence of gold’s suitability as a safe haven in the event of extreme currency movements (Reboredo, 2013). The findings in literature relate to large developed markets such as the US, Japan, and Europe. But what of China? The inclusion of China in this study may provide insight into the effect of the CNY real exchange rate on the gold price.

2.2.2.5 Gold and the risk of corporate distress

Jones and Sackley (2016) included a quantum of corporate default risk (being the spread between Aaa and Baa rated bonds) in their study in order to effectively expand the study of Levin and Wright (2006), without demonstrating the potential link between this measure and the price of gold. Nevertheless, the default premium had been shown to be a factor of significance, when modelling the effect of EPU on gold (Jones & Sackley, 2016). The inclusion of the default premium in previous studies concerning gold was seen as sufficient motivation to include this measure as a control variable in this research.

2.2.2.6 Leasing gold

Leasing gold, which is a means of deriving a return on an asset which otherwise produces no yield, had declined steadily from 5000 tonnes per annum in the year 2000 to less than 1000 tonnes in 2012 (O’Connor et al., 2015). The decline in the gold leasing market was further illustrated by the convergence between the London inter-bank offered rate (LIBOR) and the Gold Lease Rate (which is defined as LIBOR less the London Bullion Market Association’s (LMBA) Gold Forward Offer Rate) (O’Connor et al., 2015), to the point where the LBMA discontinued the publication of the Gold Forward Offer Rate at the beginning of 2015.

2.2.2.7 Gold and oil

Jones and Sackley (2016) hypothesised that the political risk in oil producing countries was a necessary control variable in their study, however this was not found to be the case following their research, and their research indicated that no significant relationship existed between oil producer political risk and the price of gold (Jones & Sackley, 2016).

Nevertheless, with oil prices driving inflation, and inflation driving gold, (O’Connor et al., 2015), there was a body of work that deals with this relationship. A meta-analysis by O’Connor et al. (2015) found a temporal convergence between the relationship between oil prices and gold prices, which suggested that there is the potential for gold to behave as a safe haven in times of high oil prices in the future (O’Connor et al., 2015).

2.2.3 Safe havens

This section addressed safe havens assets in the current academic literature, since this study dealt with gold as a safe haven in times of economic policy uncertainty. A distinction needed to be drawn between assets considered as hedges, and those viewed as safe havens. Hedges were found to be those instruments such as options and futures which afford the opportunity to offset risk in well-diversified portfolios, in other words they are assets that are linked negatively to another asset under normal market conditions (Baur & Lucey, 2010). Safe havens, by contrast were found to be assets which were unlinked to a specific portfolio asset, or were inversely correlated to that asset under circumstances of extreme market movements (Baur & Lucey, 2010).

In addition to the distinctions in terminology, the factors that drove hedging in normal periods, and those that drove safe haven seeking were viewed as distinct (C.-S. Liu, Chang, Wu, & Chui, 2016). There was also no universal hypothesis as to which assets were suitable as hedges and which were suitable as safe havens, but rather, this status was found to be country-dependent (C.-S. Liu et al., 2016).

2.2.3.1 <u>Safe haven currencies</u>

The concept of safe haven currencies was of interest following the 2008-2009 global financial crisis. Habib and Stracca (2012) sought to explain the forces that determined whether or not a currency was a safe haven. A feature of global currency markets was what was known as the carry trade, where exchange rates failed to negate the effects of interest rate differentials between low yield economies and high yield economies, which led to an opportunity for speculators to borrow at low interest and lend in countries with high interest rates (Menkhoff, Sarno, Schmeling, & Schrimpf, 2012). Conversely, Habib and Stracca (2012) argued that in times of global financial distress this scenario was reversed and returns on currencies of lower interest rate countries exceed those in higher interest rate regimes. They suggested that this was due to the risk profiles of lower interest rate countries being lower, and that these countries have larger economies with lower risk profiles (Habib & Stracca, 2012). Despite this finding, the research suggested that more financially open countries had a higher exposure to global risk, and thus their currencies were less likely to be safe havens (Habib & Stracca, 2012), and that countries' net financial asset position is the most likely attractor of safe haven behaviour.

It was questionable as to whether relative strengthening in currencies that were considered safe havens was purely due to the reversal of carry trade positions, or if they truly were used as a safe haven (Hossfeld & MacDonald, 2015). The relationship between countries with low interest rates and their status of safe havens had largely been written off thanks to the very fact that as low interest regimes, their currencies were used to fund carry trades, meaning that the bulk of sudden appreciations in times of distress could be attributed to the closing out of carry trade positions (Hossfeld & MacDonald, 2015). Among the G10 currencies they studied, Hossfeld & McDonald (2015) did find a statistically significant negative correlation between global stock market returns and the Swiss franc (CHF) after having controlled for the effects of carry trade unwinding, and thus they concluded that the CHF was a true safe haven currency.

2.2.3.2 Gold and other assets and commodities

Around the time of the 2008-2009 global financial crisis Baur and McDermott (2010) undertook research to determine gold's role in the financial system and found that in the face of extreme market shocks, gold was the subject of panic buying, and during the time that the Federal Reserve implemented its stimulus regime, gold prices reached higher as US Bond yields declined sharply (Poshakwale & Mandal, 2016).

With regard to the real rate of capital return on gold, Barro and Misra (2016) analysed gold returns from 1836 to 2011 and found that on average prices changed by 1.1%. This was roughly in line with the yield on US treasury bills, a factor that underpinned gold's attractiveness as a hedge or safe haven while consumption growth of gold was found to be insignificant to its price through to 2011 (Barro & Misra, 2016).

Liu et al. (2016), found that the utility of gold as a safe haven against crises in stock markets is country dependent. In a study of the interaction of gold with the stock markets of the UK, USA, Germany, Switzerland, Canada, Japan and Australia, the authors found that gold is a strong safe haven for the UK, USA and Germany, and a weak safe haven for other countries except for Switzerland, where gold is not a safe haven (C.-S. Liu et al., 2016).

With reference to Barro and Misra (2016) and Liu et al. (2016) the author's opinion is that while there exists a body of research to suggest gold functions effectively as a safe haven under certain circumstances, this research could be expanded by including a quantitative measure of economic uncertainty.

2.2.4 Efficient market hypothesis and gold

While the concept of the efficiency of capital markets (where prices can be expected to reflect all available information at any point in time) was commonly credited to Fama (1970), the study of the role of information asymmetry in prices consumer markets was studied as far back as the late 1950's and early1960's (Stigler, 1961). Fama (1970) performed three forms of tests which were termed the weak, semi-strong, and strong form. Of most interest to this study were the weak form tests (where the only determinant of future prices was past prices) (Fama, 1970) and semi-strong form tests where prices assimilated information that was publicly available, in addition to momentum (Fama, 1970). The strong form tests conducted by Fama (1970) were of concern where monopoly information is available. Such monopoly information included pure market information such as trading strategies and market depth, and it went as far as proprietary company information Fama (1970).

The efficient market hypothesis (EMH) has proved to be a contentious topic. A central tenet of EMH was the assumption that market participants were rational actors (Russell & Thaler, 1985). This was argued by Russel and Thaler (1985) to be an ideal situation which did not occur in real-world markets where weak-form inefficiencies have been demonstrated in instances where participants overreact to adverse information (De Bondt & Thaler, 1985). Nevertheless, continued research into the behaviour of market participants in the face of adverse events underpinned the argument that markets react rapidly and directly to these events (Fama, 1991), while the observed appropriateness of reactions to events (the occurrence of overreaction or underreaction) are shown to be symmetrically distributed (Fama, 1998).

With reference to the gold standard in the US and UK in the late 19th century, the USD/GBP was found to be weak-form efficient as long as currencies traded within the gold points (as the limits of exchange rates between gold-standard countries were known) (Goldman, 2000). Goldman (2000) built on prior work by Clark (1984) which focussed on instances where gold points were violated, and which in those circumstances the USD/GBP market under the gold standard was found to be inefficient.

Precious metals markets including those for gold have been shown to assimilate information efficiently (Charles, Darné, & Kim, 2015), while this efficiency has been shown to have increased over the period from 1977 to 2013 (Charles et al., 2015). Stock markets in Europe have also been shown to be efficient with respect to information from metals markets with the implication that arbitrage opportunities do not exist between resources stocks and the underlying commodities which those companies produce (Irandoust, 2017).

2.3 Theoretical background of a research hypotheses

This section develops a framework for underpinning the hypotheses that have been formulated to satisfy the research objective of developing a better understanding of gold and gold futures as a safe haven in the event of economic policy shocks.

2.3.1 Theoretical underpinning of the effect of US-EPU volatility on the gold spot price as evidence of safe haven seeking (pursuant to hypothesis 1)

2.3.1.1 General theoretical background for economic policy uncertainty as a determinant of safe haven seeking in gold

The following section seeks to find a point of departure for the hypothesis that a correlation exists between EPU and the price of gold.

Variable	Description	Lag(s) in months	Significant sign
$\Delta \ln P_g$	Change in price of gold	1,3	(+),(−) respectively
Π_{USA}	Inflation in US	1	(+)
$\Delta V(\pi)_{USA}$	Volatility of US inflation	1	(+)
$\Delta \ln ER$	Change in Exchange rate	1	(−)
ΔR_g	Lease rate of gold	3	(−)
$\Delta CRDP$	Credit risk default premium	1	(+)
Ecm	Error correction mechanism	1	(−)
Political uncertainty	All 143 countries	0	(+)
Political uncertainty	Top-10 oil producers	4	(−)
Political uncertainty	Top-10 oil producers minus USA	4	(−)

Figure 11 *Levin and Wright's (2006) variable set*

Source: Jones and Sackley (2016)

In general, asset returns and their underlying drivers exhibited a dynamic relationship, which changed over time (Poshakwale & Mandal, 2016), and Tully & Lucey's (2007) findings that the relationship between USD exchange rates and gold broke down in times of crisis implied that there must be some other, conditional element, contributing to the price of gold. Since the preliminary white paper that ultimately contributed to 'Measuring Economic Policy Uncertainty' (Baker et al., 2016) was published in 2013, Adam T. Jones and William H. Sackley (Jones & Sackley, 2016) undertook the study of the effect of EPU on the price of gold using Baker et al.'s (2016) EPUI.

Levin and Wright's (2006) white paper for the World Gold Council, while not published academically, provided a valuable point of reference. The paper sought to derive a model for the gold price using a step-wise regression analysis, using the variables detailed in Figure 11 (Jones & Sackley, 2016).

Jones and Sackley (2016) built their work on the research of Levin and Wright (2006), and it featured the nascent EPUI from Baker et al.'s (2016) website: http://www.policyuncertainty.com/. Jones and Sackley (2016) used EPUI for the US, based on the assumption that the pricing of safe haven assets in USD implied a role of that country's EPU in determining the safe haven assets' pricing. The EPUI for the EU was also included as a control variable (Jones & Sackley, 2016).

The full list of variables included by Jones and Sackley (2016) in their study (which spanned from July 1997 to January 2013) are detailed in appendix section 9.2 of this study. The first three measures $\%\Delta P_{Gold}$, $\%\Delta(P_G/S\&P500)$, and $\%\Delta P_{silver}$ were dependent variables in three separate regression models, and the remainder were independent variables. With regard to the issue of autocorrelation, which can be problematic in most financial time series regressions (Kutner, 2005), the authors found that the differencing to obtain percentage changes eliminated autocorrelation, and they found acceptable values in the Durbin-Watson tests they performed. The Durbin-Watson test was prescribed to assess whether autocorrelation is present in a series, with a Durbin-Watson statistic of 2 indicating no autocorrelation, while upper and lower Durbin-Watson criticals, D_U and D_L indicate a range where the test is inconclusive, or that autocorrelation is present (Anderson, Sweeney, Williams, Freeman, & Shoesmith, 2010). Jones & Sackley (2016) found Durbin-Watson Statistics for their data of between 1.82 and 2.13, which were in the acceptable range.

Four regressions were estimated by Jones & Sackley (2016) which included the following independent variables on a monthly interval:

1. Bivariate: US Economic policy uncertainty only;
2. Multivariate: US Economic policy uncertainty and a one month lagged $\%\Delta P_{Gold}$;
3. Domestic: All the variables from 2 above, with the addition of all the US control Variables;
4. International: All the variables from 3 above, with the addition of all the Non-US control Variables.

Jones and Sackley's (2016) regression model results are shown in Figure 12.

Dependent variable: $\%\Delta P_{gold}$	(1) Bivariate	(2) Multivariate	(3) Domestic	(4) International
$\%\Delta$econ policy $uncert_{US}$	0.0272^{**}	0.0267^{**}	0.0208^{*}	0.0306^{*}
	(2.44)	(2.41)	(1.74)	(1.84)
(L) $\%\Delta P_{gold}$		0.0612	−0.0599	−0.0892
		(0.65)	(-0.67)	(-1.06)
π_{US}			0.146	0.859^{**}
			(0.48)	(1.98)
πVol_{US}			4.013^{*}	−1.137
			(1.68)	(-0.34)
$\%\Delta$dollar index			-0.310^{***}	-0.238^{***}
			(-4.01)	(-2.86)
Gold beta			6.274^{*}	4.518
			(1.97)	(1.44)
$\%\Delta$default premium			0.0232^{**}	0.0240^{**}
			(2.16)	(2.20)
$\%\Delta$lease rate			0.00106	0.00179
			(0.67)	(1.42)
Ecm			0.443	−0.371
			(0.77)	(-0.59)
π_{world}				-1.271^{**}
				(-2.30)
πVol_{World}				17.95^{*}
				(1.71)
$\%\Delta$oil country uncert				0.0355
				(0.56)
$\%\Delta$econ policy $uncert_{EU}$				−0.00757
				(-0.54)
Constant	0.801^{***}	0.741^{**}	−0.606	0.630
	(2.62)	(2.49)	(-0.45)	(0.26)
N	178	178	178	178
R^2	0.038	0.042	0.153	0.208

statistics in parentheses

$^{*}p<0.10$, $^{**}p<0.05$, $^{***}p<0.01$

Figure 12 *Summary of models estimated by Jones and Sackley (2016)*

Source: Jones and Sackley (2016)

Jones and Sackley's (2016) findings were as follows:

- For $\%\Delta P_{Gold}$ as the dependent variable:

- Bivariate and multivariate: R^2 = .038 and R^2 = .042 respectively.
- Domestic: R^2 = .153, and $\%\Delta dollar\ index$ a significant regressor, but $\%\Delta econ\ policy\ uncert_{US}$ was insignificant.
- International: R^2 = .208, and $\%\Delta dollar\ index$ a significant regressor but $\%\Delta econ\ policy\ uncert_{US}$ was insignificant.

- For $\%\Delta P_{Gold}/S\&P500$ as the dependent variable:
  - Bivariate and multivariate: R^2 = .038 and R^2 = .042 respectively.
  - Domestic: R^2 = .153, and $\%\Delta gold\ lease\ rate$ a significant regressor, and $\%\Delta econ\ policy\ uncert_{US}$ significant.
  - International: R^2 = .208, and $\%\Delta gold\ lease\ rate$ a significant regressor, and $\%\Delta econ\ policy\ uncert_{US}$ also significant.

While the addition of the EPUI to models built on the Levin and Wright's (2006) model, Jones & Sackley (2016) do not indicate the F-statistic for their model, and given that the R^2 <.208, this lead to a contention that while policy shocks do affect the gold price, there is a conditional relationship and the regression approach used by Jones and Sackley (2016) lacked the sensitivity to identify this relationship.

2.3.1.2 *The inclusion of a measure of exogenous volatility to Jones and Sackley's (2016) model*

Volatility has been widely incorporated into economic models with attention to endogenous volatility. Autoregressive conditional heteroscedasticity (ARCH) models were developed to model time varying volatilities and were first used to model inflation volatility in the UK economy (Engle, 1982). Engle's (1982) ARCH model was extended to incorporate exogenous volatilities (Engle, Ng, & Rothschild, 1990) and the real-time nature of the proposed factor-ARCH model was suggested by the authors to be appropriate for using stock market volatility as a factor in forecasting the market for treasury bills (Engle et al., 1990). Further generalisation of ARCH models was undertaken with a view to developing a model allowing multivariate ARCH processes to be incorporated into standard mean-type analyses (Engle & Kroner, 1995).

While the link between economic uncertainty has been shown to be positively linked to commodity market volatility (Brunetti, Büyükşahin, & Harris, 2016), the quantification of economic uncertainty via EPU is nascent, and the link between EPU volatility and gold prices constituted a research opportunity. Dynamic stochastic general equilibrium (DSGE) models have shown some promise in incorporating macroeconomic volatility into models of stock returns however the calibration of these models remained problematic (Diebold, Schorfheide, & Shin, 2017).

While the scope of this research does not extend to multivariate ARCH models or DSGE models, the effect of uncertainty may be augmented by the addition of a measure of the fluctuation of uncertainty. To this end the volatility of the EPUI appeared to be important since EPUI shocks drastically exceed two standard deviations and thus may have a drastic effect on short-run demand for gold. Thus, the first hypothesis was that the inclusion of a measure of EPUI Volatility may enhance Jones and Sackley's (2016) model and lead to a better understanding of gold's use as a safe haven against EPUI.

2.3.2 Theoretical underpinning of the effect of US-EPU on gold futures prices as evidence of safe haven seeking (pursuant to hypothesis 2)

This section deals with the enhancement of Jones and Sackley's (2016) model by using gold futures prices as opposed to gold spot prices as a dependent variable. Futures were found to be priced using the cost of carry model which is a function of the spot price of the underlying asset multiplied by the cost of carry (Kolb & Overdahl, 2006). Carrying costs were a percentage of the spot price, and were the costs of the seller to carry the underlying asset to maturity, including storage, and interest (Kolb & Overdahl, 2006).

The phenomenon whereby futures prices were discounted with respect to spot prices was found to be known as backwardation, while the opposite effect, where futures prices exceed spot prices was referred to as contango (Pindyck, 2001). These effects have been shown to occur due to the fact that "futures markets are likely to incorporate information more efficiently than spot markets due to futures markets' inherent leverage, low transaction costs, and the absence of any short-selling constraints" (Chen & Tsai, 2017, p. 59)

Keynes (1930) reasoned that futures prices should be below the expected future spot price, and called this difference "normal backwardation", while he reasoned further that under normal backwardation futures prices should exceed current spot prices. Normal backwardation amounted to a de-facto risk premium for the contract-holder. This view was tested empirically by Kolb (1992), and while the study found that "normal backwardation" was prevalent in some livestock futures (cattle and swine), the inverse effect "normal contango" was notable in crude oil, heating oil and lumbar (Kolb, 1992). With reference to gold, no evidence was found of normal backwardation (Kolb, 1992). The matter of normal backwardation and risk premia in commodity futures was revisited by Hamilton and Wu (2014) with specific reference to crude oil prices, with the study finding that the conclusion of Kolb (1992) no longer held following 2005. The early 2000's saw the advent of index funds, and these were hypothesised to be responsible for newly observed effects in the crude oil futures market (Hamilton & Wu, 2014). Despite this view, a subsequent study indicated that index funds were not responsible for the observed change in the futures market (Hamilton & Wu, 2015). An alternative to the normal backwardation or normal contango hypothesis to explain returns in futures markets was the view that speculators are adept at predicting future spot prices and position themselves to take advantage (Fama & French, 2013). However Lee's (2015) empirical study contradicts the view that the skill of speculators is the primary determinant of futures market returns.

Futures prices have long been held to provide a more liquid and dynamic means of conducting commodities analysis (Tully & Lucey, 2007). In their study on the relationship between the price of gold and BRICS stock markets, Bekiros, Boubake, Nguyen and Uddin (2017) used the 3-month New York Mercantile Exchange (NYMEX) futures price because these prices implicitly account for investors future expectations of spot prices. Such future expectations by investors coupled with the liquidity implicit with the leveraging of futures may lead to a closer relationship to EPU than the gold spot price (Wu & Chiu, 2017), and this requires investigation.

Lead-lag relationships between stock futures and their underlying assets are known to last not more than 30 minutes, and price differentials were shown to be promptly eliminated by arbitrageurs (Brooks et al., 2001). Brooks et al. (2001) also found that futures returns generally responded more quickly to information than returns of their underlying assets. For this reason, the models in this study which used futures price were estimated using daily returns, as opposed to monthly returns as was the case in Jones & Sackley (2016).

Recent research (Bekiros et al., 2017) has focussed on gold futures' hedging role in BRICS economies, and the specific unit of analysis used in this study was the 3-month NYMEX gold futures price. The literature suggests that futures markets provide a highly liquid and speculative environment, where information can be efficiently translated into returns, and for that reason they may prove to be a valuable extension to this study.

2.3.3 Theoretical underpinning of the effect of US-EPU volatility on gold futures prices as evidence of safe haven seeking (pursuant to hypothesis 3)

Hypothesis 3 uses the independent variable enhancement from hypothesis 1 with the dependent variable discussed in hypothesis 2, and thus the theoretical underpinnings of hypothesis 3 were evident from sections 2.3.1 and 2.3.2.

2.3.4 Theoretical underpinning for the testing of EPU in China, Europe and Japan on the spot price of gold in their respective domestic currencies (pursuant to hypothesis 4)

According to Jones & Sackley (2016) their research found no effect of European EPU on the price of gold in USD, and surmised that the effect is truly insignificant, or their results were distorted via currency movements.

A logical analysis of how an excess of buying of gold in Europe may drive prices is as follows:

- Europeans, using EUR, and buying gold, would induce supply of EUR, thus lowering the EUR price relative to other currencies.
- If they are buying gold from USD-based holders (likely since markets in gold are denominated in USD), this will necessitate that they buy USD also.
- As a result, a positive change in demand for USD and gold will arise, and the effect of increased demand for both gold and USD may minimise the differential between one and the other.

In order to revisit Jones and Sackley (2016) and determine whether or not safe haven seeking takes place in countries aside from the US, this study modelled the effect of EPU in Europe on the EUR price of gold. It went further to add China and Japan to the study, in order to take a view of a substantial portion of the world's economy.

As previously indicated, Brooks et al. (2001) found that the temporary nature of backwardation and contango means that the differential of futures prices to spot prices for gold over the period of a month may not be significant. For this reason, this analysis was conducted using spot prices.

2.3.5 Theoretical underpinning for improving previous work through estimation of an ARIMA or ARIMAX model (pursuant to hypothesis 5)

The ARMA and ARIMAX approaches to univariate forecasting was developed by Box and Jenkins (1968) in order to integrate the effect of past history into future forecasts of time series variables using both components of that past history and trends in the error terms from those autoregressive models.

One criticism of this univariate approach was that many economic processes are the subject of external influence, and ARIMA in its purest form did not account for exogenous variables (Elmaleh, 2017). While the approach has been used in economic applications including the forecasting of foreign capital flows (Dhingra, Bulsara, & Gandhi, 2015) using purely the past history of exogenous variables, this approach has been found to be deficient in applications with strong exogenous influence such as in exchange rate forecasting (Petrică, Stancu, & Tindeche, 2016), where the platykurtic nature of returns and volatility clustering suggested the action of exogenous influences (Petrică et al., 2016).

Addition of exogenous variables to ARIMA models, as suggested by Box and Tiao (1975) have produced considerably better results. The comparative performance between ARIMA and ARIMAX (ARIMA models with the inclusion of exogenous variables) has been directly tested across the Greek, Irish, Italian and Portuguese credit default swap markets with ARIMAX models having outperformed ARIMA models in all studies (Apergis, 2015). A further note with relation to Apergis (2015) is that that study used a news-based index as its exogenous variable, in much the same manner as Jones and Sackley (2016) and this study used Baker, Bloom and Davis' (2016) news based EPU indices. Thus, ARIMAX was held to be an appropriate technique for estimating models to understand gold's role as a safe haven against EPU.

2.4 Conclusion to the literature study

Chapter 2 sought to provide a theoretical background by first discussing key areas of research being economic policy uncertainty, gold price determinants, and safe havens. It then went on to provide the academic background to the hypotheses to be outlined in the forthcoming chapter.

CHAPTER 3 Research Hypotheses

Given that this study sought to build on an existing model, hypotheses were formulated to compare proposed enhancements to the existing Jones and Sackley (2016) model.

The relationships between sets of dependent and independent variables for hypothesis 1, hypothesis 2, hypothesis 3, and hypothesis 4 and their respective sub-hypotheses were as detailed in *Figure 13*:

				Dependent Variables	
	Study	**Variable set**	**Unit of analysis aggregation**	**Gold spot**	**Gold Futures**
Jones & Sackley (2016) US Independent variable sets REGRESSION	Jones & Sackley	Domestic	Monthly	Original study	
	Jones & Sackley	International	Monthly	Original study	
	Jones & Sackley	Domestic	Daily		H2d
	Jones & Sackley	International	Daily		H2i
	Enhanced EPUI Volatility	Domestic Including EPUI-Vol	Daily	H1d	H3d
	Enhanced EPUI Volatility	International Including EPUI-Vol	Daily	H1i	H3i
China REGRESSION	China EPUI	China domestic variables	Monthly	H4c	
Europe REGRESSION	Europe EPUI	Europe domestic variables	Monthly	H4e	
Japan REGRESSION	Japan EPUI	Japan domestic variables	Monthly	H4j	
ARIMAX	Best of H1 to H4	Best of H1 to H4	Best of H1 to H4	H5	

Figure 13 Tabulated summary of hypotheses

Source: Own research.

Hypothesis testing consisted of testing the effectiveness of multivariate regression models and ARIMAX models by comparing their coefficients of determination, or R^2 (Maddala, 2001). The greater the value of R^2, the greater the explanatory value of a model, and values ranged from 0 to 1 (Weiers, Gray, & Peters, 2011).

It was noted that Jones and Sackley's (2016) original coefficients would be difficult to replicate since the temporal scope of this study, from January 1997 to December 2016, differed from Jones and Sackley's (2016) scope, which spanned the period beginning July 1997 and ending January 2013.

Moreover, minor variations in the sources and timing of variables may have led to further deviations from Jones and Sackley's (2016) coefficients.

Thus, while the coefficients of determination for Jones and Sackley's (2016) study were R^2=.153 and R^2=.208 for their domestic and international models respectively, updated benchmarks were estimated for this study as follows:

Domestic: R^2=.094

International: R^2=.116

3.1 Hypothesis 1

The first objective of this research was to determine whether the model estimated by Jones and Sackley (2016) would be enhanced by adding a measure of EPU volatility. The objective was stated as follows:

- Determine whether the addition of EPUI Volatility to the multivariate regression model developed by Jones and Sackley (2016) described the relationship between EPU and gold spot prices, and thus the use of gold as an EPU safe haven asset, better than the original model.

Jones and Sackley (2016) estimated models with both a set of US domestic control variables, as well as an international set of control variables. Thus, hypothesis 1 was further divided into two parts to account for these two alternatives.

3.1.1 Hypothesis 1d

The null and alternative hypotheses for testing the enhancing value of the addition of EPU volatility in the US domestic context were as follows:

The null hypothesis: The proposed model's explanatory value did not exceed Jones and Sackley's (2016) model which had an R^2=.094.

The alternative hypothesis: The proposed model's explanatory value exceeded Jones and Sackley's (2016) model which had an R^2=.094.

Thus: $H1d_0$: $R^2_{\text{VolDom}} \leq .094$

$H1d_A$: $R^2_{\text{VolDom}} > .094$

3.1.2 Hypothesis 1i

The null and alternative hypotheses for testing the enhancing value of the addition of EPU volatility in the US international context were as follows:

The null hypothesis: The proposed model's explanatory value did not exceed Jones and Sackley's (2016) model which had an R^2=.116.

The alternative hypothesis: The proposed model's explanatory value exceeded Jones and Sackley's (2016) model which had an R^2=.116.

Thus: $H1i_0$: $R^2_{\text{VolInt}} \leq .116$

$H1i_A$: $R^2_{\text{VolInt}} > .116$

3.2 Hypothesis 2

The second objective of this research was to determine whether the model estimated by Jones and Sackley (2016) would be enhanced by using gold futures prices as a dependent variable. The objective was stated as follows:

- Determine whether estimating Jones and Sackley's (2016) model with its original set of variables against gold futures produces a better multivariate regression model, thus indicating that gold futures are a better safe haven against EPU.

Jones and Sackley (2016) estimated models with both a set of US domestic control variables, as well as an international set of control variables. Thus, hypothesis 2 was further divided into two parts.

3.2.1 Hypothesis 2d

The null and alternative hypotheses for testing the original set of Jones and Sackley's (2016) domestic independent variables against gold futures as a dependent variable were as follows:

The null hypothesis: The proposed model's explanatory value did not exceed Jones and Sackley's (2016) model which had an R^2=.094.

The alternative hypothesis: The proposed model's explanatory value exceeded Jones and Sackley's (2016) model which had an R^2=.094.

Thus: H2d$_0$: $R^2_{\text{VolDom}} \leq .094$

H2d$_A$: $R^2_{\text{VolDom}} > .094$

3.2.2 Hypothesis 2i

The null and alternative hypotheses for testing the original set of Jones and Sackley's (2016) international independent variables against gold futures as a dependent variable were as follows:

The null hypothesis: The proposed model's explanatory value did not exceed Jones and Sackley's (2016) model which had an R^2=.116.

The alternative hypothesis: The proposed model's explanatory value exceeded Jones and Sackley's (2016) model which had an R^2=.116.

Thus: H2i$_0$: $R^2_{\text{VolInt}} \leq .116$

H2i$_A$: $R^2_{\text{VolInt}} > .116$

3.3 Hypothesis 3

The third objective of this research was to determine whether the model estimated by Jones and Sackley (2016) would be enhanced by adding a measure of EPU volatility and using gold futures as the dependent variable. The third objective was stated as follows:

- Determine whether the addition of EPUI volatility to the multivariate regression model estimated by Jones and Sackley (2016) describes the relationship between EPU and the price of gold futures as a dependent variable, and thus the use of gold as an EPU safe haven asset, better than the original model does by using the spot price of gold as a dependent variable.

Hypothesis 3 was, de-facto, a combination of Hypotheses 1 and 2.

As with hypothesis 1 and 2, hypothesis 3 was divided into a domestic and international sub-hypotheses.

3.3.1 Hypothesis 3d

The null and alternative hypotheses for testing the EPU volatility enhanced version of the domestic model against gold futures were as follows:

The null hypothesis: The proposed model's explanatory value did not exceed Jones and Sackley's (2016) model which had an R^2=.094.

The alternative hypothesis: The proposed model's explanatory value exceeded Jones and Sackley's (2016) model which had an R^2=.094.

Thus: $H3d_0$: $R^2_{\text{VolDom}} \leq .094$

$H3d_A$: $R^2_{\text{VolDom}} > .094$

3.3.2 Hypothesis 3i

The null and alternative hypotheses for testing the EPU volatility enhanced version of the international model against gold futures were as follows:

The null hypothesis: The proposed model's explanatory value did not exceed Jones and Sackley's (2016) model which had an R^2=.116.

The alternative hypothesis: The proposed model's explanatory value exceeded Jones and Sackley's (2016) model which had an R^2=.116.

Thus: $H3i_0$: $R^2_{\text{VolInt}} \leq .116$

$H3i_A$: $R^2_{\text{VolInt}} > .116$

3.4 Hypothesis 4

The fourth objective of this research was to determine whether EPU in other markets influences the price of gold in those markets' currencies. The fourth objective was stated as follows:

- Pursuant to the avenues for further research in Jones and Sackley (2016), EPUI was modelled against gold spot prices in local currency, using multivariate regression, in Europe, China and Japan, which together constitute over 60% of the world's GDP (World Bank, 2017). These tests were performed to determine whether or not a statistically significant relationship existed between EPU in major economies outside the US and the price of gold.

The effect of EPU in China, Europe and Japan were considered and thus the hypothesis was divided into three sub hypotheses, for each of these economies.

3.4.1 Hypothesis 4c

The null and alternative hypotheses for testing the influence of Chinese EPU on the gold price in CNY were as follows:

The null hypothesis: The model showed no relationship between Chinese EPU and the gold price in CNY, to a 95% level of significance.

The alternative hypothesis: The model showed a relationship between Chinese EPU and the gold price in CNY, beyond a 95% level of significance.

Thus: $H4c_0$: Model significance (as indicated by ANOVA p-value) ≥ .050

$H4c_A$: Model significance (as indicated by ANOVA p-value) < .050

3.4.2 Hypothesis 4e

The null and alternative hypotheses for testing the influence of European EPU on a EUR-GBP composite gold price were as follows:

The null hypothesis: The model showed no relationship between European EPU and a EUR-GBP composite gold price, to a 95% level of significance.

The alternative hypothesis: The model showed a relationship between European EPU and a EUR-GBP composite gold price, beyond a 95% level of significance.

Thus: $H4e_0$: Model significance (as indicated by ANOVA p-value) ≥ .050

$H4e_A$: Model significance (as indicated by ANOVA p-value) < .050

3.4.3 Hypothesis 4j

The null and alternative hypotheses for testing the influence of Japanese EPU on the gold price in JPY were as follows:

The null hypothesis: The model showed no relationship between Japanese EPU and gold price in JPY, to a 95% level of significance.

The alternative hypothesis: The model showed a relationship between Japanese EPU and the gold price in JPY, beyond a 95% level of significance.

Thus: $H4j_0$: Model significance (as indicated by ANOVA p-value) ≥ .050

$H4j_A$: Model significance (as indicated by ANOVA p-value) < .050

3.5 Hypothesis 5

The fifth and final objective for this research is to determine whether or not it is possible to estimate an ARIMAX model which better fits the data than the multivariate regression model using international variables estimated by Jones and Sackley (2016). The fifth objective was stated as follows:

- In an effort to develop a more robust understanding of the nature of the relationship between EPU and the price of gold, an Autoregressive Integrated Moving Average with Exogenous Variables Model (ARIMAX) (Andrews et al., 2013; Ďurka & Silvia, 2012) was estimated using the best fitting set of variables from the previous four hypotheses (Andrews et al., 2013). This test was performed to determine whether or not a methodology incorporating autoregressive (AR) and moving average (MA) could produce a more statistically significant model, or one with better explanatory power, that those excluding these terms.

In accordance with accepted practice (Andrews et al., 2013) estimation of an ARIMAX model should follow a thorough investigation into which exogenous variables provide the best explanatory power, to estimate as parsimonious (Enders, 2004) a model as possible. Thus, the model with the best explanatory power from hypotheses 1 through 4 was used as the basis for testing hypothesis 5.

The null and alternative hypotheses for testing the potential enhancement of an ARIMAX model were as follows:

The null hypothesis: The proposed model's explanatory value did not exceed the explanatory value of the regression model on which it was based, which had an R^2=.118.

The alternative hypothesis: The proposed model's explanatory value exceeded the explanatory value of the regression model on which it was based, which had an R^2=.118.

Thus: $H5d_0$: $R^2_{\text{arimax}} \leq .118$

$H5d_A$: $R^2_{\text{arimax}} > .118$

CHAPTER 4 Methodology

4.1 Introduction to the methodology

This chapter details the methodology for obtaining the data and estimating the models for testing the hypotheses elucidated in Chapter 3. The chapter is structured as follows:

- Section 4.1 introduces the research design and time horizon;
- Section 4.2 provides an assessment of the statistical tools used for testing the hypotheses;
- Section 4.3 discusses the key data quality issues, assumptions and prerequisites associated with the statistical tools discussed in section 4.2. The tests to be used and transformations that may be performed to align the data with the assumptions are also discussed;
- Section 4.4 outlines the methodological process to be followed in the research in a step by step manner;
- The remainder of the chapter builds on section 4.4 by discussing in detail the steps used, while referring back to the toolbox of statistical methods discussed in section 4.2 and statistical tests and data transformations in section 4.3.

4.1.1 Research methodology and design

The investigation into gold's role as a safe haven asset adopted a positivist philosophy since observations were made directly of the data, in a structured manner, while controlling for inflation, currency effects, and time dependent comovement with stock indices (Jones & Sackley, 2016; Levin & Wright, 2006). This was done with the goal of developing law-like generalisations (Saunders, Lewis, & Thornhill, 2009), while taking the deductive approach of testing a hypothesis, since this research sought to test a theory, as opposed to generate new theory (Saunders et al., 2009).

This was a descriptive study (Creswell & Clark, 2010), which sought to describe the relationship between a macroeconomic variable, Economic Policy Uncertainty (EPU), and the movement in the price of an asset, Gold, with a secondary data analysis strategy with the goal of rejecting the nulls of Hypotheses 1 through 5. The choice of research methodology for addressing these hypotheses was mono-method and quantitative in nature (Saunders et al., 2009). Studies involving economic data typically have used research designs that model the effect of economic factors on other economic variables or asset prices using secondary data (Basu & Bundick, 2017; Bekiros et al., 2017; Bloom, 2009; Fatum & Yamamoto, 2016; Sjaastad & Scacciavillani, 1996; Wu & Chiu, 2017)

Whether or not causal relationships exist, was assessed in terms of the strength of the correlation, consistency, specificity, temporality, gradient and analogy (Bird, 2011; Hill, 1965; Rasmussen, Jamieson, Honein, & Petersen, 2016).

4.1.2 Time horizon

The time horizon for the study was dictated by the extent of historical data available. EPUI data, in terms of Baker et al.'s (2016) EPUI were available at http://www.policyuncertainty.com. US daily EPUI data were available since 1985 (Economic Policy Uncertainty, 2012e), however the European monthly EPUI data were only available since 1997 (Economic Policy Uncertainty, 2012b). Thus, the lower bound for the study was 1 January 1997, since Jones and Sackley's (2016) model uses European EPUI as a control variable.

Certain macroeconomic data including GDP, which were used to weight certain data, were accumulated annually with the most recent available year being 2016 (World Bank, 2017). As such the latter time boundary for this study was 31 December 2016.

A further issue was encountered with the testing of Hypotheses 4e and 4c in that the EUR real exchange rate was only available from January 1999 because this is when European monetary union took place (Howarth, 2016). In addition to this, lagged returns and volatilities require a trailing set of data for 12 months. Thus, hypothesis 4e was tested for the period January 2000 to December 2016. The CNY index was calculated using a basket of currencies including the EUR (CFETS, 2016; Shen, Ruwitch, & Yao, 2016). In addition to this, in accordance with Jones and Sackley's (2016) study on which this research was based, a 6-month log return of the renminbi index was used as a control variable. Thus, while the index was calculated from 1999, the requirement for using a 6-month log return meant that data were only available from January 2000. As a result, hypothesis 4c was tested for the period January 2000 to December 2016.

The timeframes specified encapsulated a wide range of macroeconomic conditions including elections, booms and recessions, financial crises, and geopolitical turmoil. This allowed the data to be analysed across a range of macroeconomic conditions. Standard error in statistical testing is inversely proportional to sample size (Wegner, 2016), and the sample sizes afforded by the timeframes of this study allow the minimisation of standard error, such that t-statistics for samples over 200 can be considered equivalent to z-statistics (Wegner, 2016).

Small samples are problematic when assessing the normality of data, with the Shapiro-Wilk test (discussed in detail in section 4.3.1) having little power to reject the null hypothesis of normality with samples smaller than 50 (Ghasemi & Zahediasl, 2012).

The timeframes for this study are summarised in Table 1, along with the sample sizes:

Table 1

Time periods per hypothesis

Hypothesis	Start Date	End Date	Sample size
1	1 January 1997	31 December 2016	240 Months
2	1 January 1997	31 December 2016	7305 Days
3	1 January 1997	31 December 2016	7305 Days
4e	January 2000	December 2016	204 Months
4c	January 2000	December 2016	204 Months
4j	January 1997	December 2016	240 Months
5	January 2000	December 2016	204 months

Source: Own research

4.1.3 Universe and sampling

The universe for this study consisted of all markets where gold was traded. These markets traded gold in many forms, both physical and financial. Gold markets considered included:

- Spot markets;
- Futures markets;
- ETF Markets;
- Options markets;
- Over the counter markets;
- Scrap markets;
- Coinage markets.

Gold markets were purposively sampled due to the need for the markets to meet specific criteria, in a universe with a limited population of heterogenous units.

The specific criteria for this study were as follows:

- Liquidity;
- Ease of access;
- Reliability of information;
- Clarity of price-making;
- Temporal suitability;
- Persistence;

Options markets were found to be priced using the Black-Scholes partial differential equation (Bodie, Kane, & Marcus, 2008) which depends fundamentally on participants view of volatility. Further, options contracts, being asymmetric (they constitute an option for the holder but an obligation for the counterparty) (Bodie et al., 2008), were found to introduce difficulty in pricing in cases where they fall out of the money (when the spot price of the underlying asset falls below the strike price of the option in the case of call options, or rises above the strike price in the case of put options). Thus, options were not considered.

ETF's have been issued for gold since 2003 (ETF Securities, 2017) and thus they did not meet the temporal requirement for this study, which is to maximise the number of observations. Over the counter markets and markets for scrap gold were known to be highly fragmented with poor flow of information, thus exposing them to arbitrage. The lack of regular reliable information from these markets excluded them from the study.

Gold spot markets included the London Metals Exchange (London Metal Exchange, 2017), which provides an accessible, liquid and persistent supply of reliable information. The World Gold Council publishes the LME Midday fix (World Gold Council, 2017a), and this price was used for this study.

Gold futures markets were found to provide additional liquidity to the gold market with gold futures in a range of maturities traded on exchanges including the CME Group exchanges: COMEX, CME and NYMEX (CME Group, 2017). The NYMEX 3-month gold futures contract was chosen as it provides a balance between the liquidity of a spot market combined with a sufficiently large temporal difference to spot markets, to price in traders' future expectations.

To summarise, of the universe of gold markets, the following are included or excluded:

- Spot markets were included;
- Futures markets were included;

- ETF Markets were excluded because they did not meet the temporal requirements of the study;
- Options markets were excluded due to the complexity of pricing, and the asymmetric and non-persistent nature of options contracts;
- Over the counter markets were excluded due to their informal nature, and the resulting difficulty in obtaining and indexing price information;
- Scrap markets were excluded due to their informal nature, and the resulting difficulty in obtaining and indexing price information;
- Coinage markets were excluded due to their informal nature, and the resulting difficulty in obtaining and indexing price information.

4.1.4 Unit of analysis

Table 2

Units of analysis

Hypothesis	Research test	Unit of analysis
H1d & H1i	Hypothesis test of R^2 of a regression model estimated with the Volatility enhanced Jones & Sackley (2016) US variables' effect on daily gold spot price return.	LBMA 15:00 USD gold spot price as supplied by the World Gold Council, and converted to monthly returns
H2d & H2i	Hypothesis test of R^2 of a regression model estimated with Jones & Sackley (2016) model effect on daily gold futures return	3-month NYMEX gold futures, daily close, as reported by Quandl, converted to daily returns
H3d & H3i	Hypothesis test of R^2 of a regression model estimated with Volatility enhanced US variables effect on daily gold futures return	3-month NYMEX gold futures, daily close, as reported by Quandl, converted to daily returns
H4c	Hypothesis test of significance of a regression model estimated with Chinese EPUI effect on monthly CNY gold price return	CNY gold spot price, calculated from LBMA 15:00 USD gold spot price as supplied by the World Gold Council, and converted to monthly returns
H4e	Hypothesis test of significance of a regression model estimated with European EPUI effect on monthly EUR gold price return	EUR gold spot price, calculated from LBMA 15:00 USD gold spot price as supplied by the World Gold Council, and converted to monthly returns
H4j	Hypothesis test of significance of a regression model estimated with Japanese EPUI effect on monthly JPY gold price return	JPY gold spot price, calculated from LBMA 15:00 USD gold spot price as supplied by the World Gold Council, and converted to monthly returns
H5	Hypothesis test of R^2 of an ARIMAX model using the best fitting set of variables from hypotheses 1 through 4.	EUR gold spot price, calculated from LBMA 15:00 USD gold spot price as supplied by the World Gold Council, and converted to monthly returns

Source: Own research.

While this study focussed on gold as the underlying unit of analysis, multiple research hypotheses used gold priced in different ways, such as USD denominated gold futures, and EUR, CNY and JPY denominated gold prices, and as such multiple units of analysis were required (Wegner, 2016), and are listed in Table 2.

4.1.5 Measurement instrument

This study relied on quantitative secondary data (Barro & Misra, 2016; Baur & Lucey, 2010; Baur & McDermott, 2010; Jones & Sackley, 2016; Levin & Wright, 2006), being asset prices and economic data drawn from sources that provided this information in their course of business. As a result of this, there was no measurement instrument, as defined in the research literature (Saunders et al., 2009), that would ordinarily have been used in a study involving interviews or surveys.

To replicate as closely as possible the Jones and Sackley (2016) study in the Japanese, Chinese and European contexts, control variables were chosen that were as close as possible to those in the original study. The full list of macroeconomic data, price data, and their sources, are detailed in appendix section 9.1.

The World Gold Council serves the global gold mining and trading industry with insight and analysis (World Gold Council, 2017b) and was a leading source of data for academic study in gold (Beckmann, Berger, & Czudaj, 2015; Białkowski et al., 2015; El Hedi Arouri, Lahiani, & Nguyen, 2015; Naresh, 2016) due to the high standards maintained by their researchers (World Gold Council, 2017a). The price supplied is the LBMA 15:00 fix (World Gold Council, 2017a).

The World Bank and the International Monetary Fund were valuable sources of free data concerning economic and developmental indicators, specifically GDP (The World Bank, 2017). These sources were widely used in academic study (Apergis & Eleftheriou, 2016; Bams, Blanchard, Honarvar, & Lehnert, 2017; Barro & Misra, 2016; Iqbal, 2017).

Economic Policy Uncertainty is the official site of the authors of “Measuring Economic Policy Uncertainty” (Baker et al., 2016) and is thus it was the definitive source of economic policy uncertainty data (Bekiros et al., 2017; Jones & Sackley, 2016).

Quandl is a provider of data (Quandl Inc., 2017b) including chained histories of futures prices (Quandl Inc., 2017a). The chained histories have been used in previous academic research (Allouhi et al., 2015).

The Federal Reserve Bank publishes a wealth of data on the US economy and factors that impact the US such as exchange rates and Consumer Price Indices (CPI) in both the US and its trading partners (Federal Reserve Bank of St Louis, 2017). These data were used in academics and education (Méndez-Carbajo, 2015; Méndez-Carbajo & Asarta, 2017). Eurostat is the official statistical office of the European Union (Eurostat, 2018) and supplied European economic data for government, commercial and academic use.

In order to determine the absolute strength of a currency, many central banks produce a trade weighted index of their currency against those of other countries. These currency indices were also known as real exchange rates. This was the case with the Bank of England and the GBP (Bank of England, 2017), the Bank of Japan and the JPY (Bank of Japan, 2017), and the European Central Bank and the EUR (European Central Bank, 2017). Exchange rate strength was an important control variable in this study because of gold’s potential role as a currency hedge (Iqbal, 2017; C.-S. Liu et al., 2016), and real exchange rates were used to reflect this currency strength.

4.1.6 Research ethics

This study uses secondary data, drawn from public sources. The data consists of macroeconomic variables and asset prices. Ethical concerns arising from human data gathering were not a factor in this study. Publishers of data may require that it not be used for commercial purposes. The license stipulations for data used in this research were inspected and all data were used within the providers’ stipulations.

The research did not seek to differentiate between people on the basis of race, gender, disability, or socioeconomic status. Indeed, human factors do not enter the scope of the research.

4.2 Model estimation techniques

The following section introduces the model estimation techniques that were used. It is intended to provide a theoretical justification for their use, and an overview of the methods used.

The techniques described in this section rely on critical assumptions regarding data quality and the literature requires that specific prerequisites are met. These are described in detail in section 4.3. Together, sections 4.2 and 4.3 form the toolbox for model estimation.

4.2.1 Multivariate linear regression models

Multivariate linear regression (MLR) is an appropriate technique to quantify the relationship between one dependent variable, and a range of independent variables, and it is a technique typically used in econometrics (Hair, Black, Babin, & Anderson, 2010; Wegner, 2016). Economic outcomes are frequently the result of prevailing economic conditions which can be measured quantitatively and then modelled against the outcome using regression (Kowal, 2016). MLR was the method used by Jones and Sackley (2016).

The goal of MLR is the estimation of a model of the form detailed in Equation 1:

Equation 1 - Multivariate linear regression model standard form

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 \ldots . \beta_n x_n$$

where y is the dependent variable, β are parameters estimated using the least squares method, and x represents an independent variable for all n independent variables (Hair et al., 2010; Kutner, 2005; Wegner, 2016; Weiers et al., 2011).

MLR assumes the following conditions are met with reference to the input data:

- Data are normally distributed, with reference to the detailed description in section 4.3.1;
- Data are stationarity, with reference to the detailed description in section 4.3.2;
- Minimal multicollinearity is present between the exogenous variables, with reference to the detailed description in section 4.3.3;
- Data are non-seasonal, with reference to the detailed description in section 4.3.4.;
- Data are free from outliers which may invalidate the model, with reference to the detailed description in section 4.3.5.

MLR assumes the following conditions are met with reference to the parameters and the models estimated:

- Errors are normally distributed, with reference to the detailed description in section 4.3.5.
- Residuals are linear, with reference to the detailed description in section 4.3.7.
- Homoscedastic, with reference to the detailed description in section 4.3.8.
- Errors are free from significant autocorrelation, with reference to the detailed description in section 4.3.9.
- Errors are free from significant cointegration, with reference to the detailed description in section 4.3.10.
- Coefficients are stable, with reference to the detailed description in section 4.3.12.

To maintain consistency with Jones and Sackley (2016), MLR was the method used in this study to estimate models to test hypotheses 1, 2, 3 and 4.

Jones and Sackley (2016) used trailing moving averages for certain variables, and these variables are detailed in Table 3. For this study, the Jones and Sackley (2016) moving average periods were used for monthly studies, however daily studies' moving averages were shortened due to the high level of granularity desired. The longitudinal dimensions applied are detailed in Table 3:

Table 3

Longitudinal transformation periods

Variable	Description	Transformation Type	Period: Monthly / Daily
DefaultPremium	Default premium	Log return	6-month / 20-day
IDX	Currency indices	Log return	6-month / 20-day
GoldBeta	Gold beta	Beta	36-month / 200-day
EPU	EPUI	Log return	6-month / 20-day
P_{gold} / F_{gold}	Gold spot and futures prices	Log return	1-month / 1-day
EPU_VOL_{us}	US EPUI Volatility	Volatility	20-day
Π	Inflation	Change	12-month
ΠVol	Inflation Volatility	Volatility	12 -month

Source: Jones and Sackley (2016)

Log returns were used as they are scaled identically whether they are positive or negative. Simple returns risk introducing an upward bias into models. IBM SPSS v. 25 was used to perform multivariate linear regression model estimations.

4.2.2 Autoregressive integrated moving average (ARIMA) and Autoregressive integrated moving average with exogenous variables (ARIMAX) models

Time series data frequently contains elements of trend, seasonality and cycle in addition to the random components not explained by these factors (Weiers et al., 2011). An approach to least-squares estimation of parsimonious univariate models using only previous values of a time series variable has been developed and are commonly referred to as Box-Jenkins models (Andrews et al., 2013). This term more correctly refers to the general methodology for estimating models incorporating an autoregressive and moving average component: The Box Jenkins approach for estimating ARMA models (Enders, 2004).

ARMA derives from the terms Autoregressive (AR) and Moving Average (MA) (Andrews et al., 2013; Ďurka & Silvia, 2012; Enders, 2004) components of a time series, where the AR component is expressed as in Equation 2:

Equation 2 - AR model long form

$$y_t = c + \sum_{i=1}^{p} \varphi_i \, y_{t-i} + \varepsilon_t$$

(Adhikari & Agrawal, 2013; Enders, 2004)

where c is a constant, φ is the coefficient for lag i, and ε is a stochastic error process (Adhikari & Agrawal, 2013; Enders, 2004). The common notation for AR models is AR(p) where p denotes the number of lagged periods.

The moving average (MA) component seeks to forecast future values in terms of the error term between past AR expected and observed values, and is expressed in Equation 3:

Equation 3 - MA model: long form

$$y_t = \mu + \sum_{j=1}^{q} \theta_j \varepsilon_{t-j}$$

(Adhikari & Agrawal, 2013; Enders, 2004)

where μ is the mean of the series, θ is the coefficient at lag j, and ε is the stochastic error process observed in the series (Adhikari & Agrawal, 2013; Enders, 2004). Combined, the AR and MA processes may be expressed as in Equation 4:

Equation 4 - ARMA model long form

$$y_t = c + \varepsilon_t + \sum_{i=1}^{p} \varphi_i \, y_{t-i} + \sum_{j=1}^{q} \theta_j \varepsilon_{t-j}$$

(Adhikari & Agrawal, 2013; Enders, 2004)

ARMA models are commonly referred to as ARMA(p,q) models where p and q refer to the lags on the AR and MA processes respectively. ARMA models are assumed to be trend-stationary and non-seasonal (Adhikari & Agrawal, 2013; Enders, 2004). They may be generalised by differencing, resulting in an autoregressive integrated moving average (ARIMA) model which is usually expressed in terms of ARIMA(p,d,q) where d denotes the order of differencing of the terms in the series (Adhikari & Agrawal, 2013; Enders, 2004). ARIMA models may be further generalised to Seasonal ARIMA (SARIMA) models, the standard notation of which is ARIMA (p,d,q)(P,D,Q), where P, D, and Q denote the seasonal autoregressive, difference, and moving average lags respectively (Adhikari & Agrawal, 2013; Enders, 2004).

While it may seem attractive to develop parsimonious models using only historical data in the output series, and such models have been successfully estimated in fields such as retail sales (Ramos, Santos, & Rebelo, 2015), univariate models have been found to be limited in the estimation of commodity prices such as oil (Azevedo & Campos, 2016) and copper (Sánchez Lasheras, de Cos Juez, Suárez Sánchez, Krzemień, & Riesgo Fernández, 2015), and in currencies (Petrică et al., 2016). Moreover ARIMA models' lack of causal variables results in the fact that they are unable to respond to exogenous shocks (Elmaleh, 2017) such as those from EPU.

Economic and financial time series' frequently exhibit responses to exogenous forces (Andrews et al., 2013; Ďurka & Silvia, 2012) and it is useful to capture the effects of these forces along with autoregressive effects. Box and Tiao (1975) proposed a model whereby the effect of binary interventions can be incorporated into ARIMA models with the addition of the term βz, where z is a binary variable denoting an intervention condition and β is the coefficient of the intervention's effect (Box & Tiao, 1975; Enders, 2004). This model can be further generalised to non-binary terms where z is replaced with the exogenous series x, as in Equation 5:

Equation 5 - ARIMAX model long form

$$y_t = c + \sum_{n=1}^{d} \beta_n x_{t-n} + \sum_{i=1}^{p} \varphi_i y_{t-i} + \sum_{j=1}^{q} \theta_j \varepsilon_{t-j} + \varepsilon_t$$

Adapted from Andrews et al. (Andrews et al., 2013) and Enders (2004)

This expanded approach was demonstrated by Box and Tao (1975) in both the economic sciences (with the estimation of US CPI) and the natural sciences (with estimation of atmospheric ozone levels). Moreover the ARIMAX approach has been used to estimate stock price models (Maggina, 2011) and this approach has been shown to be superior to ARIMA models in advanced economic forecasting applications (Apergis, 2015).

4.2.2.1 Model selection and the Box-Jenkins method

Box and Jenkins developed a three step iterative approach to estimating models of time series data for forecasting (Adhikari & Agrawal, 2013; Enders, 2004), as illustrated in *Figure 14*:

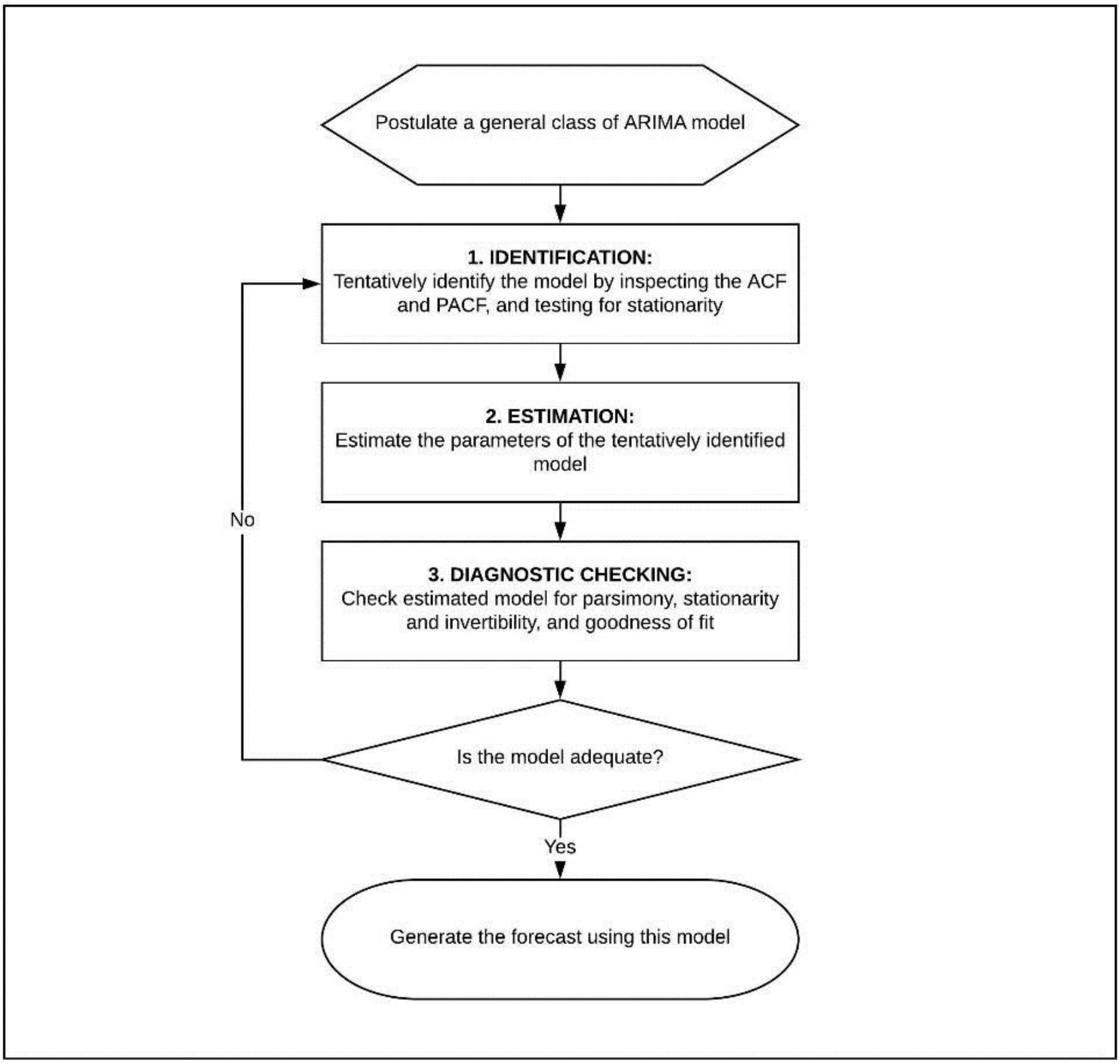


Figure 14 *Box-Jenkins methodology*

Adapted from Adhikari and Agrawal (2013) and Enders (2004)

The ARIMA model class can be postulated by inspecting a time plot of the series (Enders, 2004), while in step 1 the order of the lags of the model can provisionally be identified using the autocorrelation function (ACF) and partial autocorrelation function (PACF) plots (Enders, 2004). Tests for stationarity should be performed to determine whether or not differencing is required (Adhikari & Agrawal, 2013; Enders, 2004).

In step 2 estimation involves the least squares method to determine the coefficients φ for the AR process and θ for the MA process (Adhikari & Agrawal, 2013; Enders, 2004).

In step 3 the suitability of the model is checked using a combination of Akaike Information Criteria (AIC), per Equation 6 and Bayesian Information Criteria (BIC) per Equation 7:

Equation 6 - Akaike information criterion

$$AIC(p) = n \times \ln\left(\hat{\sigma}_e^2 / n\right) + 2p$$

Adapted from Adhikari and Agrawal (2013).

Where n is the number of observations, $\hat{\sigma}_e^2$ are the sum of the squared residual errors in the model, and p are the number of lags.

Equation 7 - Bayesian information criterion

$$BIC(p) = n \times \ln\left(\sigma_e^2 / n\right) + p + p\ln(\mathrm{n})$$

Adapted from Adhikari and Agrawal (2013).

The aim of these tests is to ensure the information criteria are as low as possible, indicating a model which maximises explanatory power and parsimony simultaneously (Adhikari & Agrawal, 2013). The AIC and BIC effectively model the trade-off between the sufficient number of regressor and the cost of adding them, being the loss of data, since every increase in p leads to a reduction in n. BIC is more sensitive to additional lags than AIC. Generally BIC is more suited to larger samples, while AIC is suited to smaller samples (Enders, 2004). Given that this study uses in excess of 200 observations for the monthly estimations and in excess of 4000 observations for the daily estimations, BIC would be more suitable for hypothesis (Enders, 2004).

It is also critical to ensure that the following criteria, which will be discussed in detail in section 4.3, are met:

- Absence of significant serial correlation of the residuals (Adhikari & Agrawal, 2013; Enders, 2004; Hair et al., 2010);
- Linearity (Hair et al., 2010);
- Homoscedasticity (Hair et al., 2010);
- Normality of the errors (Hair et al., 2010).

4.2.2.2 From ARIMA to ARIMAX

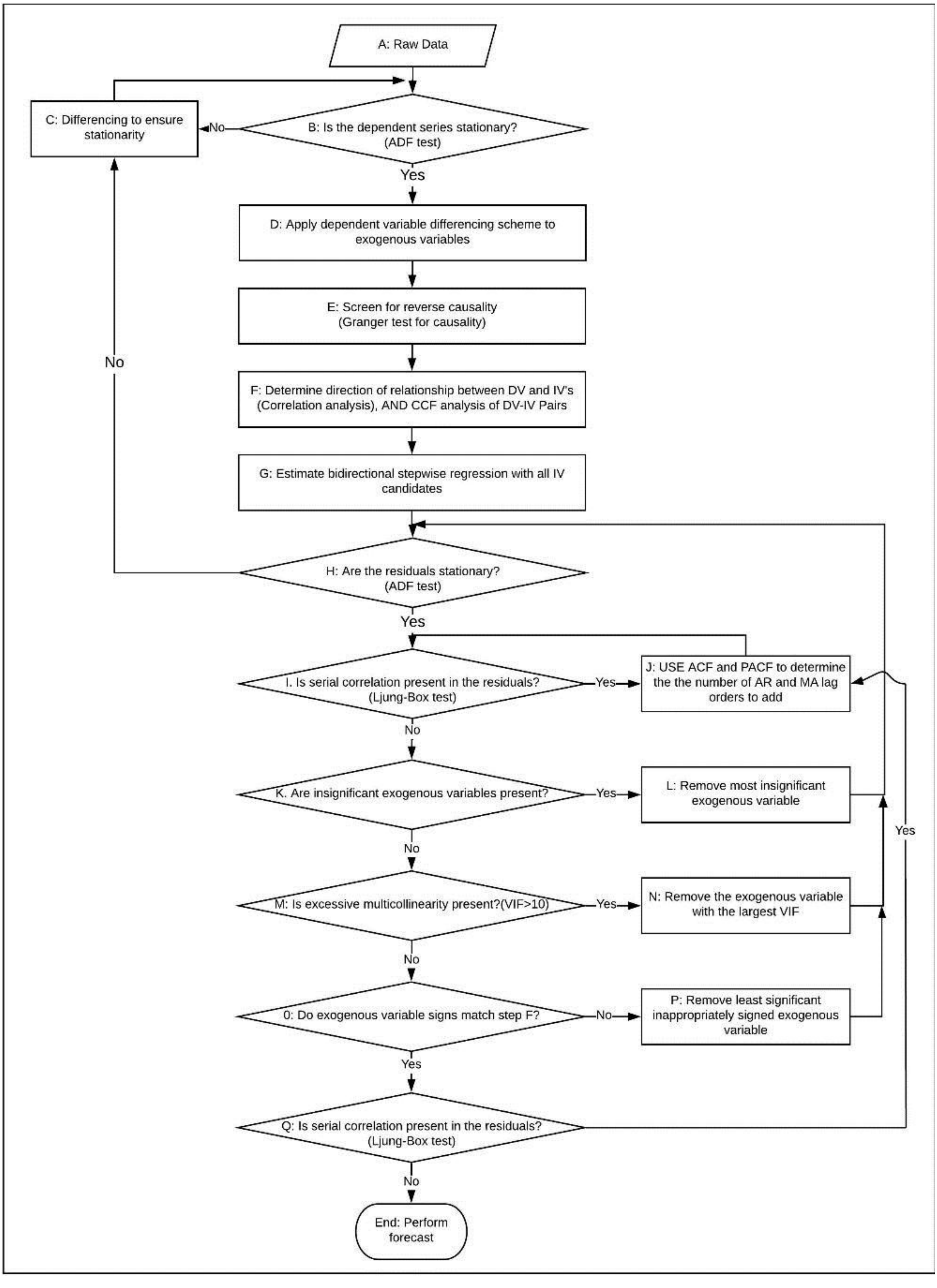


Figure 15 *ARIMAX model estimation process*

Adapted from Andrews et al. (Andrews et al., 2013, p. 38)

ARIMAX models overcome one of the most limiting aspects of ARIMA, which is that economic systems are affected by a great number of exogenous factors (Ďurka & Silvia, 2012; Petrică et al., 2016), while ARIMA relies purely on the past history of a given variable of interest (Enders, 2004). ARIMAX allows a principle of economic theory to be applied to a model in the form of exogenous variables (Andrews et al., 2013).

ARIMAX is essentially the merging or ARIMA modelling and regression (Andrews et al., 2013). This approach begins with a "logically attractive and statistically sound regression model" (Andrews et al., 2013, p. 32).

Andrews et al. (2013) propose an iterative process to estimate ARIMAX models which is analogous to the method developed in Tiao and Box (1981), and is detailed in *Figure 15*.

The methodology incorporates all the steps from the Box-Jenkins process detailed in *Figure 14*, with incorporation of further iterative steps, which are necessary since removal of insignificant variables will alter the significance and coefficients of remaining variables.

The order of lags of the exogenous variables in an ARIMAX model can be determined in an analogous manner to determining univariate lags (Enders, 2004), using cross-correlation functions (CCF) and cross-covariance functions (CCVF) (Enders, 2004; Tiao & Box, 1981).

The CCF analysis was conducted during stage F of the process detailed in *Figure 15*.

4.2.2.3 Assumptions for correctly estimated ARIMAX models

A valid ARIMAX model necessitates that six key assumptions are satisfied (Andrews et al., 2013):

1. Input data must be stationary (Andrews et al., 2013). Stationarity is discussed in section 4.3.2.
2. Residuals must be free from statistically significant autocorrelation (Andrews et al., 2013). Autocorrelation is discussed in section 4.3.9.
3. The coefficients of exogenous variables must be significantly different to zero as judged by their t-statistics (Andrews et al., 2013). Exogenous variables which are not significant should be removed from the model, and the model should be re-estimated.
4. Exogenous variables should not display any significant feedback from dependent variables (Andrews et al., 2013), as determined by a Granger causality test, which is detailed in section 4.3.11.

5. Signs of the coefficients of exogenous variables should be consistent with the signs of those found in the covariance test (Andrews et al., 2013), as detailed in step F in *Figure 15*.
6. There must be no significant multicollinearity between exogenous variables (Andrews et al., 2013). Multicollinearity is detailed in section 4.3.3.

4.2.2.4 Operationalising ARIMA and ARIMAX MODEL estimation in IBM SPSS

IBM SPSS v. 25 features a set of tools which automates much of the process of estimating ARIMA and ARIMAX models (IBM Corporation, 2016). Given that the variables for input into the hypothesis 5 model are derived from the best fitting models from the estimations for Hypotheses 1 to 4, much of the preliminary work described by Andrews et al. (2013) would already have been performed by this stage of the research.

IBM SPSS v. 25 Expert Modeller feature fully automates the ARIMA process including determination of the optimal lags and plotting the ACF and PACF for the dependent variable, as well as determining the lags for the exogenous variables in the ARIMAX modelling process (IBM Corporation, 2016). Estimation of the models to test hypothesis 5 was carried out with IBM SPSS v. 25's Expert modeller.

4.3 Tests and techniques to promote model quality

MLR and ARIMA/ARIMAX models require that critical assumptions and prerequisites are met for valid estimation of parameters. These assumptions and prerequisites were stated in section 4.2, and they are discussed in detail in this section along with the statistical tests available to ensure the assumptions are met. The techniques for transforming data should the assumptions not be met are also described.

4.3.1 Normality of the input variables

Normality is cited by Hair et al (2010) as being the most fundamental assumption in multivariate analysis, since both the f- and t-tests assume normality. However, the effect of non-normality can be less profound in large samples (over 200 observations), provided the skewness of the data are not severe. That said, regression is far less strict in its requirement for normality of the input data and departures from the normal in terms of leptokurtic distributions are acceptable (Yanagihara, 2015). The accepted test for normality is the Shapiro-Wilk W test (Alva & Estrada, 2009; Malkovich & Afifi, 1973; Shapiro & Wilk, 1965).

While the Jarque-Bera test (N. Kim, 2016; T. Lee, 2013) has also been used, it was found to be prone to type I errors in situations where distributions are leptokurtic (Thadewald & Büning, 2007). A further test, the Kolmogorov-Smirnov test has been shown to be highly sensitive to extreme values and is at risk of type II errors (Ghasemi & Zahediasl, 2012) and thus was not considered appropriate for this study.

The Shapiro-Wilk tests were performed using XLSTAT 19.7 (XLSTAT, 2017b) For the Shapiro-Wilk test:

- The conclusion of normal distribution lies in the null hypothesis (Shapiro & Wilk, 1965);
- The criteria for acceptance or rejection of the null hypothesis are as follows:
  - Fail to reject the null hypothesis when p-value is greater than or equal to α = .050, and conclude that the data are normally distributed to a 95% confidence level (Shapiro & Wilk, 1965);
  - Reject the null hypothesis when p-value is less α = .050, and conclude that the data are not normally distributed beyond a 95% confidence level (Shapiro & Wilk, 1965).

Should distributions be heavily skewed, transforming variables to ensure normality may be necessary (Hair et al., 2010). Transformations may take the form of Box-Cox logarithmic transformation (Box & Cox, 1964) in the case of data with long tails, or power transformation (Hair et al., 2010; Wegner, 2016) depending on the nature of the non-linearity. It must be noted that data that deviate from normal distribution only in being leptokurtic or platykurtic will not be transformed, since unnecessary transformations may render coefficients difficult to interpret.

4.3.2 Stationarity

Stationarity of a series of data refers to the property whereby differences between successive terms (or returns) are evenly distributed around a mean value (Enders, 2004). While the Dickey-Fuller test and Augmented Dickey-Fuller (ADF) test have been prescribed for assessing the existence of a unit root (Charemza & Syczewska, 1998; Enders, 2004; Kbłowski & Welfe, 2004)(which is closely related to non-stationarity), the KPSS test (Kwiatkowski, Phillips, Schmidt, & Yongcheol Shin, 1992) was specifically developed to test for trend stationarity in time series data.

The Phillips-Perron test has also been specified for testing for stationarity (Phillips & Perron, 1988). This test has been found to be deficient in identifying marginal cases of the existence of a unit root in cyclic data (Del Barrio Castro, Rodrigues, & Taylor, 2015). Furthermore, it has generally been found to underperform the ADF test (Leybourne & Newbold, 1999).

A weakness of the KPSS test is its high incidence of type 1 errors, where the test may indicate non-stationarity when a data series are stationary (Cappuccio & Lubian, 2010). Thus the prescribed solution (Charemza & Syczewska, 1998; Kbłowski & Welfe, 2004) is to perform both a KPSS and an ADF tests on the data.

For the study, the joint KPSS-ADF testing method was applied to all variables, with both the KPSS tests and the ADF tests having been performed using XLSTAT 19.7 (XLSTAT, 2017a).

For the KPSS test:

- The conclusion of stationarity lies in the null hypothesis (Kwiatkowski et al., 1992);
- The criteria for acceptance or rejection of the null hypothesis are as follows:
    - Fail to reject the null hypothesis when the p-value is greater than or equal to α = .050, and conclude that the data are stationary to a 95% confidence level (Kwiatkowski et al., 1992);
    - Reject the null hypothesis when the p-value is less than α = .050, and conclude that the data are not stationary beyond a 95% confidence level (Kwiatkowski et al., 1992).

For the ADF test:

- The conclusion of the existence of a unit root lies in the null hypothesis (Enders, 2004; MathWorks United Kingdom, 2017);
- The criteria for acceptance or rejection of the null hypothesis are as follows:
    - Fail to reject the null hypothesis when p-value is greater than or equal to α = .050, and conclude that the data contains a unit root to a 95% confidence level (Enders, 2004; MathWorks United Kingdom, 2017);
    - Reject the null hypothesis when p-value is less than α = .050, and conclude that the data does not contain a unit root beyond a 95% confidence level (Enders, 2004; MathWorks United Kingdom, 2017).

If both the null hypothesis of the KPSS test (indicating non-stationarity) and the null hypothesis on the ADF test are rejected (indicating the absence of a unit root in the series), it is acceptable to conclude that the series is stationary (Charemza & Syczewska, 1998; Kbłowski & Welfe, 2004). Moreover, should both tests indicate non-stationarity, it may be undesirable to transform data unless visual inspection of the time plot of the data indicates clear non-stationarity.

Non-stationarity may require that the time series is differenced to successively higher orders and retested with the KPSS-ADF method until the data are stationary (Adhikari & Agrawal, 2013; Andrews et al., 2013; Enders, 2004; Kwiatkowski et al., 1992).

4.3.3 Multicollinearity

In instances where predictor variables are highly correlated, they are said to be collinear (Wegner, 2016), a condition which poses a number of problems in multivariate regression (Hair et al., 2010; Kutner, 2005). Multicollinearity can distort coefficients and tests of significance in regression results, and suppress the instance of significant relationships (Hair et al., 2010; Kutner, 2005).

A common method for determining if multicollinearity exists is by inspecting a correlation matrix of variables (Hair et al., 2010; Kutner, 2005; Wegner, 2016). Pairwise correlations where $r<.400$ are generally considered not to affect the validity of a model (Wegner, 2016). Correlation matrices for each proposed set of variables were inspected in accordance with Hair et al. (2010), Kutner (2005) and Wegner (2016) on data prior to estimation of models for testing hypotheses 1, 2, 3, 4 and 5.

Multicollinearity can arise when data are closely related (Hair et al., 2010) and may be of particular concern in economic data where correlated effects in time series (Andrews et al., 2013). This was of concern when estimating ARIMAX models, and Andrews et al. (2013) prescribed that pairwise regressions be performed with all variables (step M in *Figure 15*). The variance inflation factor (VIF) (Andrews et al., 2013; Hair et al., 2010) of VIF<10 (Andrews et al., 2013) was prescribed. VIF was calculated in terms of Equation 8:

Equation 8 - Variance inflation factor

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

(Andrews et al., 2013; Hair et al., 2010)

VIF inspection was performed to validate whether multicollinearity was present in pairs of variables where the pairwise correlation coefficient was $r>.400$.

4.3.4 Seasonality

Economic time series are prone to seasonal effects, and this is problematic since seasonality can introduce excessive variance into a model and reduce its forecasting power (Enders, 2004) by distorting the parameters of models (Hylleberg, 2014). Moreover, the Box-Jenkins techniques (including ARIMA and ARIMAX) used to estimate the model for testing hypothesis 5 specifically require that seasonality be removed from the dependent variable (Adhikari & Agrawal, 2013; Andrews et al., 2013; Enders, 2004). Whilst reference was not made to seasonality in Jones and Sackley (2016), it was imperative, given the concerns raised by Enders (2004) and Hylleberg (2014), to address seasonality in the dependent variables for this research.

A concern when using data that has already been adjusted for seasonality by the publishing authority is that this adjustment may have been made for the purposes of simplifying that agency's analysis and thus the data may not be suitable for econometric modelling (Enders, 2004). This issue may be exacerbated when using a subset of the data available from a third party, and the adjusting indices may vary between that subset and the overall data set which was adjusted by the publisher (Enders, 2004).

Data collected for this study was specifically chosen so as not to be seasonally adjusted following these concerns. This left the opportunity for data to be tested for seasonality and adjusted in a manner that is acceptable for econometric analysis.

Seasonality may be detected by inspection of the ACF plot of data following differencing for stationarity, with particular attention to the s'th lag, s being the number of periods per year (Enders, 2004). For practical purposes, monthly data were used for all inspections, and in instances where only daily data were collected, a monthly average was used to assess seasonality.

In instances where seasonality is present, seasonal differencing was applied (Enders, 2004) in accordance with Equation 9.

Equation 9 - Seasonal differencing

$$SD = y_t - y_{t-s}$$

4.3.5 Outliers

Statistical methods including regression are exposed to significant negative consequences as a result of outliers, specifically in small samples (Hair et al., 2010; Kutner, 2005; Wegner, 2016). Data collected using questionnaires are particularly exposed to outliers (Kutner, 2005), however that is not to say that economic data (which generally represents objective fact rather than individual perception) is free from problematic outliers. Outliers may be termed beneficial or influential observations, and thus care should be taken in excluding them without proper consideration (Hair et al., 2010).

The Mahalanobis Z-score and distance (Ekiz & Ekiz, 2017; Hair et al., 2010), a multivariate outlier detection technique was used to test for outliers in data for hypotheses 1, 2,3 and 4. The technique is suitable for datasets that contain multiple independent variables (Ekiz & Ekiz, 2017; Hair et al., 2010).

One consideration when using the Mahalanobis method of detecting outliers are difficulties identified in its use in small samples (20 or smaller) (Ekiz & Ekiz, 2017). Given that this research uses datasets more than 200 observations, it was determined that notwithstanding Ekiz and Ekiz's (2017) concerns, the Mahalanobis method would be suitable in this instance.

The Mahalanobis distance for each multivariate observation can be can be converted to a p-value using the chi-squared distribution where the degrees of freedom are the number of variables tested (Ekiz & Ekiz, 2017; Hair et al., 2010). A p-value is then available for each observation.

For the Mahalanobis Z-score and distance:

- The conclusion that an observation is an outlier lies in the alternate hypothesis (Ekiz & Ekiz, 2017; Filzmoser, 2016; Hair et al., 2010; Mahalanobis, 1936);
- The criteria for acceptance or rejection of the null hypothesis are as follows:
  - Fail to reject the null hypothesis when the p-value is greater than or equal to $\alpha = .01$ (Hair et al., 2010), and conclude that the observation is not an outlier to a 99% confidence level;
  - Reject the null hypothesis when the p-value is less than $\alpha = .01$, and conclude that the observation is an outlier beyond a 99% confidence level (Ekiz & Ekiz, 2017; Filzmoser, 2016; Hair et al., 2010; Mahalanobis, 1936).

For hypotheses 1, 2, 3 and 4, IBM SPSS v. 25 was used to calculate the Mahalanobis distance, by regressing all the variables in each dataset against a chi-squared distributed random variable. The test statistic was compared to a chi-squared test-critical at α=.001 and where the degrees of freedom were the total number of independent variables (Ekiz & Ekiz, 2017; Filzmoser, 2016; Hair et al., 2010; Mahalanobis, 1936).

IBM SPSS v. 25's Expert modeller (IBM Corporation, 2016) offers the option of automatically detecting and removing outliers when performing model estimation. This method was used in detecting and removing outliers for the estimation of the model to test hypothesis 5.

4.3.6 Normal distribution of errors

A core assumption of linear models is that the error terms are normally distributed (Hair et al., 2010; Kutner, 2005; Wegner, 2016). Error terms were calculated between observed and expected values, and Shapiro-Wilk W tests were performed (Alva & Estrada, 2009; Malkovich & Afifi, 1973; Shapiro & Wilk, 1965).

Non-normal errors may arise in cases where outliers distort estimated parameters (Hair et al., 2010), where input data are not normally distributed or in instances of non-linearity or heteroscedasticity of residuals (Kutner, 2005). Additional transformations of existing variables may be required to estimate models with normal errors (Hair et al., 2010; Wegner, 2016; Weiers et al., 2011).

4.3.7 Linearity of residuals

Both Hair et al. (2010, p. 76) and Wegner (2016, p. 354) prescribe as best practice, that individual predictor variables' relationship with the dependent variable be checked for linearity. Should nonlinear relationships be observed, they recommend transforming independent variables to ensure linearity (Hair et al., 2010). These transformations may take the form of Box-Cox logarithmic transformation (Box & Cox, 1964) or power transformation (Hair et al., 2010; Wegner, 2016) depending on the nature of the non-linearity.

Hair et al. (2010) prescribes a visual inspection of residual scatterplots of each dependent-independent variable relationship to determine linearity, ex post estimation. Hair et al. (2010) further prescribe that, where the visual inspection is inconclusive a bivariate regression be performed. This bivariate regression may be compared to the univariate regression of the relationship post-transformation to determine an improvement of the linear condition.

4.3.8 Homoscedasticity of residuals

Homoscedasticity refers to the consistency of residuals across independent variables, with the absence of a trend in residual plots being an indication of homoscedasticity (Hair et al., 2010). In this sense homoscedasticity would refer to a model whose error terms are normally distributed across the entire range of the sample data.

The issues associated with statistically significant heteroscedasticity in ARIMA and ARIMAX modelling, being the distortion of calculation of t- and f-statistics, have the potential to invalidate the tests of significance for AR and MA terms (Andrews et al., 2013). Persistent heteroscedasticity may necessitate an altogether separate class of models. The Autoregressive Conditional Heteroscedasticity (ARCH) models and Generalised Autoregressive Conditional

Heteroscedasticity (GARCH) models and (Enders, 2004; Engle, 2002) have been developed for use where varying levels of volatility in data result in significant heteroscedasticity.

The practise of visual inspection of residual plots may be used to identify heteroscedasticity (Wegner, 2016). The need for rigor in this research, as well as the known sensitivity of ARIMA and ARIMAX modelling to heteroscedasticity, necessitated a rigorous statistical test to be performed.

Andrews et al. (2013) used the White's test for homoscedasticity (White, 1980), and this test has remained in use as a robust test in both the economic sciences (Ang, Green, Longstaff, & Xing, 2017; Angrist, Hull, Pathak, & Walters, 2017; Li & Sloan, 2017) and other scientific fields (Anaya et al., 2016; Wilson et al., 2017).

The Breusch-Pagan test (Breusch & Pagan, 1979) has also been prescribed to test for homoscedasticity, as has the Koenker test, which is a modified version of the Breusch-Pagan test. The Koenker test which corrects an estimation error in the Breusch-Pagan test (Koenker, 1981).

Operationalising the Breusch-Pagan and Koenker test in IBM SPSS v. 25 required third party script. The White's test may be manually constructed in IBM SPSS v. 25, while there were scripts available in MATLAB R2017b. Given the White's test's continued use in academic studies (including Andrews et al. (2013)), and the fragility of the Breusch-Pagan test highlighted by Koenker (1981), the White's test was used for this study. Oleg Komarov's (2009) script was used in MATLAB R2017b to execute White's test.

For White's test:

- The conclusion of homoscedastic residuals lies in the null hypothesis (White, 1980);
- The criteria for acceptance or rejection of the null hypothesis are as follows:
  - Fail to reject the null hypothesis when the p-value is greater than or equal to α = .050, and conclude that the residuals are homoscedastic to a 95% confidence level (White, 1980);
  - Reject the null hypothesis when the p-value is less than α = .050, and conclude that the residuals are heteroscedastic beyond a 95% confidence level (White, 1980).

Heteroscedasticity of the residuals may be rectified by log or power transforming the independent variable in question depending on the shape of the residual plot (Hair et al., 2010).

4.3.9 Autocorrelation, serial correlation, and independence of the residuals

Autocorrelation (also referred to as serial correlation, autoregression, and residual dependence) refers to the effect of momentum of an independent variable in a regression model (Weiers et al., 2011).

Absence of significant serial correlation of the residuals is essential in ensuring the validity of time series models (Adhikari & Agrawal, 2013; Enders, 2004; Hair et al., 2010); If not effectively accounted for in models, autocorrelation can lead to biases, underestimation of error terms, underestimation of the true standard deviation of the regression coefficient and distortions of the t- and f-statistics (Kutner, 2005).

The effect of autocorrelation can be determined through the Durbin-Watson test (Durbin, 1969; Kutner, 2005; Weiers et al., 2011). In its simplest the univariate autocorrelation function is expressed as follows:

Equation 10 – Simple form of autocorrelated function

$$y_t = b_0 + b_1 y_{t-1}$$

Models estimated for hypotheses 1, 2, 3 and 4 without autoregressive (AR) terms were tested for autocorrelation using the Durbin-Watson test in IBM SPSS v. 25 (IBM Corporation, 2017b).

For the Durbin-Watson test:

- The conclusion of absence of autocorrelation of residuals lies in the null hypothesis (Kutner, 2005; Weiers et al., 2011);
- Durbin-Watson statistics range from 0 to 4, with 2 indicating a complete absence from autocorrelation (Durbin, 1969; Enders, 2004; Kutner, 2005; Weiers et al., 2011);
- Durbin-Watson statistics (DW-stats) are calculated by IBM SPSS v. 25 (IBM Corporation, 2017b) based on the data;
- DW-stats between 1.5 and 2.5 generally indicate that no autocorrelation is present (Banerjee, 2014; Tabrizi, Ebrahimi, & Delpisheh, 2011);
- The criteria for acceptance or rejection of the null hypothesis are as follows:
    - Fail to reject the null hypothesis when the DW-stat is equal to or lies above the lower DW-critical and is equal to or below the upper DW-critical, and conclude that the residuals are not autocorrelated to a 95% confidence level (Durbin, 1969; Kutner, 2005; Weiers et al., 2011);

- Reject the null hypothesis when the DW-stat lies above the upper DW-critical, and conclude that the residual are positively autocorrelated beyond a 95% confidence level (Durbin, 1969; Kutner, 2005; Weiers et al., 2011);
- Reject the null hypothesis when the DW-stat lies below the lower DW-critical, and conclude that the residual are negatively autocorrelated beyond a 95% confidence level (Durbin, 1969; Kutner, 2005; Weiers et al., 2011);

It must be noted that the Durbin-Watson tests has two limitations pertinent to this study:

1. The test seeks to identify first order autocorrelation. It does not seek to identify autocorrelation at higher orders, and for this purpose, the ACF and PACF inspection to be performed for seasonality will also be relevant to identify higher order autocorrelation.
2. Jones and Sackley (2016) included a lagged dependent variable in their model, however this was found not to be significant. This is problematic since the Durbin-Watson test is not specified for instances where lagged dependent variables are included in models (Maddala, 2001). Notwithstanding Jones and Sackley (2016) having indicated that their study produced a DW-stat close to 2 with the inclusion of lagged dependent variables, it was decided, for the purpose of this study, to exclude the lagged dependent variables for the first estimation. Should significant autocorrelation be present in models, the lagged dependent variables may then be included, and the Ljung-Box test (Andrews et al., 2013; Ljung & Box, 1978) may then be applied to identify autocorrelation.

For the purpose of hypothesis 5, Andrews et al. (2013) prescribes the Ljung-Box test (Ljung & Box, 1978) to identify autocorrelation in ARIMAX methodology. The Ljung-Box test is also recommended in ARIMA models by Enders (2004).

Ljung-Box tests for hypotheses 1, 2, 3 and 4 where AR terms were included were performed using MATLAB R2017b (Mathworks, 2018b). Testing for hypothesis 5 was performed in IBM SPSS v. 25 as part of the ARIMA and ARIMAX model estimation process (IBM Corporation, 2012).

For the Ljung-Box test:

- The conclusion of absence of autocorrelation of residuals lies in the null hypothesis (Ljung & Box, 1978);
- The criteria for acceptance or rejection of the null hypothesis are as follows:

- Fail to reject the null hypothesis when the p-value is greater than or equal to α = .050, and conclude that the residuals are not autocorrelated to a 95% confidence level (Ljung & Box, 1978);
- Reject the null hypothesis when the p-value is less than α = .050, and conclude that the residuals are autocorrelated beyond a 95% confidence level (Ljung & Box, 1978).

Autocorrelation can be compensated for either by differencing the time series (in other words using the change in the variable as opposed to the variable itself), or by introducing the lagged term $b_1 y_{t-1}$ (Kutner, 2005).

4.3.10 Cointegration

Cointegration arises in time series where long run trends are integrated with short run dynamics (Maddala, 2001). In a series displaying a long run equilibrium, short run deviations from this mean have a tendency to revert to the mean (Enders, 2004).

The methodology for testing for cointegration involves determining the error attributable to mean reversion and the correlation of consecutive errors, and then introducing a series of lagged terms to the model in order to correct for this (Enders, 2004; Maddala, 2001). Engle and Granger (1987) developed tests to assess whether or not cointegration exists in a model, and these tests are available in MATLAB R2017b (Mathworks, 2018a).

For the Engle-Granger tests:

- The conclusion of absence of cointegration lies in the null hypothesis (Engle & Granger, 1987; Mathworks, 2018a);
- The criteria for acceptance or rejection of the null hypothesis are as follows:
  - Fail to reject the null hypothesis when the p-value is greater than or equal to α = .050, and conclude that no cointegration of variables is present to a 95% confidence level (Engle & Granger, 1987; Mathworks, 2018a);
  - Reject the null hypothesis when the p-value is less than α = .050, and conclude that cointegration of variables is present beyond a 95% confidence level (Engle & Granger, 1987; Mathworks, 2018a).

This effect can be eliminated by way of differencing, which risks removing important long-term trends in the data. Alternately, a Vector Error Correction Model may be estimated (Enders, 2004; Maddala, 2001).

4.3.11 Granger causality

Causality can be assessed by determining whether lagged values of one variable enter the estimated model for predicting another (Enders, 2004). Granger (1969) proposed a simple bivariate methodology using lagged variables to determine causality and noted that while information is often rapidly assimilated by efficient markets (Fama, 1998) the recording of the information about those markets experiences lagged effects (Granger, 1969). It is further proposed that the true test of causality between two variables should be considered the performance of a model containing those variable in out of sample forecasting (Ashley, Granger, & Schmalensee, 1980).

While the concept of causality based on lags faces the risk of committing the *post hoc ergo propter hoc* fallacy the methodology for estimating ARIMAX models necessitates testing for reverse causality (Andrews et al., 2013), that is where movements in dependent variables cause movements in exogenous variables.

While Granger (1980) eschews the notion of a simple procedure to test for causality, the use of CCF's is supported to identify lagged correlations that may indicate a causal relationship between a pair of variables. CCF analysis was performed in IBM SPSS v. 25 (IBM Corporation, 2017a), and Granger causality tests were conducted for selected variables using the Granger_Cause_1 script published by R. Boldi of Zayed University for MATLAB R2017b.

4.3.12 Stability of coefficients and structural change

A factor closely aligned to homoscedasticity, and particularly pertinent in time series, is that of stability of the model and coefficients (Enders, 2004). Structural change may occur across time series models where exogenous factors are not accounted for.

Cusum tests have been used in recent research employing time-series data, in the fields of development economics and energy economics (Farhani, Chaibi, & Rault, 2014; Ozturk & Acaravci, 2013; Shahbaz, Mallick, Mahalik, & Sadorsky, 2016; Sugiawan & Managi, 2016).

The Cusum tests (Brown, Durbin, & Evans, 1975) available in MATLAB R2017b provided a graphical method of determining coefficient stability (Mathworks United Kingdom, 2017a).

For the Cusum test:

- The conclusion of absence of significant structural change lies in the null hypothesis (Mathworks United Kingdom, 2017a);

- MATLAB R2017b produces a plot of the test criticals and test statistics at progressive iterations (Mathworks United Kingdom, 2017a);
- The test is conducted to a 95% confidence level consistent with the remainder of this research;
- The criteria for acceptance or rejection of the null hypothesis are as follows:
    - Fail to reject the null hypothesis as long as the test statistic remains within the upper and lower test critical bounds, and conclude that no structural change of the model is present to a 95% confidence level (Mathworks United Kingdom, 2017a);
    - Reject the null hypothesis if the test statistic exceeds either the upper or lower test critical bounds, and conclude that structural change of the model is present beyond a 95% confidence level (Mathworks United Kingdom, 2017a);

A further graphical tool to assess structural stability of coefficients were the Recursive Linear Regression (RLR) plots available in MATLAB R2017b (Mathworks United Kingdom, 2017b). RLR plots could provide an interesting view of how coefficients change with time, however the Cusum tests were preferred for testing hypotheses of stability.

4.4 The methodological process

Sections 4.2 and 4.3 constitute a toolbox for the estimation and testing of hypotheses for the study. The remainder of this chapter is organised in such a way as to correspond with the process overview detailed in *Figure 16*.

The forthcoming sections provide further context to the tools detailed in sections 4.2 and 4.3. The section numbers in the flow diagrams refer to the contextualised descriptions in sections 4.5, 4.6, 4.7, 4.8 and 4.9, while the paragraphs in the sections refer back to the tools described in sections 4.2 and 4.3.

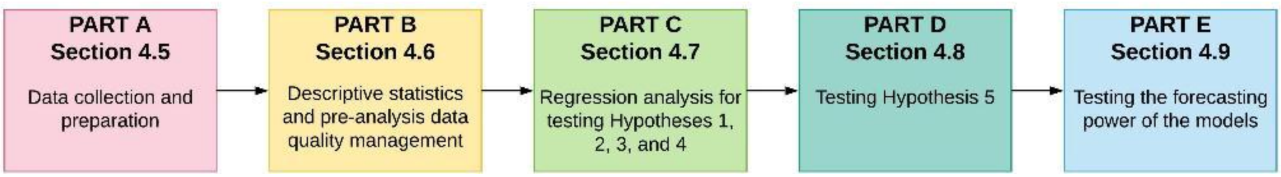


Figure 16 *Analysis process overview*

Source: Own research.

4.5 ANALYSIS PART A: Data collection and preparation

This section describes how data were sourced, cleaned, and consolidated for use in the study. The section is arranged into sections according to *Figure 17*:

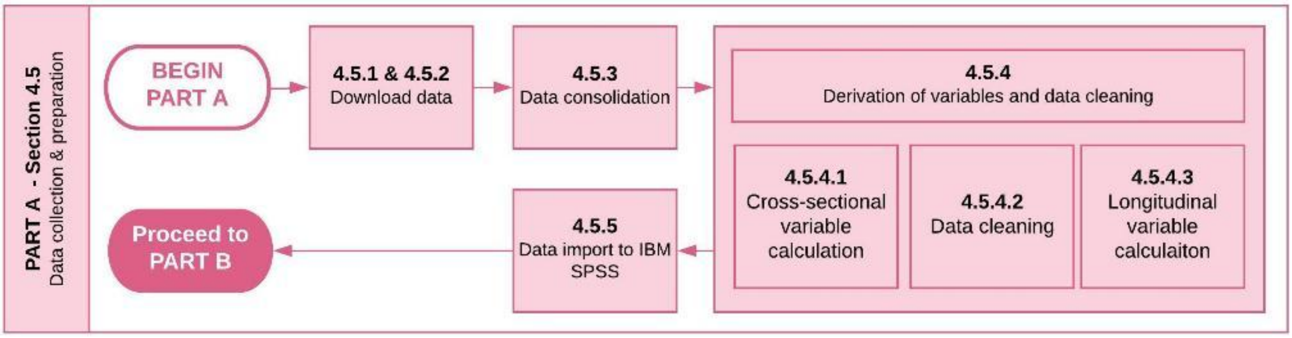


Figure 17 *Data collection and preparation process*

Source: Own research.

4.5.1 Data collection

Data were collected from the sources detailed in section 4.1.5, and the table detailed in appendix 9.1.

4.5.2 Availability of control variables

Availability of the gold lease rate, and the oil country political risk index, have been found to be problematic, and a strategy was developed to deal with this.

4.5.2.1 Gold Lease Rate

Jones and Sackley (2016) specify the gold lease rate as a control variable in their study. In the model of the effect of EPU on the price of gold, the gold lease rate was found not to meet a 95% level of significance, and the variable was included for parity with other models in their study in which it was found to be significant.

The gold lease rate is itself a derivation of the LBMA Gold Forward Offer Rate (GOFO). As described in section 2.2.2.6, gold leasing had declined considerably (O'Connor et al., 2015), resulting in a 30 January 2014 LBMA decision that it would be discontinuing the GOFO as of 30 January 2015 (London Bullion Market Association, 2014).

It was decided that given the insignificance of the variable in prior studies (Jones & Sackley, 2016), and its suspension prior to the end of the study timeframe (London Bullion Market Association, 2014), the Gold Lease Rate would be omitted from this study.

4.5.2.2 Oil country uncertainty

Jones and Sackley (2016) controlled their study for political risk in oil producing countries excluding the US, since their finding was that oil prices were linked to the price of gold, and these prices are affected by oil supply. That said, that study showed no significance when modelling EPU's effect on the price of gold with the t-statistic of t = 0.560 being substantially within the 95% t-critical which was estimated to be between t=1.44 and t=1.84 (Jones & Sackley, 2016). Despite this finding, a general link between gold and oil has been found (O'Connor et al., 2015).

The control variable that was used by Jones and Sackley (2016) was derived from PRS Group's International Country Risk Guide (ICRG) monthly risk index for the top ten oil producers excluding the US, weighted by GDP. A fundamental problem with this method is contended to be the weighting: political risk in Iraq which produces five times more oil than the UK (US Department of Energy, 2017) surely cannot have less significant effect on the supply side of oil prices, than political risk in the UK which has a GDP nearly fifteen times that of Iraq (World Bank, 2017).

A further difficulty, for this study, is the availability of the PRS Group ICRG monthly political risk index. The PRS Group is a world leader in political risk research, and its services are underpinned by the work of respected academics (PRS Group, 2015). The PRS Group ICRG political risk index was been used in academic studies (Jones & Sackley, 2016; Lessmann, 2016). An annual consolidated Political Risk Index based on the PRS monthly index is published by the World Bank via https://info.worldbank.org/governance/wgi/pdf/prs.xlsx however this dataset is problematic since it is incomplete: no data were recorded for 1997, 1999, or 2001. The monthly data used by Jones and Sackley (2016) is only available at a cost which exceeds the budget for this study.

Given the insignificance in the Jones and Sackley (2016) model of the PRS Group ICRG political risk index, as well as the difficulty in obtaining complete data, and the lack of clarity in the method for building the index, it was decided to omit this variable from the study.

4.5.3 Data consolidation

Data for this study fell into three temporal categories: Daily, monthly and annual. These categories are determined by the data publisher, and an endeavour was made to obtain data which was as temporally granular as possible. Some data, such as GDP were, for obvious reasons, impractical to publish daily or even monthly.

For model estimation purposes, it was necessary to prepare a daily data table for hypotheses 2 and 3, and a monthly data table for hypothesis 1 and 4. Hypothesis 5 was tested using a model estimated using the best possible result from hypotheses 1, 2, 3 and 4.

4.5.4 Derivation of variables and preliminary data cleaning

Derivation of variables from readily available secondary data were necessary to achieve parity with Jones and Sackley (2016). These calculations fell into two broad categories: cross-sectional formulae, whose components were obtained in the same period; and longitudinal formulae such as beta's, moving averages, and volatilities.

4.5.4.1 European variables

Given that the European EPUI includes the UK which uses the GBP, it was necessary to price gold in a notional weighted average currency. The price was constructed by first weighting the log returns of the EUR and the GBP against the USD, by their respective GDP's, and then indexing the change to 1, to create the combined exchange rate at 1 January 1999. The calculation of this rate is detailed in Equation 12, Equation 13 and Equation 14.

The Eurozone GDP was calculated for countries included in the European EPUI only.

Equation 11 – Eurozone GDP

$$GDP_{euro} = \sum GDP_{country}$$

4.5.4.1.1 Weighted EUR/GBP exchange rate

Equation 12 – GDP weighted EUR/GBP Return

$$Return_{EurGbp} = \left[Ln\left(\frac{Rate_{gbp,t}}{Rate_{gbp,t-1}}\right) \times \left(\frac{GDP_{uk}}{GDP_{uk} + GDP_{eu}}\right)\right] + \left[Ln\left(\frac{Rate_{eur,t}}{Rate_{eu,t-1}}\right) \times \left(\frac{GDP_{eu}}{GDP_{uk} + GDP_{eu}}\right)\right]$$

Equation 13 – EUR / GBP Return Multiplier

$$Multiplier = e^{ReturnEurGbp}$$

Equation 14 – EUR/GBP weighted basket exchange rate (EPWB)

$$RATE_{EuUk,t} = RATE_{EuUk,t-1} \times Multiplier$$

4.5.4.1.2 Combined EUR/GBP index

It was necessary to develop a combined weighted EUR/GBP index for the European EPU study, to include the effect of movements in the GBP. To avoid the issue where the published indices are not common-sized, this index was constructed using the following process:

Equation 15 – GDP weighted EUR/GBP index

$$CombinedReturn = \left[Ln\left(\frac{IDX_{gbp,t}}{IDX_{gbp,t-1}}\right) \times \left(\frac{GDP_{uk}}{GDP_{uk} + GDP_{eu}}\right)\right] + \left[Ln\left(\frac{IDX_{eur,t}}{IDX_{eu,t-1}}\right) \times \left(\frac{GDP_{eu}}{GDP_{uk} + GDP_{eu}}\right)\right]$$

Equation 16 – EUR / GBP index multiplier

$$Multiplier = e^{CombinedReturn}$$

Equation 17 – EUR/GBP Combined index

$$IDX_{EurGbp,t} = RATE_{EurGbp,t-1} \times Multiplier$$

Where IDX_{EurGbp},t_0 = 100

4.5.4.1.3 GDP Weighted combined Europe/UK CPI

Constructing a weighted CPI from the published European and UK CPI presents the challenge that the indices were not common-scaled.

Thus, both indices were converted to log returns and weighted. The calculation of combined EU / UK CPI is detailed in Equation 18,

Equation 19 and Equation 20.

Equation 18 – EU / UK weighted CPI return

$$CombinedReturn = \left[Ln\left(\frac{CPI_{uk,t}}{CPI_{uk,t-1}}\right) \times \left(\frac{GDP_{uk}}{GDP_{uk} + GDP_{eu}}\right)\right] + \left[Ln\left(\frac{CPI_{eu,t}}{CPI_{eu,t-1}}\right) \times \left(\frac{GDP_{eu}}{GDP_{uk} + GDP_{eu}}\right)\right]$$

Equation 19 – EU / UK CPI multiplier factor

$$Multiplier = e^{CombinedReturn}$$

Equation 20 – EU / UK combined CPI

$$CPI_{EuUk,t} = CPI_{EuUk,t-1} \times Multiplier$$

4.5.4.2 Cross-sectional calculations

The cross-sectional variables were derived according to the following equations:

4.5.4.2.1 Gold price in other currencies

Equation 21 - Price of gold in a specified currency

$$P_{gold,currency} = Rate_{currency} \times P_{gold}$$

4.5.4.2.2 CNY index

The Chinese Foreign Exchange Trade System uses a weighted basket of 26 currencies to determine the relative strength if the renminbi (CFETS, 2016; Shen et al., 2016). The currencies and weights are listed in Table 53.

The calculation of the index was in accordance with

Equation 22:

Equation 22 - CNY index

$$IDX_{cny} = \sum_{c=1}^{n} \Delta ExchangeRate_c \times Weight_c$$

where c is country and n are the number of currencies in the basket.

4.5.4.2.3 Error correction mechanism for spot price studies

Equation 23 - Error correction mechanism for spot price studies

$$Ecm_{country} = lnP_{gold,country} - lnCPI_{country}$$

Adapted from Levin and Wright (Levin & Wright, 2006) as a control variable for cointegrative effects.

4.5.4.2.4 Error correction mechanism for futures price studies

Equation 24 - Error correction mechanism for futures price US study

$$Ecm = lnF_{gold} - lnCPI_{us}$$

Adapted from Levin and Wright (Levin & Wright, 2006) as a control variable for cointegrative effects.

4.5.4.3 Data cleaning

Table 4

Summary of preliminary data cleaning

Hypothesis	Total observations	Observations removed	Valid observations
Benchmarking	240	0	240
1	240	0	240
2 & 3	7305	2356	4949
4c	204	0	204
4e	204	0	204
4j	240	0	240
5	204	0	204

Source: Own research.

In instances of weekends or national holidays, observations were not available. In these cases, partial observations were removed from the study. Data were cleaned at this point, following calculation for cross sectional variables, but before longitudinal variables, to ensure that longitudinal calculations were not distorted by observations that would subsequently need to be excluded because their being incomplete. Table 4 summarises the effect of this cleaning process on the size of the samples.

4.5.4.4 Longitudinal formulae

Longitudinal variables were calculated in terms of the following formulae:

4.5.4.4.1 Default premium

Being the average default premium on Baa rated bonds over Aaa rated bonds, calculated using 6 monthly data points:

Equation 25 – Default Premium

$$DefaultPremium_t = \frac{\sum_{t=1}^{6} Bond_{Baa} - Bond_{Aaa}}{6}$$

4.5.4.4.2 Gold beta

Being the gold price beta with respect to the S&P500 Index

Equation 26 – Gold Beta

$$GoldBeta = \frac{Cov\left(P_{gold}, S\&P500\right)}{\sigma^2_{S\&P500}}$$

Gold beta was calculated over a 36 month period, or 250 days in the case of daily data (Jones & Sackley, 2016).

Equation 27 – Covariance of gold price and S&P500

$$Cov\left(P_{gold}, S\&P500\right) = \frac{\sum_{i=1}^{n}(P_{gold,i} - \overline{P_{gold}})(S\&P500_i - \overline{S\&P500})}{n-1}$$

(Bodie et al., 2008)

4.5.4.4.3 Inflation

Calculated on a 12-month rolling basis.

Equation 28 – Inflation

$$\%\Pi_t = \frac{CPI_t - CPI_{t-12}}{CPI_t} \times 100$$

4.5.4.4.4 Inflation volatility

Being the 12-month lagged inflation volatility for a given country.

Equation 29 - ΠVolx

$$\Pi Vol_x = \sqrt{\frac{\sum_{i=1}^{n}(\Pi_{x,i} - \overline{\Pi_x})}{n-1}}$$

where n = 12 (Bodie et al., 2008).

4.5.4.4.5 Economic policy uncertainty volatility

Equation 30 - US EPU volatility

$$EPU\_VOL_{us} = \sqrt{\frac{\sum_{i=1}^{n}\left(EPU_{us,i} - \overline{EPU_{us}}\right)}{n-1}}$$

where n = 30 (Bodie et al., 2008).

Derived variables were inserted as additional columns in the final daily and monthly data tables, and the data were spot checked by a third party to ensure that consistency was maintained. Once assurance was obtained that data were correctly transcribed and that variables were calculated correctly, the study proceeded to the data description and pre-analysis quality management phase.

4.5.5 Data import to IBM SPSS v. 25

A sequential time index was added to the data sets in Microsoft Excel to ensure that time series analyses were conducted correctly, and the data were imported into two separate IBM SPSS v. 25 files, one for monthly analysis and one for daily analysis. Data in IBM SPSS v. 25 were spot checked against the original data in Microsoft Excel to ensure consistency by a third party.

4.6 ANALYSIS PART B: Descriptive statistics and pre-analysis data quality management

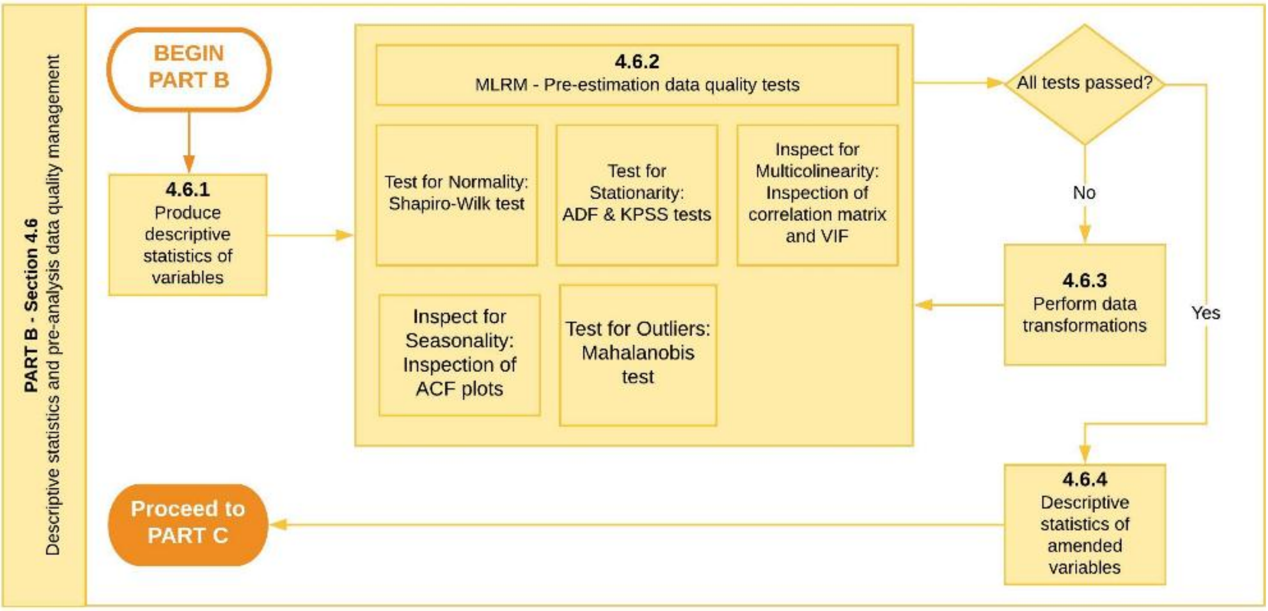


Figure 18 *Descriptive statistics and pre-analysis data quality management process*

Source: Own research.

Following the tabulation of the data and the calculation of the derived variables, descriptive statistics were performed on the final set of variables to be used in testing the hypotheses. The process flow for this section is detailed in *Figure 18*.

4.6.1 Descriptive statistics

IBM SPSS v. 25 was used to generate descriptive statistics for the preliminary set of variables.

4.6.2 Pre-estimation strategies to ensure the quality of results

Variables in regression models were required to meet specific conditions to ensure validity of the model estimations. These were as follows:

1. Normal distribution, with reference to section 4.3.1. The Shapiro-Wilk test was performed;
2. Stationarity, with reference to section 4.3.2. The tests performed were:
    a. Augmented Dickey-Fuller test;

   b. KPSS test.
3. Absence of multicollinearity, with reference to section 4.3.3. The inspections performed were:
   a. Pairwise correlation inspection;
   b. VIF inspection.
4. Absence of seasonality, with reference to section 4.3.4. ACF's and PACF's were inspected.
5. Without invalid outliers, with reference to section 4.3.5. The Mahalanobis distance method was used to detect outliers.

This process was followed iteratively, in such a way that necessary transformations were performed at each stage, and each subsequent stage was performed on transformed data.

4.6.3 Data transformations

The transformations detailed in Table 5 were performed on the data, as necessary, in IBM SPSS v. 25, following the tests described in section 4.6.2:

Table 5

Pre-estimation transformations - 1st iteration

Dataset	Variable code	Reason	Transform. type	New variable Code
Benchmark	ECMusSpot	Stationarity	Log return	ECMusSpotLRP1m
Hypothesis 1	ECMusSpot	Stationarity	Log return	ECMusSpotLRP1m
Hypothesis 2 & 3	ECMusSpot	Stationarity	Log return	ECMusSpotLRP1d
Hypothesis 2 & 3	ECMusFut	Stationarity	Log return	ECMusFutLRP1d
Hypothesis 4c	ECMcn	Stationarity	Log Return	ECMcnLRP1m
Hypothesis 4e	ECMeu	Stationarity	Log Return	ECMeuLRP1m
Hypothesis 4j	ECMjp	Stationarity	Log Return	ECMjpLRP1m

Source: Own research.

4.6.4 Description of transformed data

Descriptive statistics were restated following the transformation process. Following the transformation, the data were found to be suitable for the analysis detailed in section 4.7.

4.7 ANALYSIS PART C: Regression analysis for testing Hypotheses 1, 2, 3 and 4

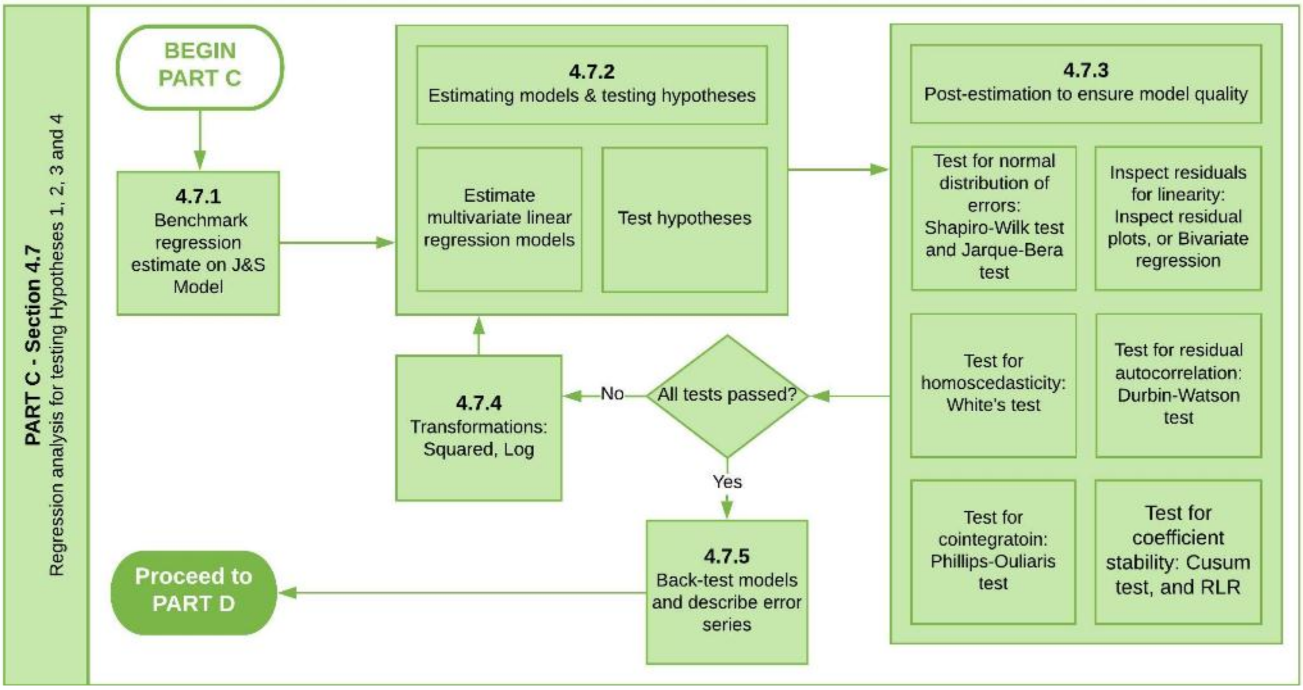


Figure 19 *Regression analysis process for testing Hypotheses 1, 2, 3 and 4*

Source: Own research.

The process for estimating models to test Hypotheses 1, 2, 3, and 4, is detailed in *Figure 19*.

4.7.1 Benchmarking

Hypotheses 1, 2 and 3 necessitated the comparison of models estimated by Jones and Sackley (2016) with those estimated in this study. Whilst care was taken to ensure that the conditions under both studies were as similar as possible, some differences were unavoidable. These differences were as follows:

1. Gold lease rate, and oil country uncertainty were excluded from the model estimation for hypotheses 1, 2 and 3.
2. It was not possible to guarantee that the same data sources were used as Jones and Sackley (2016) since that study did not detail variable sources.
3. Hypotheses 1, 2, and 3 were tested over a timeframe from 1 January 1997 to 31 December 2016, while Jones and Sackley's (2016) timeframe was July 1997 to January 2013.
4. Hypotheses 1, 2, and 3 were tested with daily data, while Jones and Sackley's (2016) model was estimated using monthly data.

The adjusted models that were proposed to be estimated to provide the benchmarks for this study were as follows:

Equation 31 - Jones and Sackley baseline model with domestic control variables only

$$\%\Delta P_{gold,t} = \beta_0 + \beta_1 \Delta EPU_{us} + \beta_2(L)\Delta P_{gold,t-1} + \beta_3 \Pi_{us,t} + \beta_4 \Pi Vol_{us,t} + \beta_5 \Delta IDX_{usd} + \beta_6 GoldBeta_t + \beta_7 \Delta DefaultPremium_t + \varepsilon_t$$

Equation 32 – Jones and Sackley baseline model with international control variables included

$$\%\Delta P_{gold,t} = \beta_0 + \beta_1 \Delta EPU_{us} + \beta_2(L)\Delta P_{gold,t-1} + \beta_3 \Pi_{us,t} + \beta_4 \Pi Vol_{us,t} + \beta_5 \Delta IDX_{usd} + \beta_6 GoldBeta_t + \beta_7 \Delta DefaultPremium_t + \beta_8 \Pi_{world,t} + \beta_9 \Pi Vol_{world,t} + \beta_{10} \Delta EPU_{eu,t} + \varepsilon_t$$

4.7.2 Methodology for testing the hypotheses

The purpose of testing Hypotheses 1, 2 and 3 was to determine whether a variety of enhancements to Jones and Sackley's (2016) gold price forecasting model delivered a better coefficient of determination (R^2) than the original model.

The purpose of hypothesis 4 was to determine whether the estimation of a model for China, Japan and the EU using gold priced in those economies' currencies could provide a non-zero coefficient of determination (R^2). Jones & Sackley (2016) had previously tested their model using gold priced in USD with no significant result.

Models for hypotheses 1, 2, 3 and 4 were estimated using multivariate linear regression, in terms of section 4.2.1, using IBM SPSS v. 25.

Hypotheses were tested along the following dimensions:

1. Where models were compared with the Jones and Sackley (2016) benchmark, a comparison of coefficients of determination (R^2) were made.
2. In instances where no benchmark was established, being the models for China, Europe and Japan, models were tested for significance by inspecting the model p-value, with the requirement that this be below α=.05.

With regard to the handling of autocorrelation:

- A first order autogregressive term (AR1) was included in all the models estimated for hypotheses 1, 2, 3 and 4 in order to maintain consistency with Jones and Sackley's (2016) study. This term was also included when stationarized series were found to be free from autocorrelation using the Durbin-Watson test.

- For comparison purposes, models were also estimated which excluded the AR1 term.

4.7.2.1 Hypothesis 1

Hypothesis 1 was divided into two parts and was tested using monthly log return data.

Hypothesis 1d, Where Jones and Sackley's (2016) model using US domestic control variables was proposed to be enhanced with the addition of EPU Volatility and the following model was estimated, and test H1d was be performed:

Equation 33 – Model to test H1d

$$\%\Delta P_{gold,t} = \beta_0 + \beta_1 \Delta EPU_{us,t} + \beta_2(L)\Delta P_{gold,t-1} + \beta_3 \Pi_{us,t} + \beta_4 \Pi Vol_{us,t} + \beta_5 \Delta IDX_{usd,t} + \beta_6 GoldBeta_t + \beta_7 \Delta DefaultPremium_t + \beta_8 EPU\_VOL_{us,t} + \varepsilon_t$$

Hypothesis H1d's criteria for acceptance or rejection were as follows:

The null hypothesis: The proposed model's explanatory value did not exceed Jones and Sackley's (2016) model which had an R^2= .094.

The alternative hypothesis: The proposed model's explanatory value exceeded Jones and Sackley's (2016) model which had an R^2= .094.

Thus: $H1d_0$: $R^2_{VolDom} \leq .094$

$H1d_A$: $R^2_{VolDom} > .094$

Hypothesis 1i, Where Jones and Sackley's (2016) model using global control variables was proposed to be enhanced with the addition of EPU Volatility and the following model was estimated, and test H1i was be performed:

Equation 34 – Model to test H1i

$$\%\Delta P_{gold,t} = \beta_0 + \beta_1 \Delta EPU_{us,t} + \beta_2(L)\Delta P_{gold,t-1} + \beta_3 \Pi_{us,t} + \beta_4 \Pi Vol_{us,t} + \beta_5 \Delta IDX_{usd,t} + \beta_6 GoldBeta_t + \beta_7 \Delta DefaultPremium_t + \beta_8 \Pi_{world,t} + \beta_9 \Pi Vol_{world,t} + \beta_{10} \Delta EPU_{eu,t} + \beta_{11} EPU\_VOL_{us,t} + \varepsilon_t$$

Hypothesis H1i's criteria for acceptance or rejection were as follows:

The null hypothesis: The proposed model's explanatory value did not exceed Jones and Sackley's (2016) model which had an R^2= .116.

The alternative hypothesis: The proposed model's explanatory value exceeded Jones and Sackley's (2016) model which had an R^2= .116.

Thus: H1i_0: $R^2_{\text{VolInt}} \leq .116$

H1i_A: $R^2_{\text{VolInt}} > .116$

4.7.2.2 Hypothesis 2

Hypothesis 2 was divided into two parts and was tested using daily data.

Hypothesis 2d, Where Jones and Sackley's (2016) model using US domestic control variables was tested against gold futures prices and the following model was estimated, and test H2d was performed:

Equation 35 – Model to test H2d

$$\%\Delta F_{gold,t} = \beta_0 + \beta_1 \Delta EPU_{us,t} + \beta_2(L)\Delta P_{gold,t-1} + \beta_3 \Pi_{us,t} + \beta_4 \Pi Vol_{us,t} + \beta_5 \Delta IDX_{usd,t} + \beta_6 GoldBeta_t + \beta_7 \Delta DefaultPremium_t + \varepsilon_t$$

Hypothesis H2d's criteria for acceptance or rejection were as follows:

The null hypothesis: The proposed model's explanatory value did not exceed Jones and Sackley's (2016) model which had an R^2= .094.

The alternative hypothesis: The proposed model's explanatory value exceeded Jones and Sackley's (2016) model which had an R^2= .094.

Thus: H2d_0: $R^2_{\text{VolDom}} \leq .094$

H2d_A: $R^2_{\text{VolDom}} > .094$

Hypothesis 2i, Where Jones and Sackley's (2016) model using global control variables was tested against gold futures prices and the following model was estimated, and test H2i was performed:

Equation 36 – Model to test H2i

$$\%\Delta F_{gold,t} = \beta_0 + \beta_1 \Delta EPU_{us,t} + \beta_2(L)\Delta P_{gold,t-1} + \beta_3 \Pi_{us,t} + \beta_4 \Pi Vol_{us,t} + \beta_5 \Delta IDX_{usd,t} + \beta_6 GoldBeta_t + \beta_7 \Delta DefaultPremium_t + \beta_8 \Pi_{world,t} + \beta_9 \Pi Vol_{world,t} + \beta_{10} \Delta EPU_{eu,t} + \varepsilon_t$$

Hypothesis H2i's criteria for acceptance or rejection were as follows:

The null hypothesis: The proposed model's explanatory value did not exceed Jones and Sackley's (2016) model which had an R^2= .116.

The alternative hypothesis: The proposed model's explanatory value exceeded Jones and Sackley's (2016) model which had an R^2= .116.

Thus: $H2i_0$: $R^2_{\text{VolInt}} \leq .116$

$H2i_A$: $R^2_{\text{VolInt}} > .116$

In order to validate the findings of this estimation, an ARIMAX model was estimated using IBM SPSS v.25's expert modeller and the same dataset. This model was used for discussion purposes only and was not used to re-test the hypothesis.

4.7.2.3 Hypothesis 3

Hypothesis 3 was divided into two parts and was tested using daily data.

Hypothesis 3d, Where Jones and Sackley's (2016) model using US domestic control variables was proposed to be enhanced with the addition of EPU Volatility and tested against gold futures prices. The following model was estimated, and test H3d was performed:

Equation 37 - Model to test H3d

$$\begin{aligned}\%\Delta F_{gold,t} = \; & \beta_0 + \beta_1 \Delta EPU_{us,t} + \beta_2(L)\Delta P_{gold,t-1} + \beta_3 \Pi_{us,t} + \beta_4 \Pi Vol_{us,t} + \beta_5 \Delta IDX_{usd,t} \\ & + \beta_6 GoldBeta_t + \beta_7 \Delta DefaultPremium_t + \beta_8 EPU\_VOL_{us,t} + \varepsilon_t\end{aligned}$$

Hypothesis H3d's criteria for acceptance or rejection were as follows:

The null hypothesis: The proposed model's explanatory value did not exceed Jones and Sackley's (2016) model which had an R^2= .094.

The alternative hypothesis: The proposed model's explanatory value exceeded Jones and Sackley's (2016) model which had an R^2= .094.

Thus: $H3d_0$: $R^2_{\text{VolDom}} \leq .094$

$H3d_A$: $R^2_{\text{VolDom}} > .094$

Hypothesis 3i, Where Jones and Sackley's (2016) model using global control variables was proposed to be enhanced with the addition of EPU Volatility and tested against gold futures prices. The following model was estimated, and test H3i was performed:

Equation 38 – Model to test H3i

$$\%\Delta F_{gold,t} = \beta_0 + \beta_1 \Delta EPU_{us,t} + \beta_2(L)\Delta P_{gold,t-1} + \beta_3 \Pi_{us,t} + \beta_4 \Pi Vol_{us,t} + \beta_5 \Delta IDX_{usd,t} + \beta_6 GoldBeta_t + \beta_7 \Delta DefaultPremium_t + \beta_8 \Pi_{world,t} + \beta_9 \Pi Vol_{world,t} + \beta_{10} \Delta EPU_{eu,t} + \beta_{11} EPU\_VOL_{us,t} + \varepsilon_t$$

Hypothesis H3i's criteria for acceptance or rejection were as follows:

The null hypothesis: The proposed model's explanatory value did not exceed Jones and Sackley's (2016) model which had an R^2= .116.

The alternative hypothesis: The proposed model's explanatory value exceeded Jones and Sackley's (2016) model which had an R^2= .116.

Thus: $H3i_0$: $R^2_{\text{VolInt}} \leq .116$

$H3i_A$: $R^2_{\text{VolInt}} > .116$

In order to validate the findings of this estimation, an ARIMAX model was estimated using IBM SPSS v.25's expert modeller and the same dataset. This model was used for discussion purposes only and was not used to re-test the hypothesis.

4.7.2.4 Hypothesis 4

Hypothesis 4 was divided into three parts, relating to EPU in China, Europe and Japan. Models based on Jones and Sackley's (2016) US Domestic variable set were derived and the extent to which they explain movements in the gold price was determined.

Hypothesis 4c, Chinese EPU was modelled against the price of gold in CNY, with a set of control variables based on Jones and Sackley's (2016) US domestic model. The following model was estimated, and test H4c was performed:

Equation 39 – Model to test H4c

$$\%\Delta P_{gold,cny,t} = \beta_0 + \beta_1 \Delta EPU_{cn,t} + \beta_2(L)\Delta P_{gold,cny,t-1} + \beta_3 \Pi_{cn,t} + \beta_4 \Pi Vol_{cn,t} + \beta_5 \Delta IDX_{cny,t} + \beta_6 GoldBeta_t + \beta_7 \Delta DefaultPremium_t + \varepsilon_t$$

Hypothesis H4c's criteria for acceptance or rejection were as follows:

The null hypothesis: The model showed no relationship between Chinese EPU and the gold price in CNY, to a 95% level of significance.

The alternative hypothesis: The model showed a relationship between Chinese EPU and the gold price in CNY, beyond a 95% level of significance.

Thus: $H4c_0$: Model significance (as indicated by ANOVA p-value) ≥ .050

$H4c_A$: Model significance (as indicated by ANOVA p-value) < .050

Hypothesis 4j, Japanese EPU was modelled against the price of gold in JPY, with a set of control variables based on Jones and Sackley's (2016) US domestic model. The following model was estimated, and test H4j was performed:

Equation 40 – Model to test H4j

$$\%\Delta P_{gold,jpy,t} = \beta_0 + \beta_1 \Delta EPU_{jpn,t} + \beta_2(L)\Delta P_{gold,jpy,t-1} + \beta_3 \Pi_{jpn,t} + \beta_4 \Pi Vol_{jpn,t} + \beta_5 \Delta IDX_{jpy,t} + \beta_6 GoldBeta_t + \beta_7 \Delta DefaultPremium_t + \varepsilon_t$$

Hypothesis H4j's criteria for acceptance or rejection were as follows:

The null hypothesis: The model showed no relationship between Japanese EPU and gold price in JPY, to a 95% level of significance.

The alternative hypothesis: The model showed a relationship between Japanese EPU and the gold price in JPY, beyond a 95% level of significance.

Thus: $H4j_0$: Model significance (as indicated by ANOVA p-value) ≥ .050

$H4j_A$: Model significance (as indicated by ANOVA p-value) < .050

Hypothesis 4e, Modelling European EPU has the complication that (at least for the time being) the UK is part of the European Union and the European EPUI contains a UK component.

Two possible approaches to resolve this were:

- Exclude the UK EPU component from the European index and measure European EPU against the EUR gold price.
- Measure European EPU against a GDP weighted composite of the EUR and GBP.

Since the precise weighting of UK EPU in the European EPU index is not readily known, a EUR/GBP composite gold price was used. The same weighting was applied to the EUR/GBP strength index and a combined UK/EU inflation rate.

European EPU was modelled against the price of gold in a weighted EUR/GBP combined currency, with a set of control variables based on Jones and Sackley's (2016) US domestic model. The following model was estimated, and test H4e was be performed:

Equation 41 – Model to test H4e

$$\%\Delta P_{gold,EurGbp,t} = \beta_0 + \beta_1 \Delta EPU_{eu,t} + \beta_2(L)\Delta P_{gold,EurGbp,t-1} + \beta_3 \Pi_{EurGbp,t} + \beta_4 \Pi Vol_{EurGbp,t} + \beta_5 \Delta IDX_{EurGbp,t} + \beta_6 GoldBeta_t + \beta_7 \Delta DefaultPremium_t + \varepsilon_t$$

Hypothesis H4e's criteria for acceptance or rejection were as follows:

The null hypothesis: The model showed no relationship between European EPU and a EUR-GBP composite gold price, to a 95% level of significance.

The alternative hypothesis: The model showed a relationship between European EPU and a EUR-GBP composite gold price, beyond a 95% level of significance.

Thus: $H4e_0$: Model significance (as indicated by ANOVA p-value) ≥ .05

$H4e_A$: Model significance (as indicated by ANOVA p-value) < .05

4.7.3 Post-estimation strategies to ensure model quality

When estimating regression models, it is essential to take cognisance of key assumptions about the nature of the estimated models, particularly when using time series data.

The specific issues considered and tested for were as follows:

- Normal distribution of the error terms, with reference to section 4.3.5. The Shapiro-Wilk test was performed on the residual values.
- Linearity of the residuals, with reference to section 4.3.7. Tests performed were:
  - Visual inspection of residual plots;
  - Where necessary, bivariate regressions.
- Homoscedasticity, with reference to section 4.3.8. White's test was performed.
- Autocorrelation, with reference to section 4.3.9. The Durbin-Watson test was performed.
- Cointegration, with reference to section 4.3.10. The Phillips-Ouliaris test was performed.
- Stability of coefficients, with reference to section 4.3.12

The tests detailed in this section were performed on significant results following the execution of the methodology details in section 4.7.2 only.

4.7.4 Error rectification

Transformations may be required. Where necessary, these were performed in IBM SPSS v. 25, following the tests described in section 4.7.3. These transformations are detailed in Table 5.

In cases of cointegration, these instances were reported. The limitation associated with cointegration was also noted.

4.7.5 Back-testing of models and description of error terms

Regression models seek to describe reality in an approximated manner using available information (Wegner, 2016). Deviations between the observed data and the data predicted by the model are denoted by the error term, ε.

Following the completion of estimation of models for Hypotheses 1, 2, 3 and 4, errors were calculated for each model by in-sample forecasting. The standard deviation of the error terms provided upper and lower confidence bounds for these.

4.8 ANALYSIS PART D: Testing hypothesis 5

The purpose of this section is to describe in detail the process of estimating the best fitting ARIMA or ARIMAX model (Andrews et al., 2013) possible, using the best fitting regression model from Hypotheses 1, 2, 3 and 4. The estimation process draws on the work of Andrews et al. (2013).

The goal of the fifth objective of this research, to which this hypothesis was linked, was stated as follows:

- In an effort to develop a more robust understanding of the nature of the relationship between EPU and the price of gold, an Autoregressive Integrated Moving Average with Exogenous Variables Model (ARIMAX) (Andrews et al., 2013; Ďurka & Silvia, 2012) was estimated using the best fitting set of variables from the previous four hypotheses (Andrews et al., 2013). This test was performed to determine whether or not a methodology incorporating autoregressive (AR) and moving average (MA) could produce a more statistically significant model, or one with better explanatory power, that those excluding these terms.

In quantitative terms, the goal of this hypothesis is to estimate a model with a higher explanatory power than the hypothesis 4e model, with R^2=.118(p<.001).

The null hypothesis: The proposed model's explanatory value did not exceed the explanatory value of the regression model on which it was based.

The alternative hypothesis: The proposed model's explanatory value exceeded the explanatory value of the regression model on which it was based.

Thus: $H5d_0$: $R^2_{arimax} \leq .118$

$H5d_A$: $R^2_{arimax} > .118$

Much of the process for developing the ARIMA or ARIMAX model is automated by IBM SPS v. 25, however it is necessary as a preliminary step, to produce cross-correlation functions to determine which exogenous variable lags may be appropriate.

The IBM SPSS v. 25 Expert Modeller was used to estimate models using the following data:

1. Significant variables from hypothesis 4e, being EPUeuLRP6m and IDXeuukLRP6m.
2. Untransformed variables: Pgoldeuuk, EPUeu, and IDXeuuk.

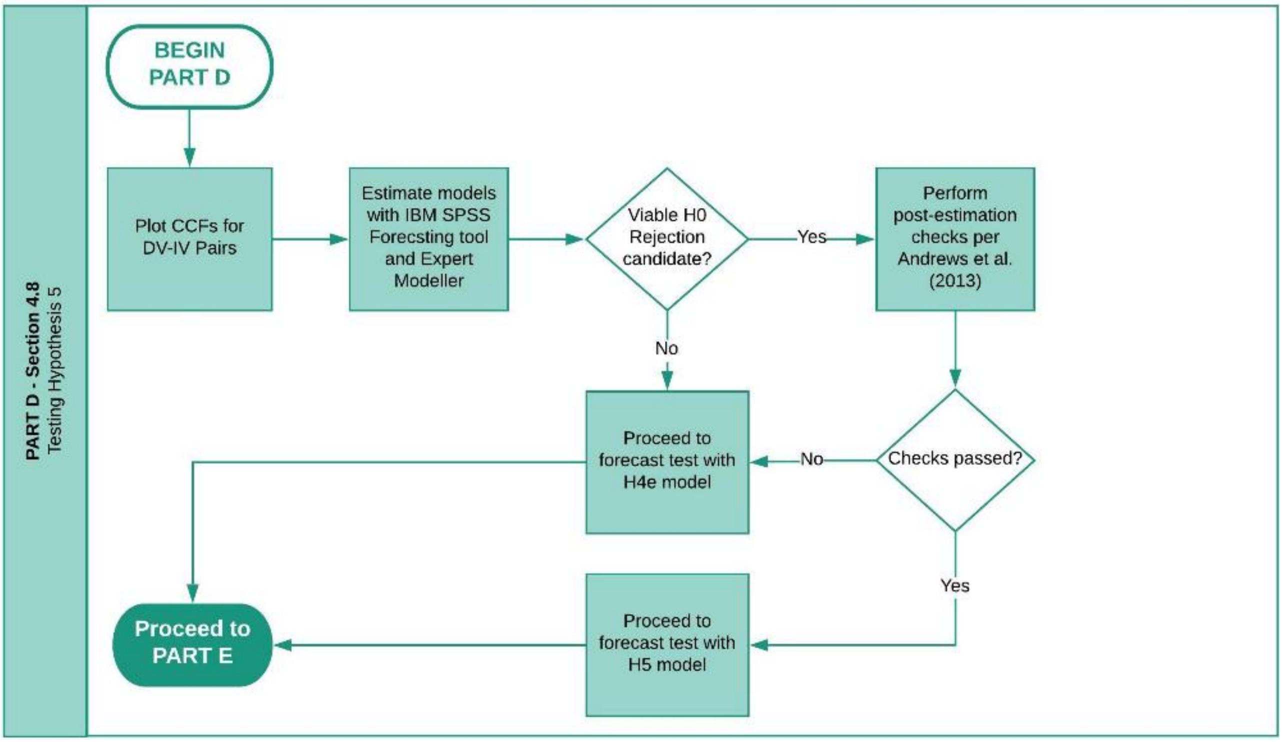


Figure 20 *Process for testing hypothesis 5*

Source: Own research

Based on these estimations, additional estimations were performed that were of interest to the researcher. In the event that a strong candidate for rejecting the null hypothesis was found, the post estimation checks specified by Andrews et al. (2013) were performed. The process for this section is graphically represented in *Figure 20*.

4.9 ANALYSIS PART E: Testing the forecasting power of the models

Out of sample testing, using 2017 economic data, was performed on the most viable model estimated in the process of testing hypotheses 1 through 5.

4.10 Research limitations noted ex ante the data analysis process

4.10.1 Omission of PRS Group ICRG data:

The cost of obtaining control variables including the PRS group ICRG Index for the 10 largest oil producing countries imposed a limitation on this study. Oil producer risk was included as a control variable in Jones and Sackley's (2016) study, however this was not found to be significant. The data to construct this index was available at a cost of $550, which exceeded the budget available for this study.

Nevertheless, oil prices and fluctuations in those prices present a source of economic uncertainty. Controlling for the effects of political risk in oil producing countries remains a relevant aspect of future studies. As was discussed in section 2.2.2.7, a relationship does exist between the price of gold and the price of oil (O'Connor et al., 2015). As such, future studies may revisit the effect of oil producer risk on gold.

4.10.2 Omission of gold lease rate

The gold lease rate, based on the spread between the GOFO rate and LIBOR was included in Jones and Sackley's (2016) study, but excluded from this study on temporal grounds: The LBMA ceased publishing GOFO at the end of January 2015.

While the gold lease rate was not significant in Jones and Sackley's (2016) studies, as a component of a complete model it would nevertheless be a valuable component. Future studies should seek an alternative to the official GOFO, for calculating the gold lease rate spread.

4.10.3 US Gold beta, and US default premium's use in non-US studies

Jones and Sackley (2016) incorporated US specific control variables in their studies. These variables were as follows:

1. Gold beta: being the volatility of the gold price relative to the S&P500.

2. Default premium: Being the spread between the interest rates of US Aaa and Baa corporate bonds.

In the EU, Japan, and China studies, the use of US control variables may limit the explanatory power of models.

4.10.4 EPUI's as an interpretivist measure in a positivist study

While Baker et al. (2016) went to great lengths to validate and test the methodology used in constructing the EPUI, the measure nevertheless remains interpretivist in nature since it relies on journalists and editors to form a view of EPU (Saunders et al., 2009), which is then subjected to quantitative techniques to produce a numeric measure.

In the process of mining keywords from news articles one risks losing the nuance of the sentiment expressed by the author. At the same time this exposes the index to the biases of that author. Baker et al. (2016) specifically ensured that their US EPUI reflected a balance of left leaning and right leaning views. With a narrower view provided by only ten European news sources or only one in the case of China, this broad spectrum of views may not have been possible.

4.10.5 Source of the gold futures prices

While effort was made in this study to obtain data directly from the source, or from reputable data sources, a concern persists concerning the source of gold futures prices. In order to create a continuous 20-year series of futures prices, the prices of consecutive 3-month contracts need to be merged together. Such data were available from http://www.quandl.com, and this data were used for this study.

A possible limitation arises with using a pre-calculated series since the reliability of the calculation cannot be guaranteed by the researcher. Had the researcher performed these calculations, the techniques used would be reported on, and they would be open for validation.

4.10.6 Gold prices in non-US studies

The prices used in non-US studies were calculated from the LBMA USD spot price of gold, and the days exchange rate for the relevant country or region. Scope exists to measure the effect of EPU on the price of gold on local exchanges in China, Europe and Japan.

4.11 Conclusion of the methodology

This chapter detailed the design of a study to test the hypotheses stated in chapter 3. It proposed a set of statistical modelling tools, as well as a battery of tests to ensure that the results of the models estimated were valid. Finally, it detailed limitations which were apparent at the time of conceptualisation of the study. The following chapter details the statistical results of the study, after having applied this chapter’s methodology.

CHAPTER 5 Results

5.1 Introduction

This chapter is arranged to correspond with the process flow described in Chapter 4. The overview of this section is graphically illustrated in *Figure 21*.

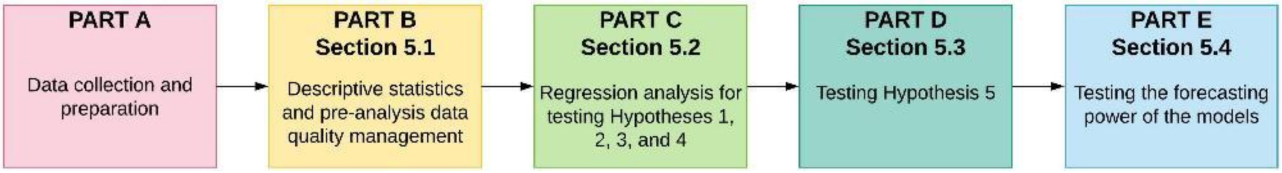


Figure 21 *Results section overview*

Source: Own research

PART A, the collection and preparation had already been performed, and by its nature, no results were produced at that stage. The results begin with the description and testing of data.

Variable codes are used throughout this chapter, and a key to the descriptions of these variables is detailed in appendix section 9.5. A general convention to naming variables was applied, and this was as follows:

- Pgold: Gold spot prices
- Fgold: Gold futures prices
- INFL: Inflation
- IDX: Currency strength indices
- Vol: Volatilities
- LRP: Log return percentages

5.2 PART B: Results of descriptive statistics and pre-analysis data quality management

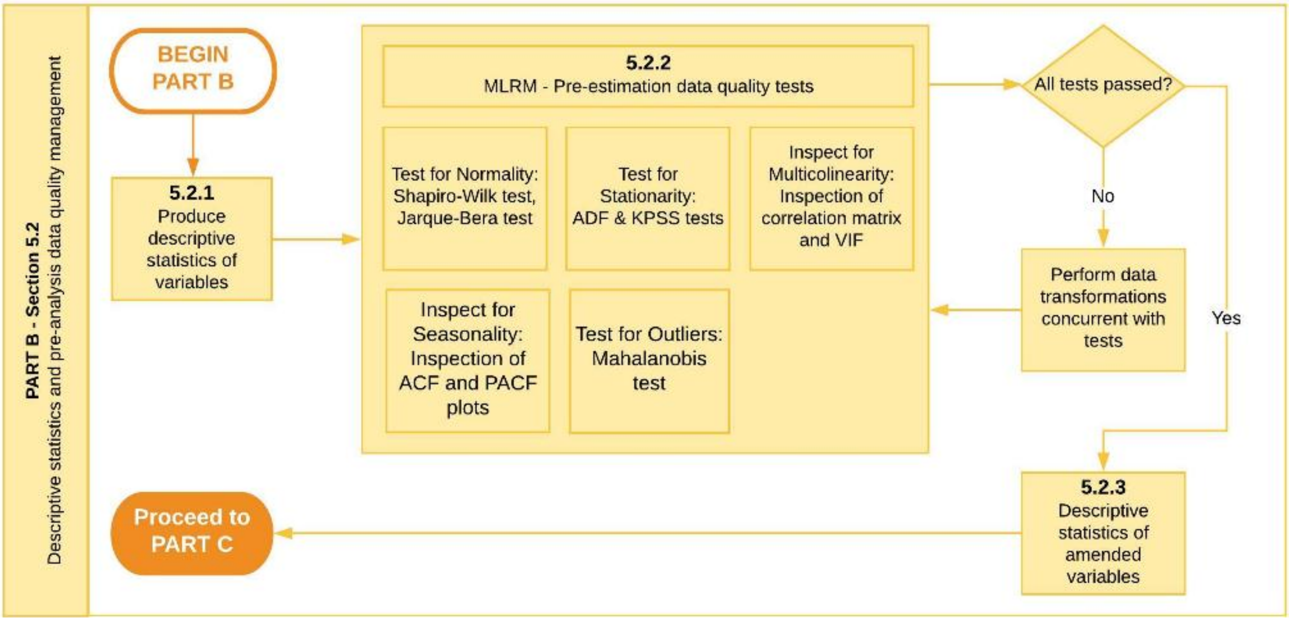


Figure 22 *Results of descriptive statistics and pre-analysis data quality management*

Source: Own research

Part B, the descriptive statistics and pre-analysis data quality management section of this research, is arranged to correspond with section 4.6 of Chapter 4. The flow of this section is illustrated in *Figure 22*. Jones and Sackley's (2016) models were also benchmarked.

5.2.1 Descriptive statistics of raw data

Descriptive statistics are arranged by hypothesis. Full descriptive statistics tables for each dataset are reproduced in appendix section 9.6.

5.2.2 Results of pre-estimation data quality tests

Data were tested in accordance with section 4.6.2. The results are summarised in this section and the detailed test results are shown in appendix section 9.7.

5.2.2.1 <u>Hypothesis 1 and benchmarking data</u>

5.2.2.1.1 Tests for normal distribution

Data were tested for normal distribution in accordance with section 4.3.2. The results of the test are detailed in appendix section 9.7.1.1.

While findings of non-normality were evident from the tests, inspection of the histograms of all the data, did not show skewness that would require transformation. Variables displaying non-normal distributions included IDXusdLRP6m, INFLus12m, and INFLusVOL.

5.2.2.1.2 Tests for stationarity

Data were tested for stationarity in accordance with section 4.3.2. The detailed results are shown in appendix sections 9.7.1.2 and 9.7.1.3, and the summary is detailed in Table 6, where necessary transformations are also indicated.

Table 6

Benchmark data: Stationarity tests summary

Variable code	KPSS test	ADF Test	Visual	Transform.	New Variable Name	KPSS test	ADF Test
PgoldLRP1m	p	p					
EPUusLRP6m	p	p					
IDXusdLRP6m	p	p					
GoldBetaUS36m	f	p	p				
DefaultPremLRP6m	p	p					
INFLus12m	f	p	p				
INFLusVol	f	f	p				
ECMusSpot	f	f	f	Log return	ECMusSpotLRP1m	p	p
EPUeuLRP6m	p	p					
INFLworld	f	p	p				
INFLworldVol	p	f	p				

p = pass; f = fail

Source: Own research

5.2.2.1.3 Tests for multicollinearity

In order to test for multicollinearity in accordance with section 4.3.3, a covariance matrix was estimated for the benchmarking data, and this is detailed in Table 75 in appendix section 9.7.1.4. Potential problematic instances of multicollinearity, where cross-correlation was r>.400 were identified, and these were further analysed. These results are summarised in Table 7.

Table 7

Benchmark data: Multicollinearity analysis

Pair	Pairwise correlation	R^2	VIF	Regression result table
INFLworld : INFLusVol	.668	.209	1.264	Table 76
INFLworldVol : INFLusVol	-.853	.578	2.370	Table 77
IDXusdLRP6m : DefaultPremLRP6m	-.517	.265	1.361	Table 78
INFLworldVol : INFLworld	-.616	.008	1.008	Table 79

Source: Own research

In all cases VIF<10, and it was concluded that no significant multicollinearity was present in the data.

5.2.2.1.4 *Inspection of ACF's for seasonality*

In accordance with section 4.3.4, it was necessary to determine whether seasonality was present in any of the data. ACF's were plotted and inspected with specific attention to the 12th lagged period. The results of this inspection are summarised in Table 8 and the individual plots are detailed in appendix section 9.7.1.5.

Table 8

ACF plot inspection summary: Benchmark data

Variable code	Seasonality present
PgoldLRP1m	None
EPUusLRP6m	None
IDXusdLRP6m	None
GoldBetaUS36m	None
DefaultPremLRP6m	None
INFLus12m	None
INFLusVol	None
ECMusSpotLRP1m	None
EPUeuLRP6m	None
INFLworld	None
INFLworldVol	None

Source: Own research

Lags where correlation exceeded a 95% confidence level would indicate seasonal autocorrelation. With no seasonality identified in the data, no transformations were deemed to be necessary.

5.2.2.1.5 *Test for outliers*

Datasets for the domestic and international benchmark estimations were tested separately for outliers, as discussed in section 4.3.5.

The outcome of the Mahalanobis tests are summarised in Table 9. Observations where the Mahalanobis distance was greater than the corresponding chi-square critical to a 99% confidence level were identified as outliers. The detail of the tests is shown in appendix section 9.7.1.6.

Table 9

Outliers test summary: Benchmark data

Data set	Original observations	Observations removed	Final observations
H1 & Benchmark domestic	240	6	234
H1 & Benchmark international	240	4	236

Source: Own research

5.2.2.2 Hypotheses 2 and 3

5.2.2.2.1 Tests for normal distribution

Data were tested for normal distribution in accordance with section 4.3.2. The results of the test are detailed in appendix section 9.7.2.1

While findings of non-normality were evident from the tests in all variables, inspection of the histograms of all the data did not show skewness that would require transformation. It was concluded that the finding of non-normality was on account of distributions that were leptokurtic, but nevertheless symmetrical.

5.2.2.2.2 Tests for stationarity

Data were tested for stationarity in accordance with section 4.3.2. The detailed results are shown in sections 9.7.2.2 and 9.7.2.3, and the summary is detailed in Table 10, where necessary transformations are also indicated.

Table 10

Hypotheses 1, 2 and 3: Stationarity tests summary

Variable code	KPSS test	ADF Test	Visual	Transform.	New Variable Name	KPSS test	ADF Test
PgoldLRP1d	p	p					
FgoldLRP1d	p	p					
EPUusLRP20d	p	p					
EPUusVol20d	f	p	p				
EPUusVol60d	f	p	p				
EPUusVol200d	f	f	p				
IDXusdLRP20d	f	p	p				
GoldBeta200d	f	p	p				
DefaultPremLRP20d	p	p	p				
INFLus12	Tested with H1						
INFLusVol	Tested with H1						
INFLworld	Tested with H1						
INFLworldVol	Tested with H1						
ECMusSpot	f	f	f	Log return	ECMusSpotLRP1d	p	p
ECMusFut	f	f	f	Log return	ECMusFutLRP1d	p	p
EPUeuLRP1m	To be tested with H4e data						

p = pass; f = fail

Source: Own research

5.2.2.2.3 Tests for multicollinearity

In order to test for multicollinearity in accordance with section 4.3.3, a covariance matrix was estimated for the input data for Hypotheses 1, 2 and 3, and this is detailed in Table 94 in appendix section 9.7.2.4. Potential problematic instances of multicollinearity, where cross-correlation was r>.400, were identified and further analysed. Instances of potential multicollinearity already identified in the previous analysis of benchmarking data, and which were passed following pairwise regression, were not re-tested. These results are summarised in Table 11.

Table 11

Hypothesis 1, 2 and 3: Multicollinearity analysis

Pair	Pairwise correlation	R^2	VIF	Regression result table
INFLus12 : INFLworld	-.619	.328	1.488	Table 95

Source: Own research

In all cases VIF<10, and it was concluded that no significant multicollinearity was present in the data.

5.2.2.2.4 Inspection of ACF's for seasonality

In accordance with section 4.3.4, it was necessary to determine whether seasonality was present in any of the data. ACF's were plotted and inspected with specific attention to the 12th lagged period. The results of this inspection are summarised in Table 12 and the individual plots are detailed in appendix section 9.7.2.5.

Lags where correlation exceeded a 95% confidence level would indicate seasonal autocorrelation. With no seasonality identified in the data, no transformations were deemed to be necessary.

Table 12

ACF plot inspection summary: Hypotheses 1, 2 and 3

Variable code	Seasonality present
PgoldLRP1d	Tested with benchmarks
FgoldLRP1d	None
EPUusLRP20d	Tested with benchmarks
EPUusVol20d	None
EPUusVol60d	None
EPUusVol200d	None
IDXusdLRP20d	Tested with benchmarks
GoldBeta200d	Tested with benchmarks
DefaultPremLRP20d	Tested with benchmarks
INFLus12	Tested with benchmarks
INFLusVol	Tested with benchmarks
INFLworld	Tested with benchmarks
INFLworldVol	Tested with benchmarks
ECMusSpotLRP1d	Tested with benchmarks
ECMusFutLRP1d	None
EPUeuLRP1m	Tested with benchmarks

Source: Own research

5.2.2.2.5 Test for outliers

Datasets for Hypotheses 1, 2 and 3’s estimations were tested separately for outliers, as discussed in section 4.3.5.

The outcome of the Mahalanobis tests are summarised in Table 13. Observations where the Mahalanobis distance was greater than the corresponding chi-square critical to a 99% confidence level were identified as outliers. The detail of the tests are shown in appendix section 9.7.2.6.

Table 13

Outliers test summary: Hypotheses 1, 2 and 3

Data set	Original observations	Observations removed	Final observations
Hypothesis 1 domestic	4949	161	4788
Hypothesis 1 international	4949	148	4801
Hypothesis 2 domestic	4949	144	4805
Hypothesis 2 international	4949	122	4827
Hypothesis 3 domestic	4949	150	4799
Hypothesis 3 international	4949	135	4814

Source: Own research

5.2.2.3 Hypothesis 4

5.2.2.3.1 Tests for normal distribution

Data were tested for normal distribution in accordance with section 4.3.2. The results of the test are detailed in appendix section 9.7.3.1

While findings of non-normality were evident from the tests in all variables, inspection of the histograms of all the data, did not show skewness that would require transformation. It was concluded that the finding of non-normality was on account of distributions that were leptokurtic, but nevertheless symmetrical.

5.2.2.3.2 Tests for stationarity

Table 14

Hypotheses 4c: Stationarity tests summary

Variable code	KPSS test	ADF Test	Visual	Transform.	New Variable Name	KPSS test	ADF Test
PgoldCnyLRPerc1m	p	p					
EPUcnLRP6m	p	p					
IDXcnyLRP6m	p	p					
INFLcn12	f	p	p				
INFLcnVol	f	f	p				
ECMcn	f	f	f	Log Return	ECMcnLRP1m	p	p
GoldBetaUS36m	Tested with benchmark						
DefaultPremLRP6m	Tested with benchmark						

p = pass; f = fail
Source: Own research

Data for hypothesis 4c were tested for stationarity in accordance with section 4.3.2. The detailed results are shown in sections 9.7.3.2 and 9.7.3.3, and the summary is detailed in Table 14.

Table 15

Hypotheses 4e: Stationarity tests summary

Variable code	KPSS test	ADF Test	Visual	Transform.	New Variable Name	KPSS test	ADF Test
PgoldEurGbpLRP1m	p	p					
EPUeuLRP6m	p	p					
IDXeurgbpLRP6m	p	p					
INFLeuuk12	f	p	p				
INFLeuukVol	f	f	p				
ECMeu	f	f	f	Log Return	ECMeuLRP1m	p	p
GoldBetaUS36m	Tested with benchmark						
DefaultPremLRP6m	Tested with benchmark						

p = pass; f = fail
Source: Own research

Data for hypothesis 4e were tested for stationarity in accordance with section 4.3.2. The detailed results are shown in sections 9.7.3.4 and 9.7.3.5, and the summary is detailed in Table 15.

Table 16

Hypotheses 4j: Stationarity tests summary

Variable code	KPSS test	ADF Test	Visual	Transform.	New Variable Name	KPSS test	ADF Test
PgoldJpyLRPerc1m	p	p					
EPUjpLRP6m	p	p					
IDXjpyLRP6m	p	p					
INFLjpn12	f	p	p				
INFLjpnVol	f	f	p				
ECMjp	f	f	f	Log Return	ECMjpLRP1m	P	p
GoldBetaUS36m	Tested with benchmark						
DefaultPremLRP6m	Tested with benchmark						

p = pass; f = fail
Source: Own research

Data for hypothesis 4j were tested for stationarity in accordance with section 4.3.2. The detailed results are shown in sections 9.7.3.6 and 9.7.3.7, and the summary is detailed in Table 16.

5.2.2.3.3 Tests for multicollinearity

Hypothesis 4c

In order to test for multicollinearity in accordance with section 4.3.3, a covariance matrix was estimated for the input data for Hypotheses 4c and this is detailed in Table 120 in appendix section 9.7.3.8. Potential problematic instances of multicollinearity, where cross-correlation was r>.400, were identified and these were further analysed. Instances of potential multicollinearity already identified in the previous analysis of benchmarking data, and which were passed following pairwise regression, were not re-tested. These results are summarised in Table 17

Table 17

Hypothesis 4c: Multicollinearity analysis

Pair	Pairwise correlation	R^2	VIF	Regression result table
IDXcnyLRP6m : DefaultPremLRP6m	.685	.469	1.883	Table 121
INFLcn12 : GoldBetaUS36m	-.420	.188	1.232	Table 122

Source: Own research

In all cases VIF<10, and it was concluded that no significant multicollinearity was present in the data to be input for hypothesis4c.

Hypothesis 4e

In order to test for multicollinearity in accordance with section 4.3.3, a covariance matrix was estimated for the input data for Hypotheses 4e and this is detailed in Table 123 in appendix section 9.7.3.9. Potential problematic instances of multicollinearity, where cross-correlation was r>.400, were identified and these were further analysed. Instances of potential multicollinearity already identified in the previous analysis of benchmarking data, and which were passed following pairwise regression, were not re-tested. These results are summarised in Table 18.

Table 18

Hypothesis 4e: Multicollinearity analysis

Pair	Pairwise correlation	R^2	VIF	Regression result table
IDXeurgbpLRP6m : DefaultPremLRP6m	.437	.179	1.218	Table 123
INFLeuuk12 : GoldBetaUS36m	-.714	.507	2.028	Table 124

Source: Own research

In all cases VIF<10, and it was concluded that no significant multicollinearity was present in the data to be input for hypothesis4c.

Hypothesis 4j

In order to test for multicollinearity in accordance with section 4.3.3, a covariance matrix was estimated for the input data for Hypotheses 4j and this is detailed in Table 126 in appendix section 9.7.3.10. Potential problematic instances of multicollinearity, where cross-correlation was r>.400, were identified and these were further analysed. Instances of potential multicollinearity already identified in the previous analysis of benchmarking data, and which were passed following pairwise regression, were not re-tested. These results are summarised in Table 19.

Table 19

Hypothesis 4j: Multicollinearity analysis

Pair	Pairwise correlation	R^2	VIF	Regression result table
INFLjpnVol : GoldBetaUS36m	.460	.253	1.339	Table 127

Source: Own research

In all cases VIF<10, and it was concluded that no significant multicollinearity was present in the data to be input for hypothesis4c.

5.2.2.3.4 Inspection of ACF's for seasonality

Hypothesis 4c

In accordance with section 4.3.5, it was necessary to determine whether seasonality was present in any of the data. ACF's were plotted and inspected with specific attention to the 12th lagged period. The results of this inspection are summarised in Table 20 and the individual plots are detailed in appendix section 9.7.3.11.

Table 20

ACF plot inspection summary: Hypothesis 4c

Variable code	Seasonality present
PgoldCnyLRPerc1m	None
EPUcnLRP6m	None
IDXcnyLRP6m	None
INFLcn12	None
INFLcnVol	None
ECMcnLRP1m	None
GoldBetaUS36m	Tested with H1
DefaultPremLRP6m	Tested with H1

Source: Own research

Lags where correlation exceeded a 95% confidence level would indicate seasonal autocorrelation. With no seasonality identified in the data, no transformations were deemed to be necessary.

Hypothesis 4e

In accordance with section 4.3.5, it was necessary to determine whether seasonality was present in any of the data. ACF's were plotted and inspected with specific attention to the 12th lagged period. The results of this inspection are summarised in Table 21 and the individual plots are detailed in appendix section 9.7.3.11.

Table 21

ACF plot inspection summary: Hypothesis 4e

Variable code	Seasonality present
PgoldEurGbpLRP1m	None
EPUeuLRP6m	None
IDXeurgbpLRP6m	None
INFLeuuk12	None
INFLeuukVol	None
ECMeuLRP1m	None
GoldBetaUS36m	Tested with H1
DefaultPremLRP6m	Tested with H1

Source: Own research

Lags where correlation exceeded a 95% confidence level would indicate seasonal autocorrelation. With no seasonality identified in the data, no transformations were deemed to be necessary.

Hypothesis 4j

In accordance with section 4.3.5, it was necessary to determine whether seasonality was present in any of the data. ACF's were plotted and inspected with specific attention to the 12th lagged period. The results of this inspection are summarised in Table 22 and the individual plots are detailed in appendix section 9.7.3.11.

Table 22

ACF plot inspection summary: Hypothesis 4j

Variable code	Seasonality present
PgoldJpyLRPerc1m	None
EPUjpLRP6m	None
IDXjpyLRP6m	None
INFLjpn12	None
INFLjpnVol	None
ECMjpLRP1m	None
GoldBetaUS36m	Tested with H1
DefaultPremLRP6m	Tested with H1

Source: Own research

Lags where correlation exceeded a 95% confidence level would indicate seasonal autocorrelation. With no seasonality identified in the data, no transformations were deemed to be necessary.

5.2.2.3.5 Test for outliers

Table 23

Outliers test summary: Hypothesis 4

Data set	Original observations	Observations removed	Final observations
Hypothesis 4 China	204	2	202
Hypothesis 4 Europe	204	2	202
Hypothesis 4 Japan	240	4	236

Source: Own research

Datasets for hypothesis 4's estimations were tested separately for outliers, as discussed in section 4.3.5. The outcome of the Mahalanobis tests are summarised in Table 23. Observations where the Mahalanobis distance was greater than the corresponding chi-square critical to a 99% confidence level were identified as outliers. The details of the tests are shown in appendix section 9.7.3.12.

5.2.2.4 Summary of data quality tests

Table 24

Summary of data removed following pre-testing

Dataset	Valid observations	Outliers	Final observations
Benchmark domestic	240	6	234
Benchmark international	240	4	236
Hypothesis 1d	240	6	234
Hypothesis 1i	240	5	235
Hypothesis 2d	4949	144	4805
Hypothesis 2i	4949	122	4827
Hypothesis 3d	4949	150	4799
Hypothesis 3i	4949	135	4814
Hypothesis 4c	204	2	202
Hypothesis 4e	204	2	202
Hypothesis 4j	240	4	236

Source: Own research.

Table 25

Summary of transformed variables

Dataset	Variable code	Reason	Transform. type	New variable Code
Benchmark	ECMusSpot	Stationarity	Log return	ECMusSpotLRP1m
Hypothesis 1	ECMusSpot	Stationarity	Log return	ECMusSpotLRP1m
Hypothesis 2 & 3	ECMusSpot	Stationarity	Log return	ECMusSpotLRP1d
Hypothesis 2 & 3	ECMusFut	Stationarity	Log return	ECMusFutLRP1d
Hypothesis 4c	ECMcn	Stationarity	Log return	ECMcnLRP1m
Hypothesis 4e	ECMeu	Stationarity	Log return	ECMeuLRP1m
Hypothesis 4j	ECMjp	Stationarity	Log return	ECMjpLRP1m

Source: Own research.

To summarise the results of the previous section:

- While some data were found to be non-normally distributed, this was data were nevertheless symmetrical, and the findings of non-normality were in instances where distributions were leptokurtic.
- Transformations of the ECM variables to log returns (Hair et al., 2010) were performed to achieve stationarity.
- Independent variable pairs with correlations r>.400 were tested via bivariate regression. The resulting VIF from these tests were VIF<10, and it was concluded that no multicollinearity was present.
- No significant seasonality was observed in the data.

- Outliers were observed in the data for hypotheses 1, 2 3 and 4 and these were excluded from these studies. The impact on the dataset from their removal is summarised in Table 24 Outliers were tested for and removed from hypothesis 5's data automatically by IBM SPSS v.25 during estimation.
- Variables transformed following the pre-testing process are listed in Table 25.

5.2.3 Descriptive statistics of finalised input variables

The final data sets to be used for estimating models were described, and the results of this analysis are tabulated in appendix section 9.8. Descriptive statistics were estimated following outlier detection and removal, because these statistics are dependent on all the data in the dataset. Removal of outliers can significantly alter the range of the data, as well as the variance.

With the data having been tested for the assumptions associated with the analyses to be conducted, and the data having been described, the study proceeded to the following phase: PART C: Regression analyses for testing Hypotheses 1, 2, 3 and 4.

5.3 PART C: Regression analyses for testing Hypotheses 1, 2, 3 and 4

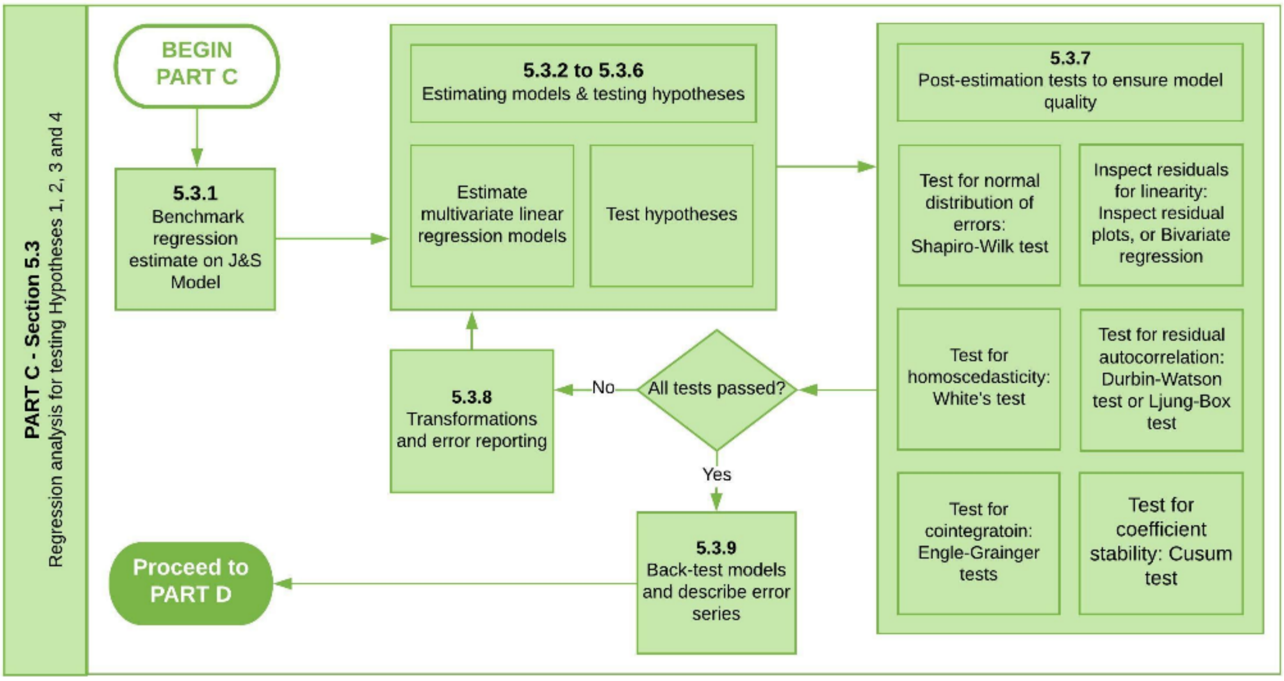


Figure 23 *Process flow for regression analysis for hypotheses 1, 2, 3 and 4*

Source: Own research

Part C, the model estimation section of this research for hypotheses 1, 2, 3 and 4, is arranged to correspond with section 4.7 of Chapter 4. The process flow of this section is illustrated in *Figure 23*.

Prior to testing the hypotheses, it was necessary to obtain updated benchmarks by estimating models using the same variables as in Jones and Sackley's (2016) original study, but without the variables excluded for this study.

5.3.1 Benchmark regression estimation

5.3.1.1 Exclusion of ECM variables

Estimation of the benchmark model with the domestic dataset indicated that the model displayed a substantially higher explanatory value (R^2 =.791, F (7,226) = 122.487, p < .001) than that of Jones and Sackley (2016). The model summary is shown in appendix section 9.9.1.1.

On closer inspection it was found that there was an unacceptable level of correlation between the dependent variable, *PgoldLRP1m* and *ECMusSpotLRP1m*. Given that *ECMusSpotLRP1m* is a function of the gold price and CPI (as show in Equation 23 on page 86), the close correlation was believed to introduce a problematic spurious result.

The significance of *ECMusSpotLRP1m* (t (234) =27.869, p<.001) in the model, along with the close relationship to the dependent variable illustrated in *Figure 76* and *Figure 77* in section 9.9.1.1, suggested a spurious correlation between *ECMusSpotLRP1m* and the dependent variable. As a result, the ECM terms were excluded from the remainder of the study.

The original domestic and international models of the Jones and Sackley (2016) study were estimated with data obtained for this study. The models including the AR1 term (being the dependent variable, lagged by one period) were used for benchmarking purposes. The parameters estimated for benchmarking are summarised in Table 26, while appendix section 9.9.1 details the model statistics and plots.

5.3.1.2 Benchmark model estimations following exclusion of ECMusSpotLRP1

Table 26

Summary of benchmark model estimation

Dependent variable: PgoldLRP1m	(1) Domestic Benchmark		(2) International Benchmark		(3) Domestic AR1		(4) International AR1	
PgoldLRP1m_L1					-0.1401	**	-0.1900	***
					(-2.224)		(-3.044)	
EPUusLRP6m	0.0070	*	0.0019		0.0070	*	0.0018	
	(1.737)		(0.419)		(1.751)		(0.408)	
DefaultPremLRP6m	0.0193		0.0239	*	0.0231	*	0.0284	**
	(1.501)		(1.797)		(1.801)		(2.157)	
GoldBetaUS36m	-0.7631		-0.4250		-0.8103		-0.5448	
	(-1.23)		(-0.675)		(-1.317)		(-0.880)	
IDXusdLRP6m	-0.2501	***	-0.2078	**	-0.2936	***	-0.2672	***
	(-2.765)		(-2.203)		(-3.198)		(-2.821)	
INFLus12m	0.0568		.03086		0.0902		0.3802	
	(0.182)		(0.789)		(0.291)		(0.988)	
INFLusVol	1.9068	**	1.0885		2.1115	***	1.4485	
	(2.526)		(0.701)		(2.800)		(0.946)	
EPUeuLRP6m			0.0182	*			0.0194	**
			(1.949)				(2.112)	
INFLworld			-0.5147				-0.5796	
			(-0.875)				(-1.003)	
INFLworldVol			0.3421				0.2534	
			(0.157)				(0.119)	
(Constant)	-0.6613		1.1456		-0.7654		1.1950	
	(-0.667)		(0.544)		(-0.778)		(0.578)	
N	234		236		234		236	
Model significance	(2.51)	**	(2.187)	**	(3.362)	***	(2.966)	***
R^2	.062		.080		.094		.116	
Adjusted R^2	.037		.043		.066		.077	

statistics in parentheses

**p<.10, **p<.05, ***p<.01*

Source: own research

5.3.2 Testing hypothesis 1 with multivariate regression estimation

Table 27

Summary of hypothesis 1 model estimation

Dependent variable: PgoldLRP1m	(1) H1 Domestic		(2) H1 International		(3) H1 AR1 Domestic		(4) H1 AR1 International	
PgoldLRP1m_L1					-0.1392	**	-0.1753	***
					(-2.103)		(-2.708)	
EPUusLRP6m	0.0020		-0.0010		0.0026		-0.0004	
	(0.458)		(-0.206)		(0.602)		(-0.093)	
EPUusVol1m	0.0267	*	0.0303	*	0.0236		0.0250	
	(1.68)		(1.789)		(1.487)		(1.484)	
DefaultPremLRP6m	0.0191		0.0254	*	0.0234	*	0.0293	**
	(1.444)		(1.873)		(1.762)		(2.174)	
GoldBetaUS36m	-0.5959		-0.5463		-0.6685		-0.6532	
	(-0.948)		(-0.852)		(-1.07)		(-1.031)	
IDXusdLRP6m	-0.2613	***	-0.2276	**	-0.3006	***	-0.2795	***
	(-2.805)		(-2.363)		(-3.187)		(-2.884)	
INFLus12m	0.0514		0.2681		0.0852		0.3439	
	(0.160)		(0.664)		(0.267)		(0.861)	
INFLusVol	1.6528	**	1.0768		1.8960	**	1.4352	
	(2.124)		(0.679)		(2.428)		(0.914)	
EPUeuLRP6m			0.0129				0.0144	
			(1.295)				(1.467)	
INFLworld			-0.5244				-0.5614	
			(-0.868)				(-0.942)	
INFLworldVol			-0.0027				-0.0395	
			(-0.001)				(-0.018)	
(Constant)	-1.6177		0.1643		-1.6085		0.2957	
	(-1.367)		(0.075)		(-1.369)		(0.138)	
N	234		235		234		235	
Model significance	(2.598)	**	(2.103)	**	(2.86)	***	(2.632)	***
R^2	.074		.086		.092		.115	
Adjusted R^2	.046		.045		.060		.071	

statistics in parentheses

**p<.10, **p<.05, ***p<.01*

Source: own research

The first objective of this research was to determine whether the model estimated by Jones and Sackley (2016) would be enhanced by adding a measure of EPU volatility. The objective was stated as follows:

- Determine whether the addition of EPUI Volatility to the multivariate regression model developed by Jones and Sackley (2016) described the relationship between EPU and gold spot prices, and thus the use of gold as an EPU safe haven asset, better than the original model.

Jones and Sackley (2016) estimated models with a set of US domestic control variables, as well as an international set of control variables. Thus, hypothesis 1 was further divided into two parts to account for these two alternatives.

The parameters estimated for hypothesis 1 are summarised in Table 27, while appendix section 9.9.2 details the model statistics and plots. Models excluding and including the AR1 term were estimated.

5.3.2.1 Statistical observations for hypothesis 1d

The statistical observations following the estimation of models to test hypothesis 1d were as follows:

1. The non-AR1 model was statistically significant (F (7,226) =2.598, p=.013) beyond a 95% confidence level.
2. The AR1 model was statistically significant (F (8,225) =2.860, p=.005) beyond a 95% confidence level.
3. The AR1 term was significantly inversely related to the gold price with β=-0.1392 (t (233) =-2.103, p=.037).
4. INFLusVol, being US inflation volatility, was significant in the non-AR1 model beyond a 95% confidence level with β=1.6528 (t (233) =2.124, p=.035).
5. INFLusVol, being US inflation volatility, was significant In the AR1 model beyond a 95% confidence level with β=1.8690 (t (233) =2.428, p=.016).
6. The non-AR1 model had lower explanatory value with R^2=.074 (F (7,226) =2.598, p p=.013), compared to the model including AR1 with R^2=.092 (F (8,225) =2.860, p=.005).
7. IDXusdLEP6m was significant (β=-0.2613, t (233) =-2.805, p=.005) in the non-AR1 beyond a 95% confidence level.
8. IDXusdLEP6m was significant (β=-0.3006, t (233) =-3.187, p=.002) in the AR1 model beyond a 95% confidence level.

5.3.2.2 Testing hypothesis 1d

The null and alternative hypotheses for testing the enhancing value of the addition of EPU volatility in the US domestic context were as follows:

The null hypothesis: The proposed model's explanatory value did not exceed Jones and Sackley's (2016) model which had an R^2= .094.

The alternative hypothesis: The proposed model's explanatory value exceeded Jones and Sackley's (2016) model which had an R^2= .094.

Thus: $H1d_0$: $R^2_{VolDom} \leq .094$

$H1d_A$: $R^2_{VolDom} > .094$

The statistical results were as follows:

- For the model excluding the AR1 term: R^2=.074, [F (7,226) =2.598, p=.013] < .094.
    - The study failed to reject the null hypothesis, and it was concluded that the addition of EPU Volatility to the existing Jones and Sackley (2016) domestic model did not enhance that model.
- For the model including the AR1 term: R^2=.092, [F (8,225) =2.860, p=.005] < .094.
    - The study failed to reject the null hypothesis, and it was concluded that the addition of EPU Volatility to the existing Jones and Sackley (2016) domestic model did not enhance that model.

5.3.2.3 *Statistical observations for hypothesis 1i*

The statistical observations following the estimation of models to test hypothesis 1i were as follows:

1. The non AR1 model was statistically significant F (10,224) =2.103, p=.025 beyond a 95% confidence level.
2. The AR1 model was statistically significant F (11,223) =2.632, p=.004 beyond a 95% confidence level.
3. The AR1 term was significantly inversely related to the gold price with β=-0.1753, t (234) =-2.708, p=.007.
4. DefaultPremLRP6m was significant in the AR1 model, beyond a 95% confidence level with β=0.0293, t (234) =2.174, p=.031.
5. The non-AR1 model had lower explanatory value with R^2=.086 (F (10,224)=2.103, p=.025) compared to the model including AR1 with R^2=.115 (F (11,223) =2.632, p=.004).
6. IDXusdLEP6m was significant (β=-0.2276, t (234) =-2.363, p=.019) in the non-AR1 beyond a 95% confidence level.

7. IDXusdLEP6m was significant (*β*=-0.2795, *t* (234) =-2.884, *p*=.004) in the AR1 model beyond a 95% confidence level.

5.3.2.4 *Testing hypothesis 1i*

The null and alternative hypotheses for testing the enhancing value of the addition of EPU volatility in the US international context were as follows:

The null hypothesis: The proposed model's explanatory value did not exceed Jones and Sackley's (2016) model which had an R^2= .116.

The alternative hypothesis: The proposed model's explanatory value exceeded Jones and Sackley's (2016) model which had an R^2= .116.

Thus: $H1i_0$: $R^2_{\text{VolInt}} \leq .116$

$H1i_A$: $R^2_{\text{VolInt}} > .116$

The statistical results were as follows:

- For the model excluding the AR1 term:
  - R^2=.086, (*F* (10,224) =2.103, *p*=.025) < .116.
  - The study failed to reject the null hypothesis, and it was concluded that the addition of EPU Volatility to the existing Jones and Sackley (2016) international model did not enhance that model.
- For the model including the AR1 term:
  - R^2=.115, (*F* (11,223) =2.632, *p*=.004) < .116.
  - The study failed to reject the null hypothesis, and it was concluded that the addition of EPU Volatility to the existing Jones and Sackley (2016) international model did not enhance that model.

5.3.2.5 *Granger causality tests for hypothesis 1*

Table 28

Granger causality test results for variables of interest in hypothesis 1

Variable	Direction	Result
DefaultPremLRP6m	Direct	DefaultPremLRP6m does not Granger-cause PgoldLRP1m
DefaultPremLRP6m	Reverse	PgoldLRP1m does not Granger-cause DefaultPremLRP6m
IDXusdLRP6m	Direct	IDXusdLRP6m does not Granger-cause PgoldLRP1m
IDXusdLRP6m	Reverse	PgoldLRP1m does not Granger-cause IDXusdLEP6m

Source: Own research

As a means of augmenting the discussion and interpretation of the results of estimating this model, granger causality tests were conducted to assess direct and reverse causality between variables in this study that were found to be significantly linked to gold. The results of these tests are summarised in Table 28, and the detailed test results are shown in appendix section 9.9.2.5.

5.3.3 Testing hypothesis 2 with multivariate regression estimation

The second objective of this research was to determine whether the model estimated by Jones and Sackley (2016) would be enhanced by using gold futures prices as a dependent variable. The objective was stated as follows:

- Determine whether estimating Jones and Sackley's (2016) model with its original set of variables against gold futures produces a better multivariate regression model, thus indicating that gold futures are a better safe haven against EPU.

Jones and Sackley (2016) estimated models with both a set of US domestic control variables, as well as an international set of control variables. Thus, hypothesis 2 was further divided into two parts.

The parameters estimated for hypothesis 2 are summarised in Table 29, while appendix section 9.9.3 details the model statistics and plots. Models excluding and including the AR1 term were estimated.

Table 29

Summary of hypothesis 2 model estimation

Dependent variable: FgoldLRP1d	(1) H2 Domestic		(2) H2 International		(3) H2 AR1 Domestic		(4) H2 AR1 International	
FgoldLRP1d_L1					-0.0318	**	-0.0307	**
					(-2.466)		(-2.361)	
EPUusLRP20d	-0.0000		-0.0001		-0.0000		-0.0001	
	(-0.113)		(-0.355)		(-0.083)		(-.321)	
DefaultPremLRP20d	0.0009		0.0013		0.0010		0.0014	
	(0.541)		(0.783)		(.0589)		(0.829)	
GoldBeta200d	0.0232		0.0136		0.0237		0.0141	
	(0.869)		(0.483)		(0.886)		(0.499)	
IDXusdLRP20d	-0.0621	***	-0.0641	***	-0.0640	***	-0.0663	***
	(-5.97)		(-6.067)		(-6.141)		(-6.255)	
INFLus12m	0.0116		0.0173		0.0120		0.0176	
	(0.916)		(1.060)		(0.941)		(1.077)	
INFLusVol	0.0782	**	0.0811		0.0808	**	0.0827	
	(2.269)		(1.156)		(2.346)		(1.179)	
EPUeuLRP1m			0.0011	*			0.0011	*
			(1.779)				(1.842)	
INFLworld			-0.0144				-0.0149	
			(-0.567)				(-0.585)	
INFLworldVol			-0.0355				-0.0358	
			(-0.366)				(-0.369)	
(Constant)	-0.0429		0.0147		-0.0442		0.0160	
	(-0.997)		(0.160)		(-1.027)		(0.175)	
N	4805		4827		4805		4827	
Model significance	(8.110)	***	(5.848)	***	(7.828)	***	(5.826)	***
R^2	.010		.011		.011		.012	
Adjusted R^2	.009		.009		.010		.010	

statistics in parentheses

**p<.10, **p<.05, ***p<.01*

Source: own research

5.3.3.1 *Statistical observations for hypothesis 2d*

The statistical observations following the estimation of models to test hypothesis 2d were as follows:

1. The non-AR1 model was statistically significant (F (6,4798) =8.110, p<.001) beyond a 95% confidence level.
2. The AR1 model was statistically significant (F (7,4797) =7.828, p<.001) beyond a 95% confidence level.
3. The AR1 term was significantly negatively related to the gold price with β=-0.0318 (t (4804) =-2.466, p=.014).
4. INFLusVol, being US inflation volatility, was significant in the non-AR1 beyond a 95% confidence level with β=0.0782 (t (4804) =2.269, p=.023);
5. INFLusVol, being US inflation volatility, was significant in the AR1 model beyond a 95% confidence level with β=0.0808 (t (4804) =2.346, p=.019).
6. The non-AR1 model had lower explanatory value with R^2=.010 (F (6,4798) =8.110, p<.001) compared to the model including AR1 with R^2=.010 (F (7,4797) =7.828, p<.001).
7. IDXusdLEP6m was significant (β=-0.0621, t (4804) =-5.970, p<.001) in the non-AR1 beyond a 95% confidence level.
8. IDXusdLEP6m was significant (β=-0.0640, t (4804) =-6.141, p<.001) in the AR1 model beyond a 95% confidence level.

5.3.3.2 *Testing hypothesis 2d*

The null and alternative hypotheses for testing the original set of Jones and Sackley's (2016) domestic independent variables against gold futures as a dependent variable were as follows:

The null hypothesis: The proposed model's explanatory value did not exceed Jones and Sackley's (2016) model which had an R^2= .094.

The alternative hypothesis: The proposed model's explanatory value exceeded Jones and Sackley's (2016) model which had an R^2= .094.

Thus: $H2d_0$: $R^2_{VolDom} \leq .094$

$H2d_A$: $R^2_{VolDom} > .094$

The statistical results were as follows:

- For the model excluding the AR1 term: R^2=.010 (*F (*6,4798) =8.11, *p*<.001) < .094.
    - The study failed to reject the null hypothesis, and it was concluded that testing the Jones and Sackley (2016) domestic model using daily futures data did not enhance that model.
- For the model including the AR1 term: R^2=.011, (*F (*7,4797) =7.828, *p*<.001) < .094.
    - The study failed to reject the null hypothesis, and it was concluded that testing the Jones and Sackley (2016) domestic model using daily futures data did not enhance that model.

5.3.3.3 Statistical observations for hypothesis 2i

The statistical observations following the estimation of models to test hypothesis 2i were as follows:

1. The non-AR1 model was statistically significant (*F (*9,4817) =5.848, *p*<.001) beyond a 95% confidence level.
2. The AR1 model was statistically significant (*F (*10,4816) =5.826, *p*<.001) beyond a 95% confidence level.
3. The AR1 term was significantly negatively related to the gold price with *β*=-0.0307 (*t (*4827) =-2.361, *p*=.018).
4. The non-AR1 model had lower explanatory value with R^2=.011 (*F (*9,4817) =5.848, *p*<.001) compared to the model including AR1 with R^2=.012 (*F (*10,4816) =5.826, *p*<.001).
5. IDXusdLEP6m was significant (*β*=-0.0641, *t (*4826) =-6.067, *p*<.001) in the non-AR1 beyond a 95% confidence level.
6. IDXusdLEP6m was significant (*β*=-0.0663, *t (*4826) =-6.255, *p*<.001) in the AR1 model beyond a 95% confidence level.

5.3.3.4 Testing hypothesis 2i

The null and alternative hypotheses for testing the original set of Jones and Sackley's (2016) international independent variables against gold futures as a dependent variable were as follows:

The null hypothesis: The proposed model's explanatory value did not exceed Jones and Sackley's (2016) model which had an R^2= .116.

The alternative hypothesis: The proposed model's explanatory value exceeded Jones and Sackley's (2016) model which had an R^2= .116.

Thus: $H2i_0$: $R^2_{\text{VolInt}} \leq .116$

$H2i_A$: $R^2_{\text{VolInt}} > .116$

The statistical results were as follows:

- For the model excluding the AR1 term: R^2=.011 (F (9,4817) =5.848, p<.001) < .116.
  - The study failed to reject the null hypothesis, and it was concluded that testing the Jones and Sackley (2016) international model using daily futures data did not enhance that model.
- For the model including the AR1 term: R^2=.012, (F (10,4816) =5.828, p<.001) < .116.
  - The study failed to reject the null hypothesis, and it was concluded that testing the Jones and Sackley (2016) international model using daily futures data did not enhance that model.

5.3.3.5 Additional models estimated for hypothesis 2

In order to augment the discussion of hypothesis 2, the data were used to estimate an ARIMAX model using IBM SPSS v. 25's Expert modeller. The results of these models are detailed in appendix section 9.9.7.

5.3.4 Testing hypothesis 3 with multivariate regression estimation

The third objective of this research was to determine whether the model estimated by Jones and Sackley (2016) would be enhanced by adding a measure of EPU volatility and using gold futures as the dependent variable. The third objective was stated as follows:

- Determine whether the addition of EPUI Volatility to the multivariate regression model estimated by Jones and Sackley (2016) describes the relationship between EPU and the price of gold futures as a dependent variable, and thus the use of gold as an EPU safe haven asset, better than the original model does by using the spot price of gold as a dependent variable.

Hypothesis 3 was, de-facto, a combination of Hypotheses 1 and 2. As with hypothesis 1 and 2, hypothesis 3 was divided into a domestic and international sub-hypotheses.

Table 30

Summary of hypothesis 3 model estimation

Dependent variable: FgoldLRP1d	(1) H3 Domestic		(2) H3 International		(3) H3 AR1 Domestic		(4) H3 AR1 International	
FgoldLRP1d_L1					-0.0255	*	-0.0273	**
					(-1.947)		(-2.089)	
EPUusLRP20d	0.0000		-0.0000		0.0000		-0.0000	
	(0.170)		(-0.202)		(0.187)		(-0.180)	
EPUusVol20d	0.0006		0.0005		0.0006		0.0006	
	(0.856)		(0.711)		(0.879)		(0.750)	
DefaultPremLRP20d	0.0009		0.0006		0.0010		0.0006	
	(0.566)		(0.331)		(0.598)		(0.372)	
GoldBeta200d	0.0273		0.0110		0.0279		0.0115	
	(1.007)		(0.389)		(1.031)		(0.405)	
IDXusdLRP20d	-0.0573	***	-0.0575	***	-0.0591	***	-0.0593	***
	(-5.406)		(-5.391)		(-5.552)		(-5.545)	
INFLus12m	0.0065		0.0224		0.0065		0.0226	
	(0.503)		(1.358)		(0.506)		(1.373)	
INFLusVol	0.0681	**	0.0597		0.0698	**	0.0613	
	(1.973)		(0.844)		(2.020)		(0.867)	
EPUeuLRP1m			0.0009				0.0009	
			(1.388)				(1.433)	
INFLworld			-0.0267				-0.0271	
			(-1.035)				(-1.051)	
INFLworldVol			-0.0135				-0.0141	
			(-0.141)				(-0.147)	
(Constant)	-0.0535		0.0335		-0.0546		0.0335	
	(-1.034)		(0.363)		(-1.055)		(0.363)	
N	4799		4814		4799		4814	
Model significance	(5.995)	***	(4.628)	***	(5.723)	***	(4.608)	***
R^2	.009		.010		.009		.010	
Adjusted R^2	.007		.007		.008		.008	

statistics in parentheses

**p<.10, **p<.05, ***p<.01*

Source: own research

The parameters estimated for hypothesis 3 are summarised in Table 30, while appendix section 9.9.4 details the model statistics and plots. Models excluding and including the AR1 term were estimated.

5.3.4.1 *Statistical observations for hypothesis 3d*

The statistical observations following the estimation of models to test hypothesis 3d were as follows:

1. The non-AR1 model was statistically significant (F (7,4791) =5.995, p<.001) beyond a 95% confidence level.
2. The AR1 model was statistically significant (F (8,4790) =5.723, p<.001) beyond a 95% confidence level.
3. The AR1 term was not significantly related to the gold price beyond a 95% confidence level, with β=-0.0255 (t (4798) =-1.947, p=.052).
4. INFLusVol, being US inflation volatility, was significant in the non-AR1 beyond a 95% confidence level with β=0.0681 (t (4798) =1.973, p=.049).
5. INFLusVol, being US inflation volatility, was significant in the AR1 model beyond a 95% confidence level with β=0.0698 (t (4798) =2.020, p=.043).
6. The non-AR1 model had higher explanatory value with R^2=.009 (F (7,4791) =5.995, p<.001) compared to the model including AR1 with R^2=.009 (F (8,4790) =5.723, p<.001).
7. IDXusdLEP6m was significant (β=-0.0573, t (4798) =-5.406, p<.001) in the non-AR1 beyond a 95% confidence level.
8. IDXusdLEP6m was significant (β=-0.0591, t (4798) =-5.723, p<.001) in the AR1 model beyond a 95% confidence level.

5.3.4.2 *Testing hypothesis 3d*

The null and alternative hypotheses for testing the EPU volatility enhanced version of the domestic model against gold futures were as follows:

The null hypothesis: The proposed model's explanatory value did not exceed Jones and Sackley's (2016) model which had an R^2= .094.

The alternative hypothesis: The proposed model's explanatory value exceeded Jones and Sackley's (2016) model which had an R^2= .094.

Thus: $H3d_0$: $R^2_{VolDom} \leq .094$

$H3d_A$: $R^2_{VolDom} > .094$

The statistical results were as follows:

- For the model excluding the AR1 term: R^2=.009 (F (7,4791) =5.995, p<.001) < .116.
    - The study failed to reject the null hypothesis, and it was concluded that testing the Jones and Sackley (2016) domestic model using daily futures data and EPU volatility did not enhance that model.
- For the model including the AR1 term: R^2=.009 (F (8,4790) =5.723, p<.001) < .116.
    - The study failed to reject the null hypothesis, and it was concluded that testing the Jones and Sackley (2016) domestic model using daily futures data and EPU volatility did not enhance that model.

5.3.4.3 Statistical observations for hypothesis 3i

The statistical observations following the estimation of models to test hypothesis 3i were as follows:

1. The non-AR1 model was statistically significant (F (10,4803) =4.628, p<.001) beyond a 95% confidence level.
2. The AR1 model was statistically significant (F (11,4802) =4.608, p<.001) beyond a 95% confidence level.
3. The AR1 term was significantly negatively related to the gold price beyond a 95% confidence level, with β=-0.0273 (t (4813) =-2.089, p=.037).
4. The non-AR1 model had similar explanatory value with R^2=.010 (F (10,4803) =4.628, p<.001) to the model including AR1 with R^2=.010 (F (11,4802) =4.608, p<.001).
5. IDXusdLEP6m was significant (β=-0.0575, t (4814) =-5.391, p<.001) in the non-AR1 beyond a 95% confidence level.
6. IDXusdLEP6m was significant (β=-0.0593, t (4814) =-5.545, p<.001) in the AR1 model beyond a 95% confidence level.

5.3.4.4 Testing hypothesis 3i

The null and alternative hypotheses for testing the EPU volatility enhanced version of the international model against gold futures were as follows:

The null hypothesis: The proposed model's explanatory value did not exceed Jones and Sackley's (2016) model which had an R^2= .116.

The alternative hypothesis: The proposed model's explanatory value exceeded Jones and Sackley's (2016) model which had an R^2= .116.

Thus: H3i$_0$: $R^2_{\text{VolInt}} \leq .116$

H3i$_A$: $R^2_{\text{VolInt}} > .116$

The statistical results were as follows:

- For the model excluding the AR1 term: R^2=.010 (F (10,4803) =4.628, p<.001) < .116.
  - The study failed to reject the null hypothesis, and it was concluded that testing the Jones and Sackley (2016) international model using daily futures data and EPU volatility did not enhance that model.
- For the model including the AR1 term: R^2=.010, (F (11,4802) =4.608, p<.001) < .116.
  - The study failed to reject the null hypothesis, and it was concluded that testing the Jones and Sackley (2016) domestic model using daily futures data and EPU volatility did not enhance that model.

5.3.4.5 Additional models estimated for hypothesis 3

In order to augment the discussion of hypothesis 2, the data were used to estimate an ARIMAX model using IBM SPSS v. 25's Expert modeller. The results of these models are detailed in appendix section 9.9.7. It is noted that the differentiating factor between hypotheses 2 and 3 is the inclusion of EPU volatility. Since EPU volatility was not found to be significant in the model estimated for hypothesis 3, the ARIMAX model is identical to that of hypothesis 2.

5.3.4.6 Additional analysis of backwardation and contango, for discussion

For discussion purposes, an analysis of the extent of backwardation and contango in the gold market, with reference to 3-month gold futures used in the testing of hypotheses 2 and 3 was conducted. The plots and statistics following this analysis are detailed in appendix section 9.9.6.

5.3.5 Testing hypothesis 4 with multivariate regression estimation

The fourth objective of this research was to determine whether EPU in other markets influences the price of gold in those markets' currencies. The objective was stated as follows:

- Pursuant to the avenues for further research in Jones and Sackley (2016), EPUI was modelled against gold spot prices in local currency, using multivariate regression, in Europe, China and Japan, which together constitute over 60% of the world's GDP (World Bank, 2017). These tests were performed to determine whether or not a statistically significant relationship existed between EPU in major economies outside the US and the price of gold.

The effect of EPU in China, Europe and Japan were considered and thus the hypothesis was divided into three sub hypotheses, for each of these economies.

The parameters estimated for hypothesis 3 are summarised in Table 31 and Table 32, while appendix section 9.9.5 details the model statistics and plots. Models excluding and including the AR1 term were estimated.

Table 31

Summary of hypothesis 4 model estimation

Dependent variable: Pgold_x_LRP1m	(1) H4 China		(2) H4 Europe		(3) H4 Japan	
EPU_x_LRP6m	0.0063		0.0242	***	.00189	*
	(1.075)		(2.690)		(1.862)	
DefaultPremLRP6m	0.0241		-0.0059		0.0091	
	(1.456)		(-0.453)		(0.768)	
GoldBetaUS36m	-0.1043		-0.7205		0.2572	
	(-0.162)		(-0.915)		(0.417)	
IDX_x_LRP6m	0.2118	**	-0.3248	***	0.0339	
	(2.327)		(-2.664)		(0.809)	
INFL_x_12	0.0016		0.6834		-0.3289	
	(0.009)		(1.284)		(-1.075)	
INFL_x_Vol	0.9106		0.5202		-0.2942	
	(1.573)		(0.374)		(-0.235)	
(Constant)	-0.0195		-0.6795		0.8096	
	(-0.027)		(-0.662)		(1.106)	
N	202		202		236	
Model significance	(1.550)		(3.073)	***	(1.207)	
R^2	.046		.086		.031	
Adjusted R^2	.016		.058		.005	

statistics in parentheses

*p<.10, **p<.05, ***p<.01

Source: own research

Table 32

Summary of hypothesis 4 model estimation, with AR1 term

Dependent variable: Pgold_x_LRP1m	(1) H4 China AR1		(2) H4 Europe AR1		(3) H4 Japan AR1	
Pgold_x_LRP1m_L1	-0.1923	***	-0.1817	***	-0.1828	***
	(-2.794)		(-2.632)		(-3.104)	
EPU_x_LRP6m	0.0071		0.0267	***	0.0186	*
	(1.225)		(2.996)		(1.861)	
DefaultPremLRP6m	0.0283	*	-0.0051		0.0100	
	(1.735)		(-0.396)		(0.859)	
GoldBetaUS36m	-0.1438		-0.7521		0.2915	
	(-0.228)		(-0.969)		(0.481)	
IDX_x_LRP6m	0.2551	***	-0.3656	***	0.0208	
	(2.810)		(-3.019)		(0.503)	
INFL_x_12	0.0117		0.7346		-0.4024	
	(0.064)		(1.400)		(-1.336)	
INFL_x_Vol	1.0637	*	0.6495		-0.3750	
	(1.861)		(0.474)		(-0.306)	
(Constant)	-0.0322		-0.7042		0.9296	
	(-0.045)		(-0.696)		(1.292)	
N	202		202		236	
Model significance	(2.490)	**	(3.704)	***	(2.450)	**
R^2	.082		.118		.070	
Adjusted R^2	.049		.086		.041	

statistics in parentheses

**p<.10, **p<.05, ***p<.01*

Source: own research

5.3.5.1 Statistical observations for hypothesis 4c

The statistical observations following the estimation of models to test hypothesis 4c were as follows:

1. The AR1 model was statistically significant (F (7,194) =2.490, p=.018) beyond a 95% confidence level.
2. The AR1 term was significantly negatively related to the gold price beyond a 95% confidence level, with β=-0.1923 (t (201) =-2.794, p=.006).
3. IDXcnyLRP6m was significant in the AR1 model, beyond a 95% confidence level with β=0.2551 (t (201) =2.810, p=.005).

4. The coefficient of determination for the AR1 model, R^2=.082 (*F (*7,194) =2.490, *p*=.050).

5.3.5.2 Testing hypothesis 4c

The null and alternative hypotheses for testing the influence of Chinese EPU on the gold price in CNY were as follows:

The null hypothesis: The model showed no relationship between Chinese EPU and the gold price in CNY, to a 95% level of significance.

The alternative hypothesis: The model showed a relationship between Chinese EPU and the gold price in CNY, beyond a 95% level of significance.

Thus: $H4c_0$: Model significance (as indicated by ANOVA p-value) ≥ .050

$H4c_A$: Model significance (as indicated by ANOVA p-value) < .050

The statistical results were as follows:

- For the model excluding the AR1 term: Model significance (as indicated by ANOVA p-value): .164 > .05.
  - The study failed to reject the null hypothesis, and it was concluded that the model showed no relationship between Chinese EPU and the gold price in CNY.
- For the model including the AR1 term:
  - Model significance (as indicated by ANOVA p-value): p=.018 < .050.
  - The null hypothesis was rejected, and it was concluded that the model showed a relationship between Chinese EPU and the gold price in CNY.
  - It was noted that Chinese EPU was not itself statistically significant (*β*=0.007, *p*=.222, *t (*201) =1.225) in the model beyond a 95% confidence level.

5.3.5.3 Statistical observations for hypothesis 4e

The statistical observations following the estimation of models to test hypothesis 4e were as follows:

1. The non-AR1 model was statistically significant (*F (*6,195) =3.073, *p*=.007) beyond a 95% confidence level.
2. The AR1 model was statistically significant (*F (*7,194) =3.704, *p*=.001) beyond a 95% confidence level.
3. The AR1 term was significantly negatively related to the gold price beyond a 99% confidence level, with *β*=-0.1817 (*t (*201) =-2.632, *p*=.009).

4. EPUeuLRP6m was statistically significant in the non-AR1 model, beyond a 95% confidence level with *β*=0.0242 (*t (*201) =2.690, *p*=.008).
5. EPUeuLRP6m was statistically significant in the AR1 model, beyond a 95% confidence level with *β*=0.0267 (*t (*201) =2.996, *p*=.003).
6. IDXeuukLRP6m was significantly negatively related in the non-AR1 model beyond a 95% confidence level with *β*=-0.3248 (*t (*201) =-2.664, *p*=.008).
7. IDXeuukLRP6m was significantly negatively related in the AR1 model beyond a 95% confidence level with *β*=-0.3656 (*t (*201) =-3.019, *p*=.003).
8. The coefficient of determination for the AR1 model, R^2=.118 (*F (*7,194) =3.704, *p*=.001), was greater than that of the non-AR1 model, R^2=.086 (*F (*6,195) =3.073, *p*=.007).

5.3.5.4 Testing hypothesis 4e

The null and alternative hypotheses for testing the influence of European EPU on a EUR-GBP composite gold price were as follows:

The null hypothesis: The model showed no relationship between European EPU and a EUR-GBP composite gold price, to a 95% level of significance.

The alternative hypothesis: The model showed a relationship between European EPU and a EUR-GBP composite gold price, beyond a 95% level of significance.

Thus: $H4e_0$: Model significance (as indicated by ANOVA p-value) ≥ .050

$H4e_A$: Model significance (as indicated by ANOVA p-value) < .050

The statistical results were as follows:

- For the model excluding the AR1 term:
  - Model significance (as indicated by ANOVA p-value): .007 < .050.
  - The null hypothesis was rejected, and it was concluded that the model showed a significant relationship between European EPU and the EUR-GBP composite gold price.
- For the model including the AR1 term:
  - Model significance (as indicated by ANOVA p-value): .001 < .050.
  - The null hypothesis was rejected, and it was concluded that the model showed a significant relationship between European EPU and the EUR-GBP composite gold price.

5.3.5.5 Statistical observations for hypothesis 4j

The statistical observations following the estimation of models to test hypothesis 4j were as follows:

1. The AR1 model was statistically significant beyond a 95% confidence level, $F(7,228) = 2.450$, $p = .019$.
2. The AR1 term was significantly negatively related to the gold price beyond a 95% confidence level, with $\beta = -0.1828$, $t(236) = -3.104$, $p = .002$.
3. The coefficient of determination for the AR model, $R^2 = .070$ ($F(7,228) = 2.450$, $p = .019$).

5.3.5.6 Testing hypothesis 4j

The null and alternative hypotheses for testing the influence of Japanese EPU on the gold price in JPY was as follows:

The null hypothesis: The model showed no relationship between Japanese EPU and gold price in JPY, to a 95% level of significance.

The alternative hypothesis: The model showed a relationship between Japanese EPU and the gold price in JPY, beyond a 95% level of significance.

Thus: $H4j_0$: Model significance (as indicated by ANOVA p-value) ≥ .050

$H4j_A$: Model significance (as indicated by ANOVA p-value) < .050

The statistical results were as follows:

- For the model excluding the AR1 term: Model significance (as indicated by ANOVA p-value): .303 > .050.
  - The study failed to reject the null hypothesis, and it was concluded that the model showed no relationship between Japanese EPU and the gold price in JPY.
- For the model including the AR1 term:
  - Model significance (as indicated by ANOVA p-value): .019 < .050.
  - The null hypothesis was rejected, and it was concluded that the model showed a significant relationship between European EPU and the EUR-GBP composite gold price.
  - It was noted that EPUjpLRP6m was not itself statistically significant in the AR1 model beyond a 95% confidence level ($\beta = 0.0186$, $t(236) = 1.861$, $p = .064$).

5.3.5.7 Granger causality tests for hypothesis 4

As a means of augmenting the discussion and interpretation of the results of estimating this model, granger causality tests were conducted to assess direct and reverse causality between variables in this study that were found to be significantly linked to gold. The results of these tests are summarised in Table 28, and the detailed test results are shown in appendix section 9.9.2.5.

Table 33

Granger causality test results for variables of interest in hypothesis 4

Variable	Direction	Result
IDXcnyLRP1m	Direct	IDXcnyLRP1m does not Granger-cause PgoldCnyLRP1m
IDXcnyLRP1m	Reverse	PgoldCnyLRP1m does not Granger-cause IDXcnyLRP1m
IDXeurgbpLRP6m	Direct	IDXeurgbpLRP6m does not Granger-cause PgoldEurGbpLRP1m
IDXeurgbpLRP6m	Reverse	PgoldEurGbpLRP1m does not Granger-cause IDXeurgbpLRP6m
EPUeuLRP1m	Direct	EPUeuLRP1m does not Granger-cause PgoldEurGbpLRP1m
EPUeuLRP1m	Reverse	PgoldEurGbpLRP1m does not Granger-cause EPUeuLRP1m

Source: Own research

5.3.6 Summary of results, Hypotheses 1, 2, 3 and 4

The results for the model estimations are summarised in Table 34.

Table 34

Summary of acceptance/rejection of null hypotheses, H1, 2, 3 and 4

	Scope	Null hypothesis, non-AR1	Null hypothesis, AR1
Hypothesis 1	Domestic	Fail to reject	Fail to reject
Hypothesis 1	International	Fail to reject	Fail to reject
Hypothesis 2	Domestic	Fail to reject	Fail to reject
Hypothesis 2	International	Fail to reject	Fail to reject
Hypothesis 3	Domestic	Fail to reject	Fail to reject
Hypothesis 3	International	Fail to reject	Fail to reject
Hypothesis 4	China	Fail to reject	Reject (R^2 = .082)
Hypothesis 4	Europe	Reject (R^2 = .086)	Reject (R^2 = .118)
Hypothesis 4	Japan	Fail to reject	Reject (R^2 = .064)

Source: Own research

The model displaying the highest significance is that for the European EPU study (for hypothesis 4e). By the estimation detailed in Table 32, the 1-month log return of the combined EUR/GBP gold price is estimated to be expressed in terms of Equation 42:

Equation 42 – Estimated model for the log return of the gold price in a combined EUR/GBP index

$$PgoldEurGbpLRP1m_t = -0.704 - (0.182 \times PgoldEurGbpLRP1m_{t-1}) + (0.027 \times EPUeuLRP6m_t) - (0.005 \times DefaultPremLRP6m_t) - (0.752 \times GoldBetaUS36m_t) - (0.366 \times IDXeurgbpLRP6m_t) + (0.735 \times INFLeuuk12) + (0.649 \times INFLeuukVol) + \varepsilon_t$$

To ensure the validity of this model, tests were conducted as detailed in section 5.3.7.

5.3.7 Post-estimation tests to ensure model quality

Table 35

Summary of post-estimation tests for model quality

Condition	Test	Outcome	Detail section
Normality of residuals	Shapiro-Wilk	Residuals are normal	9.10.1
Homoscedasticity of residuals	White's test	No heteroscedasticity present in residuals	9.10.3
Linearity of DV-IV relationships	Visual inspection	Relationships are linear	9.10.2
Autocorrelation of the residuals	Ljung-Box test	Residuals not autocorrelated	9.10.4
Structural change	Cusum test	Model structure stable	9.10.6
Cointegration	Engle-Granger test	Cointegration is present	9.10.5

Source: Own research

Tests were performed in terms of section 4.7.3 to ensure the validity of the model estimated and detailed in section 5.3.6. The tests, and their outcomes are summarised in Table 35, and the details of the tests are shown in appendix section 9.9.7.

5.3.8 Handling of cointegration

The cointegration detected in the model from hypothesis H4e necessitated further investigation. Cross-correlation plots were drawn, to indicate the direction of causality, and stationarity was analysed. The plots are detailed in appendix section 9.10.7.

Tests for stationarity of the residuals were also conducted. The ADF test found absence of a unit root to a significant level ($p<.001$) and the KPSS test found that the no significant non-stationarity ($p=.268$).

The Cross-correlation functions showed a causal relationship whereby lagged EPUeu and IDXeuuk values were significant beyond a 95% level, however no positive correlation was present. While this does not unequivocally indicate causality (considering the *post hoc ergo propter hoc* fallacy), the sequence of these significant lags does indicate the absence of reverse causality.

Given the stationarity of the series and the absence of reverse causality, it was decided to continue with this model. Additional techniques including Vector Error Correction Models (Enders, 2004; Maddala, 2001) lay outside the scope of this research.

5.3.9 Describing error terms

Table 36

Descriptive statistics of the residuals, predicted and actual values for H4e estimation

		Unstandardized Residual	Unstandardized Predicted Value	PgoldEurGbpLRP1m	Valid N (listwise)
N	Statistic	202	202	214	202
Minimum	Statistic	-16.3880	-3.9240	-15.8586	
Maximum	Statistic	11.2923	7.3670	15.0249	
Mean	Statistic	0.0000	0.7421	0.6894	
Std. Deviation	Statistic	4.5053	1.6470	4.8579	
Skewness	Statistic	-0.3366	0.5936	0.1116	
	Std. Error	0.1711	0.1711	0.1663	
Kurtosis	Statistic	0.8859	1.1091	0.6221	
	Std. Error	0.3405	0.3405	0.3311	

Source: Own research

For the model estimated for hypothesis 4e, error terms were recorded by IBM SPSS v. 25 in the process of estimation and these are described in Table 36, and a time plot of predicted and actual log returns for gold are shown in *Figure 24*.

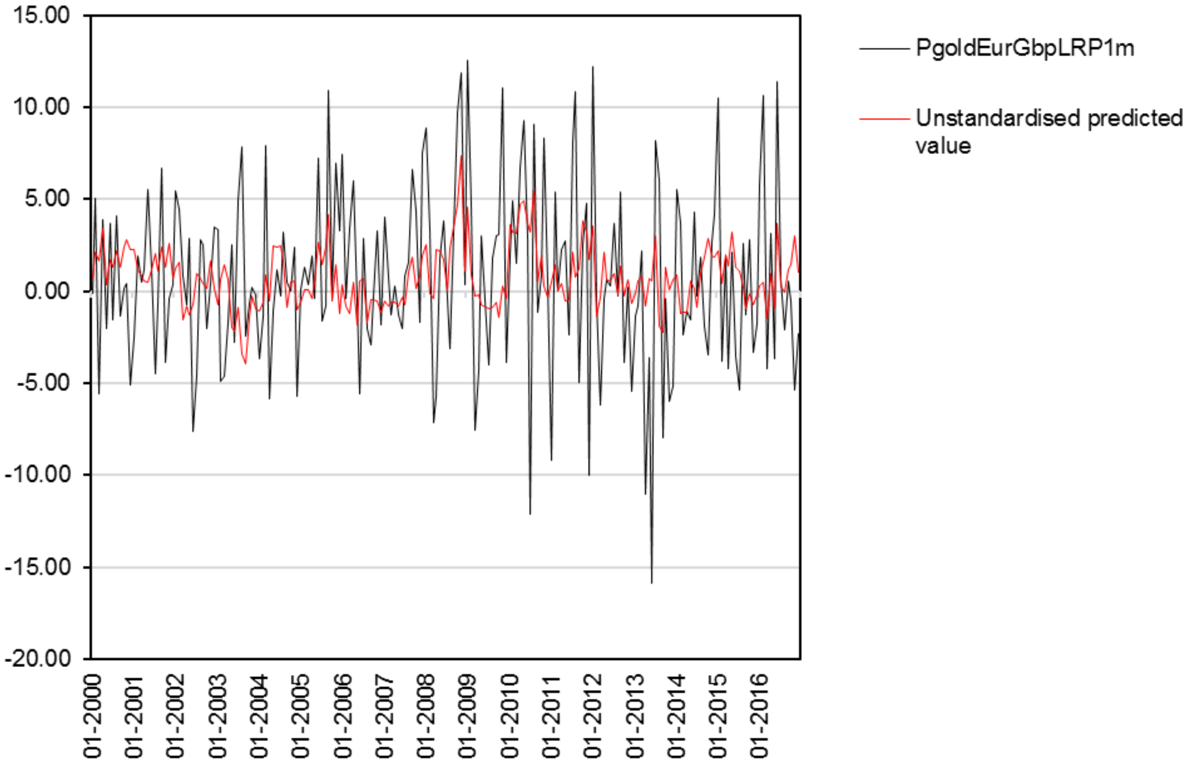


Figure 24 *Actual and predicted in-sample log returns for gold from the H4e model, January 2000 to December 2016*

Source: own research

The significant result obtained in rejecting the null of hypothesis 4e, the European EPU study, indicated suitability of this data for use in hypothesis 5, which was the subject of the next phase of the research, detailed in Part D.

5.4 PART D: Testing hypothesis 5 using ARIMA/ARIMAX

Part D, the ARIMA/ARIMAX model estimation section of this research for testing hypotheses 5 is arranged to correspond with section 4.8 of Chapter 4. The process flow of this section is outlined in *Figure 25*.

This section uses the same dataset as that for hypothesis 4e and uses IBM SPSS Forecasting function in a process of discovery.

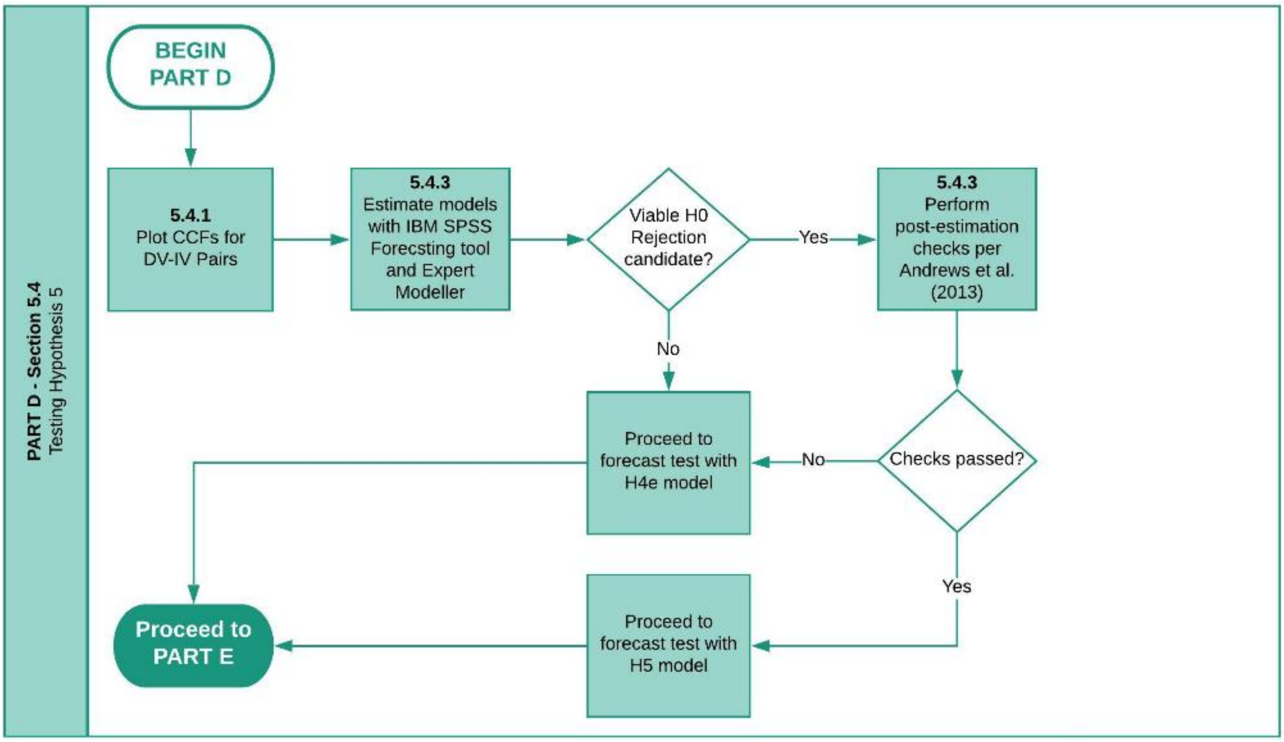


Figure 25 *Process flow for estimation of models for hypothesis 5*

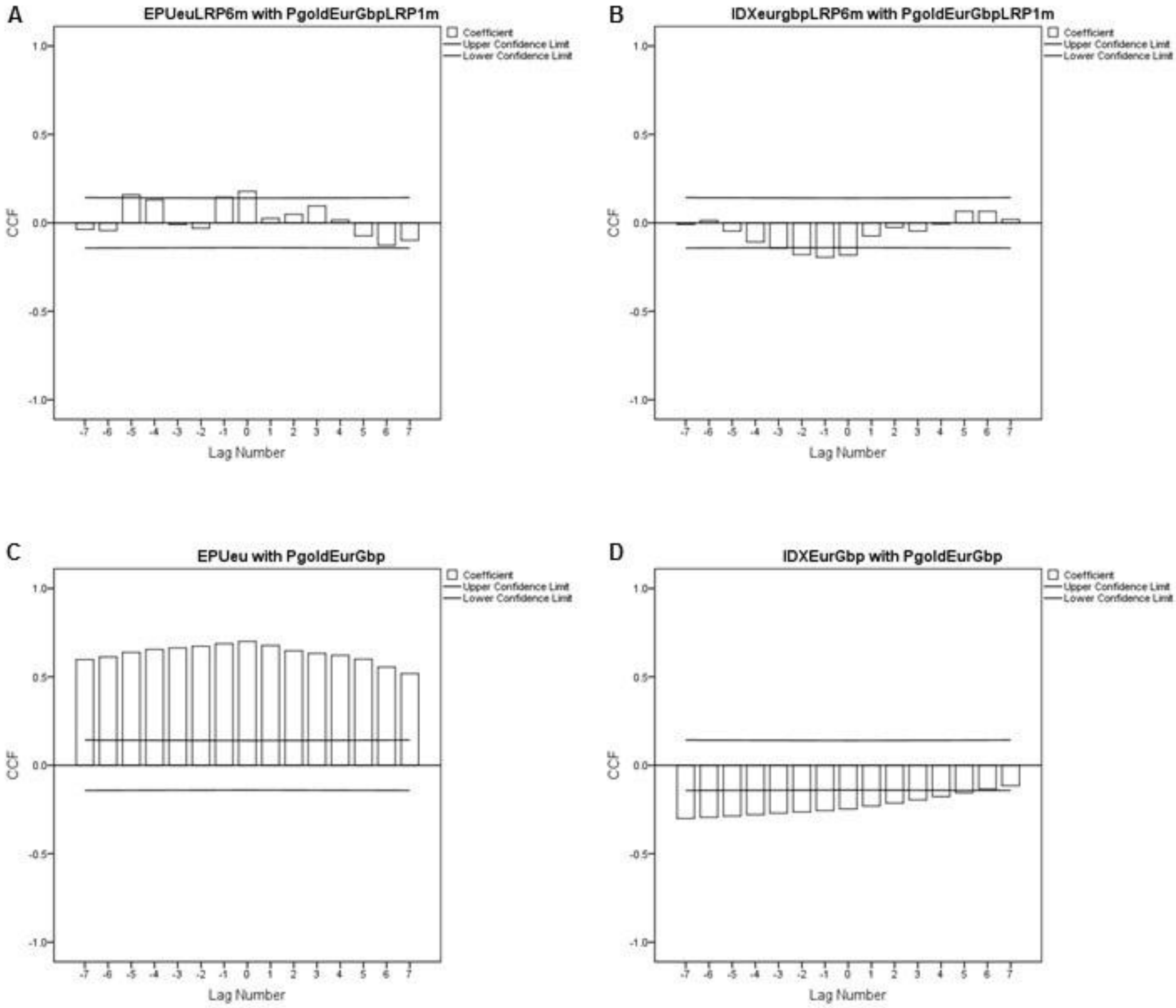
Source: Own research

5.4.1 CCF's for Dependent-Independent variable pairs

Cross-correlation functions for the DV-IV pairs for hypothesis 5, which were derived from hypothesis 4e's model, are indicated in *Figure 26*.

- Notable lags, beyond a 95% confidence level, in the PgoldEurGbpLEP1m-EPUeuLRP6m pair are:
  - Lag -1 (cross-correlation r=.145)
  - Lag -4 (cross-correlation r=.130)
  - Lag -5 (cross-correlation r=.159)
- Notable lags, beyond a 95% confidence level, in the PgoldEurGbpLEP1m-IDXeurgbpLRP6m pair are:
  - Lag -1 (cross-correlation r=.194)

- Lag -2 (cross-correlation r=.179)



Panel's A and B indicate CCF's for the significant variables from H4e, as differenced for that study. Panel's C and D indicate the CCF's for the undifferenced variables from the H4e study.

Figure 26 *CCF's for DV-IV pairs for the hypothesis 5 model estimation*

Source: Own research

5.4.2 Model Estimation

Two models were estimated using IBM SPSS v. 25 with the data from hypothesis 4e, the model with the best explanatory power estimated to this point in the research. The models were as follows:

1. Estimation of ARIMAX model with H4e stationarized data: Data for this analysis were stationarized manually by the researcher using percentage log returns.
2. Estimation of ARIMAX model with H4e unstationarized data: Data for this analysis were stationarized automatically by IBM SPSS Expert Modeller.

Model statistics are summarised in Table 37, and model parameters are detailed in Table 38:

Table 37

Hypothesis 5 model estimation statistics

Model		Stationarized (1)	Unstationarized (2)
Model Type		ARIMA (0,0,0) (1,0,1)	ARIMA (0,1,0) (0,0,0)
Number of Predictors		2	2
Model Fit statistics	Stationary R-squared	.068	**.373**
	R-squared	.068	.992
	RMSE	4.757	36.687
	MAPE	180.414	**3.165**
	MAE	3.632	26.020
	MaxAPE	5933.775	11.404
	MaxAE	14.839	127.724
	Normalized BIC	**3.228**	7.418
Ljung-Box Q (18)	Statistics	13.354	16.087
	DF	16	18
	Sig.	.647	.586
n		204	200
Number of Outliers		0	4

Source: Own research

Critical observations from Table 37 are noted in the forthcoming section number 5.4.2.1.

Table 38

Hypothesis 5 estimated model parameters

Panel A: Using stationarized data (1)

Variable	Transformation			Estimate	SE	t	p
PgoldEurGbpLRP1m	None	AR, Seasonal	Lag 1	0.965	0.129	7.453	.000
		MA, Seasonal	Lag 1	0.913	0.200	4.570	.000
EPUeuLRP6m	None	Delay		10			
		Numerator	Lag 0	0.021	0.009	2.194	.029
IDXeurgbpLRP6m	None	Numerator	Lag 0	-0.357	0.113	-3.160	.002

Panel B Using Unstationarized data (2)

Variable	Transformation			Estimate	SE	t	p
PgoldEurGbp	Natural Log	Constant		0.006	0.003	2.283	.024
		Difference		1			
EPUeu	Natural Log	Numerator	Lag 0	0.049	0.012	4.237	.000
			Lag 4	-0.042	0.011	-3.658	.000
		Difference		1			
IDXEurGbp	Natural Log	Numerator	Lag 0	-1.091	0.232	-4.706	.000
		Difference		1			

Source: Own research

5.4.2.1 Statistical observations for hypothesis 5

Observations concerning model statistics and parameters were as follows:

1. Using input data that was manually stationarized (Model 1) results in a seasonal pattern, the optimum model being an ARIMA (0,0,0) (1,0,1).
2. Non-stationarized input data (Model 2) was automatically stationarized by IBM SPSS Expert Modeller, at the same order (1) as the manually stationarized data. The resulting model was an ARIMA (0,1,0) model.
3. Four outliers were removed from Model 2 and these are detailed in Table 196 in appendix section 9.11. Dates of these outliers are noteworthy and will be discussed in Chapter 6.
4. Model 1 has a lower BIC=3.228 (n = 204) than Model 2, BIC = 7.418 (n = 200).

5. Model 2 has a higher explanatory value (R^2 = .373, n=200), than Model 1 (R^2=.373, n = 204).
6. Model 2 has an in-sample mean absolute percentage error of MAPE = 3.165. The implication of this is that on average the actual observation deviates from the expected observation by 3.165%

5.4.2.2 Testing hypothesis 5

The null and alternative hypotheses for testing the potential enhancement of an ARIMAX model were as follows:

The null hypothesis: The proposed model's explanatory value did not exceed the explanatory value of the regression model on which it was based.

The alternative hypothesis: The proposed model's explanatory value exceeded the explanatory value of the regression model on which it was based.

Thus: $H5d_0$: $R^2_{arimax} \leq .118$

$H5d_A$: $R^2_{arimax} > .118$

The statistical results are as follows:

- For the model with stationarized input data (Model 1): R^2=.068 (*n=204*) < .118:
  - The study failed to reject the null hypothesis, and it was concluded that the ARIMAX (0,0,0)(1,0,1) model estimated using the IBM SPSS Expert modeller does not further enhance the model on which it was based, being the hypothesis 4e model.
- For the model with unstationarized input data (Model 2): R^2=.373 (*n=200*) < .118:
  - The null hypothesis was rejected, and it was concluded that the ARIMAX (0,1,0) model estimated using the IBM SPSS Expert modeller further enhances the model on which it was based, being the hypothesis 4e model.

5.4.3 Post estimation mode quality checks

With reference to section 4.2.2.3, the following checks were performed on the input and output data for hypothesis 5, Model 2:

Stationarity of the input data:

While data input into Model 2 was non-stationary, data were stationarized by first order differencing in the estimation process for an ARIMA (0,1,0) model.

Residuals must be free from autocorrelation:

With reference to section 4.3.9, the Ljung-Box test was specified for testing the existence of autocorrelation of residuals in models where lagged variables are incorporated.

For the Ljung-Box test:

- The conclusion of absence of autocorrelation of residuals lies in the null hypothesis (Ljung & Box, 1978);
- The criteria for acceptance or rejection of the null hypothesis are as follows:
    - Fail to reject the null hypothesis when the p-value is greater than or equal to α = .050, and conclude that the residuals are not autocorrelated to a 95% confidence level (Ljung & Box, 1978);
    - Reject the null hypothesis when the p-value is less than α = .050, and conclude that the residuals are autocorrelated beyond a 95% confidence level (Ljung & Box, 1978).

For Model 2, p=.586 (Q (18) = 16.087), which is greater than α = .050. The analysis failed to reject the null hypothesis, and it was concluded that the residuals of model 2 are free from autocorrelation.

Significance of exogenous variables

The significance of exogenous variables for Model 2 are detailed in Table 38, and these were confirmed to all be lower than α = .050.

It was concluded that all exogenous variables included in the model were significant.

Independent variables must be free from feedback from dependent variables

Cross-correlation functions were estimated for both exogenous variable in Model 2. The plots are detailed in *Figure 26*, in section 5.4.1.

Panel A and B of *Figure 26* show CCF's with significant negative lagged correlations, where prior periods of the exogenous variables are correlated with t_0 of the dependent variable. This effect was not observed in any *t + 1* periods. This may indicate an absence from instances where movements in the dependent variable are causing effects in the exogenous variable at a later stage, which in turn may indicate an absence of feedback. The researcher was satisfied that the dataset was free from spurious feedback.

Signs of exogenous variable coefficients are consistent with correlation coefficients of exogenous-dependent variable pairs

With reference to the previous multivariate linear regression model estimation which was conducted, the parameters of which are detailed in Table 32, in section 5.3.5: The signs of the un-lagged exogenous variables for hypothesis 4e's model matched with the signs of those of the parameters of hypothesis 5 Model 2. The researcher was satisfied that results of the regression model for hypothesis 4e are consistent with hypotheses 5 model 2.

Exogenous variables must be free from multicollinearity

Input data for estimating the model for hypothesis 5 Model 2 were tested in the course of the pre-estimation tests for hypothesis 4e. The input data were found not to be colinear in a manner which would invalidate the results. The test is detailed in section 5.2.2.3.3.

Conclusion of post estimation tests

The post estimation tests provided no reason to reject the model estimated for hypothesis 5. Thus, the model defined by the parameters detailed in Table 39 was accepted as the model which has the highest explanatory power of those estimated in this study.

Table 39

Parameters of the final model estimated for hypothesis 5, using the H4e model as a base, with unstationarized input variables

Variable	Transformation			Estimate	SE	t	p
PgoldEurGbp	Natural Log	Constant		0.006	0.003	2.283	.024
		Difference		1			
EPUeu	Natural Log	Numerator	Lag 0	0.049	0.012	4.237	.000
			Lag 4	-0.042	0.011	-3.658	.000
		Difference		1			
IDXEurGbp	Natural Log	Numerator	Lag 0	-1.091	0.232	-4.706	.000
		Difference		1			

Source: Own research

5.5 PART E: Testing the forecasting power of the model

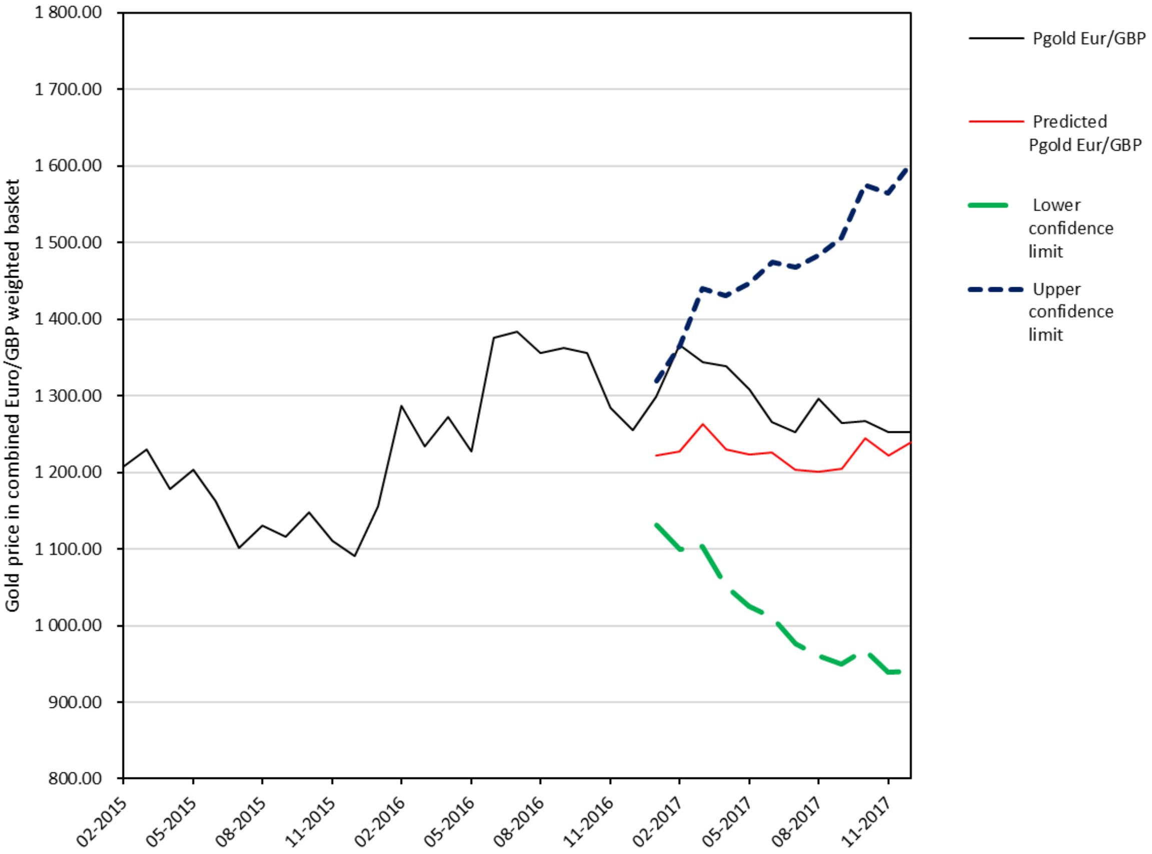


Figure 27 *Forecast plot for model from hypothesis 5's model*

Source: Own research

Table 40

Comparison of in-sample and out-of-sample forecast statistics for hypothesis 5's model

Statistic	In sample	Out of sample
Root mean squared error (RMSE)	36.687	65.14
Mean absolute percentage error (MAPE)	**3.165**	5.07
Mean absolute error (MAE)	26.02	31.18
MaxAPE	11.404	11.96
MaxAE	127.724	139.12

Source: Own research

A forecast was prepared using the model estimated in hypothesis 5, using EPU data and the combined EUR/GBP index for 2017. The results of this forecast are illustrated in *Figure 27*, and comparative statistics between the model's in-sample and out-of-sample errors are summarised in Table 40.

A concern relating to the forecast model was the deviation from the in-sample MAPE = 3.165 and the out-of-sample MAPE = 5.07. The difference between these two statistics indicates a potential shortfall in the model insofar as a significant effect is unaccounted for. The forecast is discussed in further detail in Chapter 6.

5.6 Conclusion of the results of the data analysis

Table 41

Summary of estimation results

Hypothesis	Analysis detail	Null hypothesis	Conclusion
1: To determine whether the addition of EPU volatility to Jones and Sackley's (2016) model would enhance the explanatory power of that model, using monthly data.			
1d	Domestic, without AR1	Failed to reject	Model not enhanced
1d	Domestic, with AR1	Failed to reject	Model not enhanced
1i	International, without AR1	Failed to reject	Model not enhanced
1i	International, with AR1	Failed to reject	Model not enhanced
2: To determine whether using futures as the dependent variable in Jones and Sackley's (2016) model would enhance the explanatory power of that model, using daily data			
2d	Domestic, without AR1	Failed to reject	Model not enhanced
2d	Domestic, with AR1	Failed to reject	Model not enhanced
2i	International, without AR1	Failed to reject	Model not enhanced
2i	International, with AR1	Failed to reject	Model not enhanced
3: To determine using futures as the dependent variable in Jones and Sackley's (2016) model, together with adding EPU volatility, would enhance the explanatory power of that model, using daily data			
3d	Domestic, without AR1	Failed to reject	Model not enhanced
3d	Domestic, with AR1	Failed to reject	Model not enhanced
3i	International, without AR1	Failed to reject	Model not enhanced
3i	International, with AR1	Failed to reject	Model not enhanced
4: To determine whether using a model based on that of Jones and Sackley (2016) to test whether EPU in other economies was statistically related to the price of gold in those economies currencies.			
4c	China, without AR1	Failed to reject	No relationship exists
4c	China, with AR1	Rejected	A relationship exists [a]
4e	**Europe, without AR1**	**Rejected**	**A relationship exists**
4e	**Europe, with AR1**	**Rejected**	**A relationship exists**
4j	Japan, without AR1	Failed to reject	No relationship exists
4j	Japan, with AR1	Rejected	A relationship exists [a]
5: Using the model with the best explanatory power from the previous hypotheses, can the use of an ARIMA/ARIMAX model estimated using IBM SPSS Expert modeller enhance the model upon which it was based, being the hypothesis 4e model			
5 (Model 1)	Europe, manually stationarized	Failed to reject	Model not enhanced
5 (Model 2)	**Europe, SPSS stationarized**	**Rejected**	**Model enhanced**

a: While a statistically significant model was estimated, EPU itself is not a statistically significant regressor in this model

Source: Own research

The outcome of the analysis in this chapter is summarised in Table 41. The highlights of the data analysis were the estimation of 2 models of better explanatory power than the benchmark for Jones and Sackley's (2016) study. These were as follows:

1. The multivariate linear regression model detailed in Equation 42, in section 5.3.6. This was estimated in the process of testing hypothesis 4e, and describes the relationship between gold, priced in a combined GDP weighted EUR/GBP currency and a basket of exogenous variables including European EPU.
2. The ARIMAX (0,1,0) model with parameters detailed in Table 39, in section 5.4.3. This was estimated in the process of testing hypothesis 5, and describes the relationship between gold, priced in a combined GDP weighted EUR/GBP currency, and the exogenous variables European EPU and a weighted EUR/GBP currency index.

The statistical findings relating to these models was detailed in this chapter. The following chapter will discuss the economic significance of the results and their implication for the use of gold as a safe haven when faced with economic policy uncertainty.

CHAPTER 6 Discussion of the results

6.1 Introduction

The purpose of this chapter is to link the results detailed in Chapter 5 to the literature study of Chapter 2. This chapter seeks to cast the results against the backdrop of economic theory and develop a better understanding of gold as a safe haven against economic policy uncertainty.

6.2 Benchmarking Jones and Sackley (2016)

The purpose of benchmarking Jones and Sackley's (2016) study was primarily to establish an updated coefficient of determination against which to test this study's hypotheses. This was necessary given the temporal expansion from Jones and Sackley's study (2016), and the omission of oil producer political risk and gold lease rate as control variables.

The benchmark study also provided an important secondary purpose, that of ensuring consistency in the magnitude and direction of the relationships found in this study, with those found in Jones and Sackley (2016). Consistency of the direction of relationships (as evidenced by the sign of the coefficients of the estimated parameters) should be linked to the economic rationale of a relationship.

The consistency checks were particularly important given the substantial differences between the two studies' coefficients of determination, as indicated in the side-by-side comparison of the two studies shown in Table 42.

Three inconsistencies are evidenced between the two studies:

1. In both contexts of Jones and Sackley's (2016) study, Gold beta (GoldBetaUS36m) was positively correlated with gold, however they were inversely correlated in the benchmark study.
2. In the international context, Jones and Sackley (2016) reported a negative coefficient for US Inflation volatility (INFLusVol), whereas the benchmark study reported a positive coefficient.
3. In Jones and Sackley's (2016) international study, European EPU (EPUeuLRP6m) was inversely correlated with gold, however it was positively correlated in the benchmark study.

Table 42

Comparison between the original Jones and Sackley (2016) study parameters and the benchmarks

Dependent variable: PgoldLRP1m	(1) Jones and Sackley (2016) Domestic		(2) Benchmark Domestic AR1		(1) Jones and Sackley (2016) International		(4) Benchmark International AR1	
PgoldLRP1m_L1	-0.0599		-0.1401	**	-0.0892		-0.1900	***
	(-0.067)		(-2.224)		(-1.060)		(-3.044)	
EPUusLRP6m	0.0208	*	0.0070	*	0.0306	*	0.0018	
	(1.740)		(1.751)		(1.840)		(0.408)	
DefaultPremLRP6m	0.0232	**	0.0231	*	0.0240		0.0284	**
	(2.160)		(1.801)		(2.200)		(2.157)	
GoldBetaUS36m	**6.274**	*****	**-0.8103**		**4.518**		**-0.5448**	
	(1.970)		**(-1.317)**		**(1.44)**		**(-0.880)**	
IDXusdLRP6m	-0.3100	***	-0.2936	***	-0.2380	***	-0.2672	***
	(-4.010)		(-3.198)		(-2.860)		(-2.821)	
INFLus12m	0.1460		0.0902		0.8590	**	0.3802	
	(0.480)		(0.291)		(1.980)		(0.988)	
INFLusVol	4.0130		2.1115	***	**-1.1370**		**1.4485**	
	(1.680)		(2.800)		**(-0.340)**		**(0.946)**	
EPUeuLRP6m					**-0.0076**		**0.0194**	**
					(0.540)		**(2.112)**	
INFLworld					-1.2710	**	-0.5796	
					(-2.300)		(-1.003)	
INFLworldVol					**17.9500**	*****	**0.2534**	
					(1.710)		**(0.119)**	
(Constant)	-0.6060		-0.7654		0.6300		1.1950	
	(0.450)		(-0.778)		(0.260)		(0.578)	
N	178		234		178		236	
Model significance			(3.362)	***			(2.966)	***
R^2	.153		.094		.208		.116	

statistics in parentheses

**p<.10, **p<.05, ***p<.01*

Source: Jones and Sackley (2016), and own research

These inconsistencies did not occur in instances where the variables were significant (and this was the case in both Jones and Sackley's (2016) study and the benchmark model estimation of this paper), however one unexpected result was the finding that EU EPU is a significant contributor to the gold price in the international benchmark study. This highlights the level to which adverse effects in specific regions can affect others and result in contagion (Ozkan & Unsal, 2012).

6.3 A note on the interpretation of coefficients of log return variables

A substantial proportion of the variables used in this study have been differenced using log returns. These were interpreted by assuming a change factor that was aligned with normal movement in the variable (EPU innovations may be well beyond 100% of the index value in a day, while currencies may only move 1%). The researcher-defined change factor was multiplied by the coefficient from the model estimation. This process is detailed in Equation 43 and Equation 44.

Equation 43 Interpretation of log returns, change coefficient equation

$$Change\ coefficient = e^{\beta \times x}$$

Where x is the log return of the variable chosen for interpretation of the coefficient.

Equation 44 Interpretation of log returns, price forecast equation

$$P_{forecast} = P_{current} \times Change\ coefficient$$

Where P is the gold price.

The current gold price used in all calculations in this section is $1300, which was approximately the average gold price in the opening week of January 2018 (World Gold Council, 2018a).

6.4 Hypothesis 1

Testing hypothesis 1 (H1) was pursuant to fulfilling the first research objective, which was stated as follows:

- Determine whether the addition of EPUI Volatility to the multivariate regression model developed by Jones and Sackley (2016) described the relationship between EPU and gold spot prices, and thus the use of gold as an EPU safe haven asset, better than the original model.

6.4.1 Results of testing hypothesis 1

This hypothesis was divided into two sub-hypotheses, for a purely domestic set of control variables (H1d), and an international set of control variables (H1i). Both were tested with and without a 1 period lag of the dependent variable (referred to as an AR1 term). The AR1 term was included to maintain consistency with Jones and Sackley's (2016) study, notwithstanding the finding that stationarized series were free from autocorrelation.

All the H1 models were statistically significant, however none showed a greater explanatory power than their corresponding benchmarks. Volatility in dependent variables has been shown to have significant impacts on returns (Brunetti et al., 2016) while the volatility of predictor variables has been an area of development of advanced techniques including GARCH (Engle & Kroner, 1995; Engle et al., 1990). This study did not employ a GARCH technique but rather incorporated a measure of EPU volatility, based on the measure of inflation volatility used in the benchmark study (Jones & Sackley, 2016).

Given the methodological limitations of this study, it would be premature to conclude that volatility of US EPU was not a significant contributor to the price of gold. Incorporation of a GARCH function to the model may yet provide the necessary methodological power.

6.4.2 Further observations from modelling hypothesis 1

Despite the fact that none of the models estimated to test this hypothesis had a greater explanatory power than those of Jones and Sackley (2016), all models were statistically significant. This section will refer specifically to the models that included the AR1 term, since the terms were significant in both the domestic and international contexts.

With reference to the 1-month lagged term, in both cases these were negative: In the international model β=-0.1393 (p =.037, t (233) = -2.103) and in the international model β=-0.1753 (p=.007, t (234) = -2.708). In practical terms when considering the international model, a 1% increase in the price of gold to a level of $1313, from $1300 in a given month can be expected, beyond a 95% confidence level, to revert to $1310.71 in the following month, according to the calculation detailed in Table 43.

Table 43

Hypothesis 1: Gold price mean reversion effect

Indicator	Formula	Value	Arithmetic return %	Log return %
Pgold t-1		1 300.00		
Pgold t		1 313.00	1.00%	1.00%
β		-0.1753		
Change	$e^{\beta \times \text{Log return}}$	0.9983		
Current price		1 313.00		
Forecast price	*Current price x change*	1 310.71	-0.17%	

Source: Own research

Studies have argued that there is a direct link between the risk of corporate distress and the price of gold (Jones & Sackley, 2016; Levin & Wright, 2006). The default premium was used as the measure of the risk of corporate default (Jones & Sackley, 2016). In the 20-year period of this study, the mean default premium was 1% and the standard deviation was .43%, while its overall range was from .5% to 3.5%, however in any one year it has been known to vary substantially. In 2016 alone, the range was .75% to 1.5%, and the average change in a 6-month period is 21% of the value.

Table 44

Hypothesis 1: Default premium positive effect on gold

Indicator	Formula	Value	Arithmetic return %	Log return %
Pgold t-1		1.00		
Pgold t		1.21	21.00%	19.06%
β		0.0293		
Change	$e^{\beta \times \text{Log return}}$	1.0056		
Current price		1 300.00		
Forecast price	*Current price x change*	1 307.28	0.56%	

Source: Own research

As detailed in Table 44, with a β=0.0293 (p = .031, t (234) = 2.174), and on a gold price of $1300, changes in the default premium could be expected to increase the gold price by $7.28, beyond a 95% level of certainty. This is hardly a substantial move and while this was significant, the magnitude is hardly significant. A $7.28 change in a $1300 investment over 6 months sounds paltry, especially in a model where 88.5% of the movement is unaccounted for.

The safe haven property of gold and currencies was strongly argued in literature (Baur et al., 2016; O'Connor et al., 2015; Pukthuanthong & Roll, 2011; Reboredo, 2013), and this was a view supported by this study. Coefficients for IDXusLRP6m (the 6-month log return of the USD real exchange rate) were negative in all H1 estimations. In the H1 international AR1 model β=-0.2795 (p=.004, t (234) = -2.884), and in on average over a 6-month period since 1997 the USD real exchange rate moved 3%. Thus, a 3% decline in the dollar can be expected to increase the gold price by $11.11 from a level of $1300, as detailed in Table 45.

Table 45

Hypothesis 1: USD Real exchange rate effect on gold

Indicator	Formula	Value	Arithmetic return %	Log return %
Pgold t-1		100.00		
Pgold t		97.00	-3.00%	-3.05%
β		-0.2795		
Change	$e^{\beta \times \text{Log return}}$	1.0085		
Current price		1 300.00		
Forecast price	*Current price x change*	1 311.11	0.85%	

Source: Own research

A further point of interest was that the relationship between gold and the dollar, is neither zero, nor perfectly inverse. This has implications insofar as gold's properties as a USD hedge are concerned. The findings of this study fall in the temporally conditional grey area between those recent studies which hold that gold is a hedge against the USD (Baur & Lucey, 2010), and older work which held that the relationship was insignificant (Sjaastad & Scacciavillani, 1996). While the result of this study was certainly statistically significant, it points to a relatively low significance in economic terms: for a given 1% movement in the dollar, investors can only expect a 0.3% move in gold in the opposite direction. The fascinating aspect of this result is the fact that 70% of gold demand exists not in countries that use USD, but in the one that uses CNY (O'Connor et al., 2015; Zhang et al., 2015). The model suggests that during the period of this study (1997 to 2016) gold is not a 1:1 USD hedge, despite previous studies which suggest that it is significantly negatively correlated (Tully & Lucey, 2007) in periods of crisis.

The finding of this study, that there was no significant relationship between inflation and the price of gold was consistent with Tully and Lucey (2007) and was contrary to that of Levin and Wright (2007). While this study found no direct relationship with nominal inflation it did find that inflation volatility was significant, in the models with domestic variables only. This can be interpreted such that it is not so much the magnitude of inflation that the market seeks a safe haven in gold against, but the uncertainty of inflation. A possible explanation for this is that when inflation is rising, investors gear their portfolios to assets with high returns in inflationary environments, however when there is uncertainty surrounding inflation, they take a safe haven in gold until the outlook for inflation coalesces to a modicum of certainty.

6.4.3 Outcome of testing hypothesis 1 with reference to the first research objective

It was determined to a satisfactory extent that volatility of the US EPUI has no significant effect on the price of gold. Moreover, the study found no significant evidence to suggest that gold was used as a safe haven against EPU in the US. The objective was satisfied, in the negative.

6.5 Hypothesis 2

Testing hypothesis 2 was pursuant to fulfilling the second research objective, which was stated as follows:

- Determine whether estimating Jones and Sackley's (2016) model with its original set of variables against gold futures produces a better multivariate regression model, thus indicating that gold futures are a better safe haven against EPU.

6.5.1 Results of testing hypotheses 2

The hypotheses were divided into two sub-hypotheses, for purely domestic sets of control variables (H2d), and international sets of control variables (H2i). These were tested with and without an AR1 term. The AR1 term was included to maintain consistency with Jones and Sackley's (2016) study, notwithstanding the finding that stationarized series were free from autocorrelation.

While all four models were statistically significant, the coefficients of determination of all models was in the region of R^2=.010, indicating a remarkably low explanatory value when assessing the daily movement of the gold price. Commodity futures prices have been found to display a more dynamic means of assimilating information into markets (Tully & Lucey, 2007; Wu & Chiu, 2017), and the effects of contango and backwardation were evident in the gold market, as is illustrated in the results of the additional analysis introduced in section 5.3.4.6, and which are shown in *Figure 28*. This raised methodological issues which are discussed in the forthcoming section.

6.5.2 Methodological weaknesses in the testing of hypothesis 2

Instances of significant backwardation and contango are marked on *Figure 28*. These include 11 September 2001 where the futures price of gold was 4.32% lower than the spot price, and 3 September 2007 (the date German bank IKB announced over $1bn in subprime losses (Guillén, 2009)) when the futures price exceeded the spot price by 8.79%. Another noteworthy instance of backwardation occurred on 10 October 2008 at the height of the global financial crisis when major world markets fell sharply (some indices, including the FTSE 100 and the Nikkei 225 tumbled by 10%) (Guillén, 2009). Does this indicate instances of the shifting landscape of futures markets (Hamilton & Wu, 2014)?

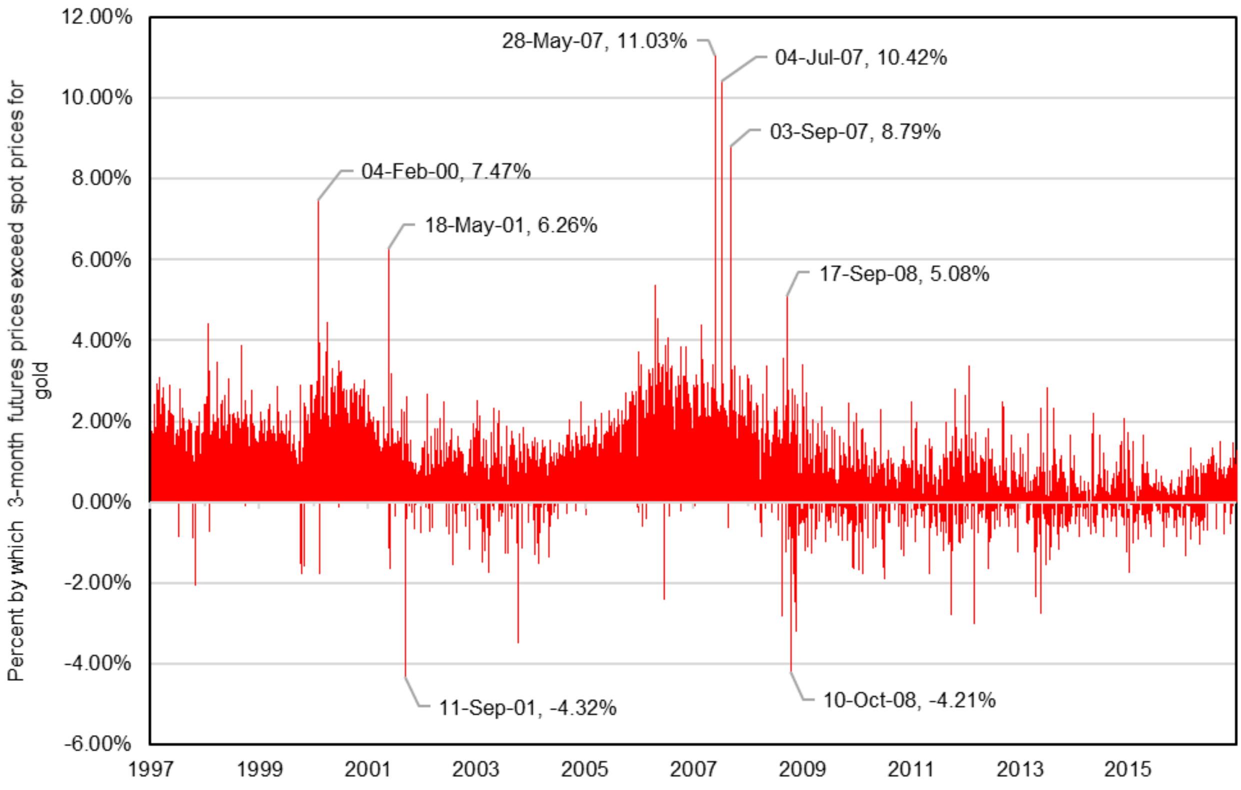


Figure 28 *3-month gold futures, backwardation and contango, 1997 to 2016*

Source: Own research

The supplemental analysis conducted in this study (the details of which are shown in section 9.9.6) suggested that indeed the pattern of backwardation and contango has shifted: prior to 2008 the market was dominated by contango with futures prices exceeding spot prices by 1.3% (consistent with Keynes (1930) view that under natural backwardation current spot prices should be below current futures prices), while the period since then has seen no dominance of either effect.

An alternative explanation for the negligible finding of the MLR model may relate to the four-hour lag between the spot prices (the LBMA 15:00 GMT fix) and futures prices (NYMEX closing at 16:00 EDT) used in this study. In order to add methodological rigor to discussion of this hypothesis, an ARIMAX model was estimated using IBM SPSS v.25's Expert modeller.

6.5.3 An ARIMAX approach to hypothesis 2's data

While the ARIMA or ARIMAX approach fell outside of the hypothesis testing approach defined in the research, it nevertheless provided a fascinating and fruitful point of departure for the US context. IBM SPSS v.25's expert modeller's estimates are detailed in section 9.9.7 and the statistics are summarised as follows:

- For the domestic variable set, an ARIMA (0,1,11) model with three exogenous predictors was estimated with an R^2=.325, and a mean absolute percentage error (MAPE) of 0.681%;
- For the international variable set, an ARIMA (0,1,11) model with five exogenous predictors was estimated with an R^2=.328, and a mean absolute percentage error (MAPE) of 0.680%;

As these studies were conducted to augment the discussion only, it must be stated that the post-estimation checks for developing a forecasting model were not performed. Nevertheless the USD real exchange rate's significance in both models supported the view that the USD is a significant factor in gold prices (Baur et al., 2016; Baur & Lucey, 2010; Pukthuanthong & Roll, 2011; Reboredo, 2013) and the inverse relationship suggests gold's suitability as a hedge against declines in the USD. Notwithstanding this conclusion, other studies have found a conditional relationship between the USD and gold (Sjaastad & Scacciavillani, 1996; Tully & Lucey, 2007), however this study did not seek to develop conditional correlation data, and thus does not express a view on gold's suitability as a safe haven (where a safe haven is an asset whose inverse relationship to the dollar would hold even in times of crisis).

The extent of the relationship between the USD and gold shown by both studies was also an interesting one. The models estimated suggested that a 1% decline in the USD real exchange rate delivers a 1.59% increase in the price of gold (as detailed in Table 46). The implication of this is that users of the USD do not set the price of gold: the gold price is determined globally (with a potentially strong influence from China as the dominant gold market (J. Liu, 2016;

O'Connor et al., 2015)) and the USD price of gold moves in response to changes in the dollar, and in order to eliminate the opportunity for arbitrage (Fama, 1970, 1991, 1998). A weak dollar only impacts the gold price insofar as gold is priced in dollars (and not a market weighted basket of currencies) and thus this research proposes the publication of a trade-weighted index price for gold.

Table 46

Hypothesis 2: USD Real exchange rate effect on gold

Indicator	Formula	Value	Arithmetic return %	Log return %
IDXusd t-1		100.00		
IDXusd t		99.00	-1.00%	-1.01%
β		-1.5678		
Change	$e^{\beta \times \text{Log return}}$	1.0159		
Current price		1 300.00		
Forecast price	*Current price x change*	1 320.65	1.59%	

Source: Own research

A further finding in the models discussed in this section was the significance of US inflation as a factor in the gold price. This result aligns with the previous work by Levin and Wright (2006) and Barro and Misra (2016).

The findings apropos the USD and inflation support the earlier work of Barro and Misra (2016), however the most critical observation from this exploration relates to what is absent: Economic policy uncertainty. The IBM SPSS v.25 expert modeller uses an iterative approach to estimate ARIMA or ARIMAX models which have the highest explanatory value with the most parsimonious structure (IBM Corporation, 2016). Neither of the ARIMAX models estimated for hypothesis 2 and discussed in this section included the measure of US EPU. This directly contradicts the finding of Jones and Sackley (2016), and while these models were not going to be carried forward to hypothesis 5, it was the conclusion of this research that in the US, economic policy uncertainty is insignificant to the price of gold.

6.5.4 Outcome of testing hypothesis 2

The regression model estimated to test hypothesis 2 was deemed to be inadequate for the purpose of testing the suitability of gold futures' use as a safe haven against US EPU. A supplemental ARIMA model provided reason to conclude that US EPU and gold futures prices were not significantly related. The objective was satisfied, in the negative, supporting the finding that in the US, investors do not buy gold as a safe haven against EPU.

6.6 Hypothesis 3

Testing hypothesis 3 was pursuant to fulfilling the third research objective, which was stated as follows:

- Determine whether the addition of EPUI Volatility to the multivariate regression model estimated by Jones and Sackley (2016) describes the relationship between EPU and the price of gold futures as a dependent variable, and thus the use of gold as an EPU safe haven asset, better than the original model does by using the spot price of gold as a dependent variable.

6.6.1 Results of testing hypotheses 3

The hypotheses were divided into two sub-hypotheses, for purely domestic sets of control variables (H3d), and international sets of control variables (H3i). These were tested with and without an AR1 terms. The AR1 term was included to maintain consistency with Jones and Sackley's (2016) study, notwithstanding the finding that stationarized series were free from autocorrelation.

While all four models were statistically significant, the coefficients of determination of all models were in the region of R^2=.010, indicating a remarkably low explanatory value when assessing the daily movement of the gold price.

6.6.2 Similarity to hypothesis 2

Given that the models estimated for this hypothesis only differed from those of hypothesis 2 through the inclusion of US EPU volatility, the findings regarding individual coefficients are near-identical to those of hypothesis 2. The discussion is thus identical to that for hypothesis 2: the USD is inversely correlated to gold, and EPU and EPU volatility are insignificant.

6.6.3 Outcome of testing hypothesis 3

The regression model estimated to test hypothesis 3 was deemed to be inadequate for the purpose of testing the suitability of gold futures' use as a safe haven against US EPU. A supplemental ARIMA model did provide reason to conclude that US EPU volatility and gold futures prices are not significantly related. The objective was satisfied, in the negative, supporting the finding that in the US, investors do not buy gold as a safe haven against EPU or EPU volatility.

6.7 Hypothesis 4

Testing hypothesis 4 was pursuant to fulfilling the fourth research objective, which was stated as follows:

- Pursuant to the avenues for further research in Jones and Sackley (2016), EPUI was modelled against gold spot prices in local currency, using multivariate regression, in Europe, China and Japan, which together constitute over 60% of the world's GDP (World Bank, 2017). These tests were performed to determine whether or not a statistically significant relationship existed between EPU in major economies outside the US and the price of gold.

6.7.1 Results of testing hypothesis 4

This hypothesis was divided into three sub-hypotheses, relating to China (H4c), Europe (H4e) and Japan (H4j). All were tested with and without an AR1 term. The AR1 term was included to maintain consistency with Jones and Sackley's (2016) study, notwithstanding the finding that stationarized series were free from autocorrelation.

Among the models that excluded the AR1 term, only the European study was statistically significant, while all studies including the AR1 term were statistically significant ($p=.018$ for the China study, $p<.001$ for the Europe study, and $p=.019$ for the Japan study). This resulted in the rejection of the null hypotheses for the models including the AR1 term for China, Europe, and Japan. In the Japan model, only the AR1 term was significant ($p=.002$, t (235) = -3.104), thus aside from the tendency toward mean reversion in the dependent variable, the model is unremarkable. The study suggests that gold is not a safe haven against EPU in Japan.

Jones and Sackley (2016) tested European EPU against USD gold prices and found that there was no significant relationship. In altering the dependent variable from USD gold prices to gold prices in a EUR and GBP weighted basket (EPWB), this study showed that a significant ($p=.003$, t (201) = 2.996) relationship existed between European EPU and the price of gold in the EPWB. A further significant factor of the European study was that the study's explanatory power exceeded that of the US benchmark study based on Jones and Sackley's (2016) international variables. The result suggests that gold has a significant role as a safe haven against European EPU. Moreover, while this finding did not directly contradict Jones and Sackley (2016) it showed that exploring EPU safe havens in the EU with a local currency focus resulted in a positive finding.

The China study, while statistically significant (p=.018, F(7,194) = 2.490, R^2 = .082), showed no statistically significant relationship (p=.222, t (201) = 1.225) between Chinese EPU and the CNY price of gold. The implication from this finding was that gold was not a safe haven against EPU in China. The CNY index was found to be significant (p=.005, t (201) = 2.810) in this study, and this has serious economic implications. The specific results of the European and the China models will be discussed in the remainder of section 6.7

6.7.2 Discussion of hypothesis 4e model results

On the face of it, the significance of European EPU in the European study would suggest that the European market indeed uses gold as a safe haven when faced with economic policy uncertainty. The challenge with taking this result at face value was that this effect may be the result of an EPU driven decline in the EPWB. This study however controlled for this effect through the inclusion of the combined EUR/GBP index.

The significance of the EPWB (p=.003, t (201) = -3.019), together with the negative relationship between the EPWB and the price of gold suggests that the model already accounts for currency declines, while being consistent with previous research (Baur et al., 2016; Pukthuanthong & Roll, 2011). A change in the strength of the EUR or GBP should, independently of the effect of a change in EPU, be reflected in the gold price in the EPWB component currencies.

A further observation was that gold is not primarily priced in GBP and EUR, and this was consistent with findings of this study with respect to the USD. The practical implication of this finding is that where GBP or EUR decline in price, the gold price in other currencies remains constant and the EUR or GBP price increases to account for the change in the currency. The effect is small, but significant. Given a 10% decline in the GBP and EUR, the price of gold in those currencies is expected to rise by 3.93% on average, as illustrated in Table 47.

Table 47

Hypothesis 4e: EUR/GBP Real exchange rate effect on gold

Indicator	Formula	Value	Arithmetic return %	Log return %
Pgold t-1		100.00		
Pgold t		90.00	-10.00%	-10.54%
β		-0.3656		
Change	$e^{\beta \times Log\ return}$	1.0393		
Current price		1 300.00		
Forecast price	*Current price x change*	1 351.05	3.93%	

Source: Own research

Thus, with reference to the question of the whether the effect of European EPU on GBP and EUR priced gold is truly significant, the study controlled for the currency effect and it was concluded that the relationship was not spurious. The coefficient on the European EPU log return variable was β=.0267 (p=.003, t (203) = 2.996) which suggested that a large innovation in European EPU, of 50%, could drive the EPWB price of gold up by 9%. Should the exchange rate remain neutral this would result in a change in the USD gold price from $1300 to $1314.15, beyond a 95% confidence level, as illustrated in Table 48.

Table 48

Hypothesis 4e: European EPU effect on gold

Indicator	Formula	Value	Arithmetic return %	Log return %
Pgold t-1		100.00		
Pgold t		150.00	50.00%	40.55%
β		0.0267		
Change	$e^{\beta \times Log\ return}$	1.0109		
Current price		1 300.00		
Forecast price	*Current price x change*	1 314.15	1.09%	

Source: Own research

While the results of the regression estimation for hypothesis 4e suggest a model as detailed in Equation 42 in section 5.3.6, post-estimation testing of this model and the residuals indicate the presence of cointegration. The presence of cointegration as found by the Engle-Granger method (p<.001, τ (203) = -13.596) raises concerns over the validity of the model as a forecasting tool, as does the low R^2= .118. Despite these issues, the finding of a significant relationship between European EPU and the EUR and GBP gold prices provided a solid foundation for hypothesis 5.

A final point in the discussion of hypothesis 4e relates to the effect of inflation in the European context on gold priced in EUR or GBP. While gold has been found to be a hedge against inflation in the UK (Hoang et al., 2016), this has been found not to be the case in the eurozone (Beckmann & Czudaj, 2017). This study found that in the overall European context, inflation is an insignificant (p=.163, t (201) = 1.40) variable. This study used a portmanteau index of GBP and EUR inflation, while the four eurozone components of the index (being Germany, France, Italy and Spain) account for, on average 77.6% of that index. This study supported the earlier finding by Beckman and Czudaj (2017) that gold is unaffected by eurozone inflation. This study also reinforced the finding of Hoang et al. (2016) who found that gold was not an inflation hedge against the EUR.

6.7.3 Discussion of hypothesis 4c model results

The model estimated for hypothesis 4c had a lower explanatory power (R^2=.082, p=.018) than the H4e model, moreover Chinese EPU was insignificant (p=.222) to the CNY gold price.

Studies showed that the most major currencies are negatively correlated to gold, in other words a weakening of the currency results in an increased gold price in that currency. These include the USD (Baur et al., 2016; O'Connor et al., 2015; Pukthuanthong & Roll, 2011; Reboredo, 2013), the EUR (Baur et al., 2016; Pukthuanthong & Roll, 2011), the GBP and the JPY (Pukthuanthong & Roll, 2011).

The remarkable aspect of this study was gold's response to the CNY real exchange rate, which was not only statistically significant (p=.005, t (201) = 2.81), but also positive (β=0.2551). This result was consistent with the fact that China was as of 2017 not only the largest gold market with over 70% or global demand (O'Connor et al., 2015; Zhang et al., 2015) but also the world's largest gold producer (Lucey, Larkin, & O'Connor, 2014). The finding of the positive relationship between the CNY and CNY priced gold supports the view that gold prices are set primarily by demand in China, and non-CNY gold prices adjust in accordance with the efficient market hypothesis (Fama, 1970, 1991). The efficient market hypothesis postulated that all information available to rational participants in market is immediately and fairly reflected in prices.

Table 49

Hypothesis 4c: Dual effect of a strengthening of CNY

Indicator	Formula	Value	Arithmetic return %	Log return %
IDXcny t-1		100.00		
IDXcny t		101.00	1.00%	1.00%
β		0.2551		
Change	$e^{\beta \times \text{Log return}}$	1.0025		
Current CNY price		8 450.00		
Forecast CNY price	*Current price x change*	8 471.48	0.25%	
Current USD:CNY rate		6.50		
New USD:CNY rate		6.44		
USD gold price prior to CNY strengthning		1 300.00		
USD gold price after CNY strengthning		1 303.30		
USD gold price after currency adjustment		1 316.34		

Source: Own research

The effect of the CNY strengthening relative to all other currencies in the CNY real exchange rate basket is hypothesised, based on the findings of this research, to be subject to a dual effect when viewed from a USD point of view. The CNY gold price will not only respond positively to the strong Chinese currency, but the dollar price of gold would increase due to an increase in CNY-priced gold. The calculation of the USD gold price under these conditions is illustrated in Table 49.

This dual effect would be dominated by the currency effect: a 1% strengthening of the CNY would drive the USD gold price from $1300 to $1316.34. Only $3.30 of this would be accounted for by the higher CNY gold price, while the balance, $13.04 would be directly accounted for by the 1% strengthening of the CNY against the USD.

6.7.4 Outcome of testing hypothesis 4

No significant relationship was found between EPU and gold in the Chinese and Japanese contexts, however a significant relationship was found between European EPU and gold priced in EUR and GBP. Evidence suggested that gold was potentially used as a safe haven against EPU in Europe, but not in China or Japan. The objective was satisfied, in the affirmative.

6.8 Hypothesis 5

Testing hypothesis 5 (H5) was pursuant to fulfilling the fifth research objective, which was stated as follows:

- In an effort to develop a more robust understanding of the nature of the relationship between EPU and the price of gold, an Autoregressive Integrated Moving Average with Exogenous Variables Model (ARIMAX) (Andrews et al., 2013; Ďurka & Silvia, 2012) was estimated using the best fitting set of variables from the previous four hypotheses (Andrews et al., 2013). This test was performed to determine whether or not a methodology incorporating autoregressive (AR) and moving average (MA) could produce a more statistically significant model, or one with better explanatory power, that those excluding these terms.

This objective of the research required the expansion of the set of results from the previous models, which held the highest explanatory power. The study of hypothesis 4e (H4e) provided the model with the highest coefficient of determination to this point in the research, and the data from this model were used to estimate the hypothesis 5 model.

6.8.1 Results of testing hypothesis 5

Two models were estimated for testing this hypothesis: one using the data manually stationarized for the purposes of H4e (model 1), and one using unstationarized data which allowed the modelling process to stationarize the data automatically (model 2). The results for the model 1 estimation were unremarkable, indicating the best fitting model to be an ARIMA (0,0,0)(1,0,1) with 2 predictors. This is a seasonal white noise model (the second set of parentheses indicate the seasonal parameters of the model) (Enders, 2004; Maddala, 2001). The explanatory value of this model (R^2=.068) was lower than the H4e model on which it was based.

Estimating model 2 resulted in an R^2= .373 in an ARIMA (0,1,0) model with 2 predictors, known as a random walk model with drift (the drift being described by the d=1 term) (Enders, 2004; Maddala, 2001). This result exceeded, by a substantial margin, the result of H4e, and led to the rejection of the null hypothesis that the ARIMA/ARIMAX methodology could not enhance the result of Hypothesis 4e.

The conclusion from the results was that using the H4e unstationarized variables in an ARIMAX model enhanced the H4e result. Furthermore, this result substantially extended the understanding of gold's use as a safe haven against EPU in Europe, and this is discussed in detail in section 6.8.2.

6.8.2 Discussion of the detail of hypothesis 5's model

Model 2 incorporated, as significant exogenous predictors, European EPU ($p<.001$, $t(199) = 4.237$), and the EPWB ($p<.001$, $t(199) = -4.706$). The significance of these predictors aligns with the result obtained in the H4e model: that gold priced in EUR or GBP responds to European EPU. This develops upon Jones and Sackley's (2016) previous research which held that European EPU has no impact on dollar priced gold. As was the finding in testing H4e, the positive significance of EPU together with the negative significance of real exchange rates in Europe and the UK suggests that gold responds simultaneously to both a spike in EPU and a weakening of the currencies in the EPWB.

An enhancement of the H5 model over the H4e model was the finding of a significant negative relationship with EPU at a 4-month lag ($p<.001$, $t(199) = -3.658$). The most remarkable finding was the reversion to mean suggested by the model coefficients:

- $\beta\_EPUeu_t = 0.049$
- $\beta\_EPUeu_{t-4} = -0.042$

The following scenario serves to illustrate the effect of a change in EU EPUI on the gold price. The calculation of the positive effect at *t* is detailed in Table 50, and the negative effect at t-4 is detailed in Table 51.

Table 50

Hypothesis 5: Positive effect of EU EPU at t

Indicator	Formula	Value	Arithmetic return %	Log return %
Pgold t-1		100.00		
Pgold t		150.00	50.00%	40.55%
β		0.0490		
Change	$e^{\beta \times \text{Log return}}$	1.0201		
Current price		1 300.00		
Forecast price	*Current price x change*	1 326.09	2.01%	

Source: Own research

Table 51

Hypothesis 5: Negative effect of EU EPU at t-4

Indicator	Formula	Value	Arithmetic return %	Log return %
Pgold t-1		100.00		
Pgold t		150.00	50.00%	40.55%
β		-0.0420		
Change	$e^{\beta \times Log\ return}$	0.9831		
Current price		1 326.09		
Forecast price	*Current price x change*	1 303.70	-1.69%	

Source: Own research

The scenario is as follows (ceteris paribus):

1. Gold is trading at $1300, EU EPUI stands at 100, and the exchange rate between the EPWB currencies and the dollar is held constant throughout the scenario, as are all other variables.
2. In month 1 EPUI moves from 100 to 150. The model suggests that there is a greater than 95% probability that the gold price moves to $1326.09.
3. Assuming the EU EPUI remains at 150, in month 4, there is a greater than 95% probability that the effect of the month 1 price move in gold will almost completely revert to its previous level, with the gold price reducing to $1303.70.

The question that arises from this finding, in light of EMH (Fama, 1970, 1991), is thus: If markets respond to uncertainty and information is priced into gold efficiently, why would markets respond in the opposite direction four months later, ostensibly to no stimulus whatsoever? Is it possible that in the (very simplistic) scenario illustrated, market participants would, after four months, accept the higher level of EPU as a “new normal”, and close their gold positions in favour of assets that yield higher returns? Prices reverting without appropriate stimulus supports the view that participants are irrational (De Bondt & Thaler, 1985; Russell & Thaler, 1985). At the same time provides the basis for a trading strategy which exploits this inefficient market behaviour.

The development of such a trading strategy is further augmented by the apparent near-1:1 hedge between gold and the EPWB currencies, evidenced by the coefficient β=-1.091 ($p<.001$, $t(199) = -4.706$) for the combined EUR/GBP real exchange rate index. The model indicates that beyond a 95% level of confidence, a 1% increase in the EUR or GBP would lead to a 1% decrease in the gold price in those currencies. Thus, a long position in gold could be protected against decline by holding an equal short position in dollars. The significant negative relationship between gold and real exchange rates in the EU augments the finding of H4e, and serves to confirm the findings of previous research (Baur et al., 2016; Pukthuanthong & Roll, 2011).

6.8.3 Forecasting using the hypothesis 5 model

An out of sample forecast was conducted using the H5 model, using input variables from 2017 (the model was estimated using data from 2000 to 2016). The MAPE of the out-of-sample forecast was 5.07%, and this, together with the plot comparing the forecast and actual gold price for 2017 in *Figure 29*, suggested that far more work lies ahead to translate the model estimated in this study to one which reliably incorporates the bulk of information available.

The forecast plot, illustrated in *Figure 29* shows that the forecast and actual prices converged toward the end of 2017, and it is argued that the bulk of the difference between the out-of-sample MAPE and the in-sample MAPE (which was 3.17%) may be accounted for by the variation in the first half of 2017. Events at the beginning of 2017 which were not part of the model, but which may have driven gold prices higher include the opening months of Donald Trump's presidency in the US. February and March 2107 saw Trump initiate reviews of the Dodd-Frank act which was aimed at managing risk in the banking sector following the 2008 global financial crisis (BBC News, 2017), and excise Obama-era policies to avert climate change by executive order (Davenport & Rubin, 2017). The gold market during this time may have priced in uncertainty generated by Trump's use of his executive powers for purposes which may have been seen to spite his political rivals and enrich members of his wealthy social circle. The market may also have taken a view of allegations of Trump's close ties to Russian president Vladimir Putin and the alleged meddling by Russian intelligence in the election which brought Trump to power (Schmidt, Mazzetti, & Apuzzo, 2017).

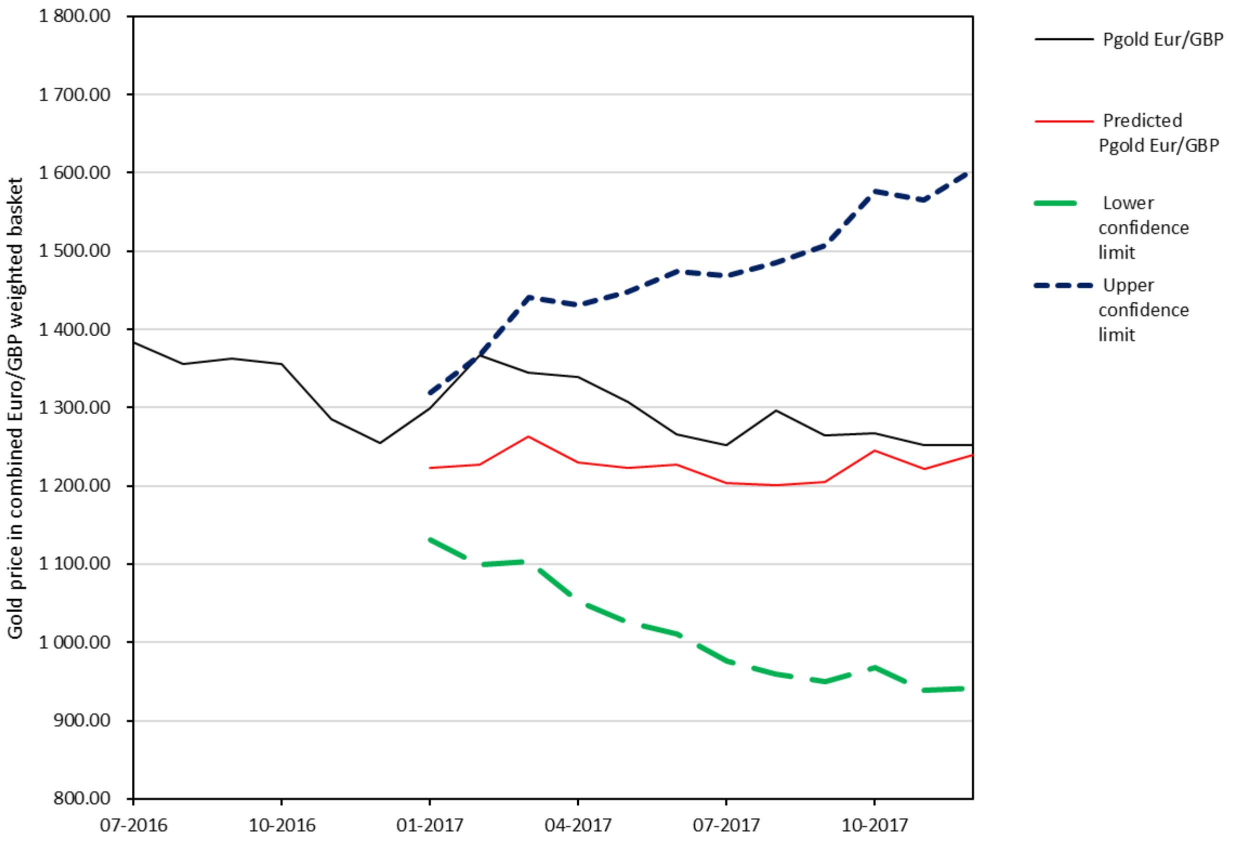


Figure 29 *Forecast plot for model from hypothesis 5's model*

Source: Own research

The H5 model explains 37.3% of gold's price. Events like those described in the US in early 2017, as well as geopolitical risks are not factored into the model and occupy the unknown realm, being the other 62.7% of gold's price determinants. The events described are quite literally that: events. They represent a force majeure that ex-ante models cannot forecast. The impact of events can be incorporated into forecasting models, for conducting what-if analyses in a similar manner to the method employed by Levin and Wright (2006), however this was not within the scope of this study.

6.8.4 Outcome of testing hypothesis 5

The ARIMA (0,1,0) model with two exogenous predictor variables was found to have higher explanatory power than the model estimated for H4e. Moreover hypothesis 5 confirmed the findings of hypothesis 4. Gold was found to behave in a manner suggesting safe haven seeking against EPU in Europe. The objective was satisfied, in the affirmative.

A further note with regard to this outcome relates to causality. Tests showed that EPU did not Granger-cause the movement in the gold price. This implies that while the model describes a relationship, no causal link was found.

6.9 Conclusion of the discussion of the results

In addition to satisfying the research objectives, relationships between other variables have provided a better understanding of gold price determinants. These relationships were as follows:

1. The inverse relationship between the USD and gold, which suggested that the primary gold market does not operate in USD.
2. The direct relationship between the CNY and gold price in that currency. This lends weight to the argument that the Chinese market is the primary price determinant of gold.

The following chapter concludes this research by relating the findings to its purpose and motivation and discusses avenues for future research.

CHAPTER 7 Conclusion

This research sought to understand the role of gold as a safe haven against economic policy uncertainty by investigating the relationships between the EPUI in the US, Europe, China and Japan.

Determining the role of gold as a safe haven against economic policy uncertainty is a critical area of research in a global economy which is dominated by fear, greed and debt. In 2008 the financial systems of the US, Europe, and other developed markets stared into the abyss thanks to a decade of reckless financial engineering. A substantial portion of the toxic debt which was responsible for the 2008 crisis coalesced in the commercial banking system and before being absorbed by sovereign entities by means of bailouts and nationalisations. Those same sovereign entities simultaneously re-inflated their financial systems by creating cheap money through low- or zero-interest rate policies in an effort to reignite economic growth. A decade after the 2008 global financial crisis, sovereign entities were indebted to an amount of $63 trillion (Desjardins, 2017) which represents 84% of gross world product (World Bank, 2017).

Sovereign debt is traded among public and private entities across the globe; it stores the wealth of nations grown fat on oil, metals and manufacturing; it is used as the assurance against which trillions of dollars change hands for trade and capital projects; and it provides an allegedly risk-free vehicle for retirement funds to earn a steady yield. The liquidity of debt markets relies on participants' confidence in the issuing entities. It is only a matter of time before this confidence falters once again, as it did in 2008, resulting in these markets grinding to a halt.

Is it worth having a golden haven to hide behind? And are there indicators that foreshadow the next economic and financial calamity? Baker, Bloom and Davis (2016) developed one such indicator, the EPUI, which the authors publish for the world's largest 15 economies (Economic Policy Uncertainty, 2016).

Jones and Sackley's (2016) earlier work on gold and the EPU indices found evidence that gold was used as a safe haven in crises that affected US stocks, while they found no evidence that European investors sought a safe haven in gold. This study expanded on Jones and Sackley's (2016) work by investigating the effect of EPUI volatility on gold, and gold futures. It modelled the effect of EPUI in China, Japan and Europe in those regions' own currencies, where Jones and Sackley (2016) had used dollar prices of gold. Finally, it augmented the MLR approach employed by Jones and Sackley (2016) with ARIMA models which included transfer functions accounting for exogenous variables (known as ARIMAX models).

The models estimated for this research addressed the influence of EPUI's with the inclusion of control variables (real exchange rates, corporate distress, and inflation) on gold spot prices and gold futures. The inclusion of control variables not only ensured that exogenous effects were controlled for, but they also provided scope for additional findings. The outcome of this study could therefore be used to propose a model of the effects, not only of EPUI, but also of the control variables on gold.

7.1 Principal findings

This study undertook to achieve the purpose of contributing to the body of understanding of the relationship between economic policy uncertainty and the price of gold and gold futures, through the fulfilment of five objectives:

1. Determine whether the addition of volatility to the multivariate regression model developed by Jones and Sackley (2016) described the relationship between EPU and gold spot prices, and thus the use of gold as an EPU safe haven asset, better than the original model (the subject of hypothesis 1).

2. Determine whether estimating Jones and Sackley's (2016) model with its original set of variables against gold futures produces a better multivariate regression model, thus indicating that gold futures are a better safe haven against EPU (the subject of hypothesis 2).

3. Determine whether the addition of EPUI Volatility to the multivariate regression model estimated by Jones and Sackley (2016) describes the relationship between EPU and the price of gold futures as a dependent variable, and thus the use of gold as an EPU safe haven asset, better than the original model does by using the spot price of gold as a dependent variable (the subject of hypothesis 3).

4. Pursuant to the avenues for further research in Jones and Sackley (2016), EPUI was modelled against gold spot prices in local currency, using multivariate regression, in Europe, China and Japan, which together constitute over 60% of the world's GDP (World Bank, 2017). These tests were performed to determine whether or not a statistically significant relationship existed between EPU in major economies outside the US and the price of gold (the subject of hypothesis 4).

5. In an effort to develop a more robust understanding of the nature of the relationship between EPU and the price of gold, an ARIMAX (Andrews et al., 2013; Ďurka & Silvia, 2012) was estimated using the best fitting set of variables from the previous four hypotheses (Andrews et al., 2013). This test was performed to determine whether or not a methodology incorporating autoregressive (AR) and moving average (MA) could produce a more statistically significant model, or one with better explanatory power, than those excluding these terms (the subject of hypothesis 5).

Further to this, the research sought to contribute to the development of a more complete pricing model for gold, and as a result, other findings of interest relating to the control variables included in this study were relevant.

7.1.1 Principal findings of hypothesis 1, 2 and 3

With specific reference to EPU in the US, this study found that there was no statistically significant link between the gold price and US EPU. The tests relating to US EPU were also conducted with the inclusion of EPU volatility as a variable in the linear regression. These tests indicated no significant relationship between EPU volatility and the price of gold or gold futures. In order to add rigor, and validate the insignificance of US EPU to gold prices, ARIMAX models were estimated to augment the understanding of this relationship. These models showed that no significant relationship existed between EPU or EPU volatility as predictors, and gold spot prices or gold futures prices as dependent variables.

The findings of insignificance would suggest that when faced with events of uncertainty around tax and economic policy, there is no substantial and significant safe haven seeking in gold by US investors. An alternative view is that as an economy the US is insignificant, and while this cannot be ruled out in the context of gold (where China accounts for 70% of annual gold demand (World Gold Council, 2017a; Zhang et al., 2015)), it is highly unlikely given that the US still represents one quarter of gross world product (World Bank, 2017). This finding contradicted the previous work of Jones and Sackley (2016) who found a significant link between US EPU and the spot price of gold. The possible reasons for this are changes to the temporal scope of the study (where this study ranged from 1997 to 2016, while Jones and Sackley's (2016) study terminated in January 2013) and changes to the scope of the control variables. This study omitted the cost associated with borrowing gold, and geopolitical risk in oil producing countries since these control variables were not found to be statistically significant in Jones and Sackley's (2016) earlier work. Nevertheless, the broader scope of analyses and methodologies employed in this study suggest a strong motivation to conclude that in the US, EPU is irrelevant to gold demand, and that gold does not see significant use as a safe haven by US investors.

7.1.2 Principal findings of hypothesis 4 and 5

The effect of EPU in China and Japan on gold was not tested by Jones and Sackley (2016) but was a subject of this study. Models estimated to measure the effect of EPU in China and Japan on gold showed that there was no significant relationship. While China is a huge market for gold, both for investment and jewellery, limitations in the China EPUI were identified (being the fact that the index was constructed from only one news source which was based in Hong Kong) which rendered it of limited use in the study. It was reasonable to conclude that Japanese EPUI and JPY-priced gold were not significantly related, however in the Chinese context, the limitations associate with the Chinese EPUI render the result of that study inconclusive. While the study led to the conclusion that Japanese investors do not use gold as a safe haven against economic policy uncertainty, the limitations in the Chinese EPUI measure ruled out an unequivocal finding against gold's use as an EPU safe haven in that market.

Jones and Sackley (2016) modelled the effect of European EPU on gold prices in USD using a multivariate regression approach, and they reported that no significant relationship existed between those variables. This study modelled the relationship between European EPU and gold priced in EUR and GBP (a combined GDP weighted basket currency was used since the European EPU index used data from Europe and the United Kingdom) together with European and UK inflation and real exchange rates. The multivariate regression model estimated for this study found a significant relationship between gold and European EPU. Moreover, the model showed greater explanatory power than the benchmark model of Jones and Sackley's (2016) US study. The significance of this result is augmented by the fact that the study included a measure of European and UK real exchange rates, and that this measure was negatively correlated to gold. Without a real exchange rate measure, there would be no accounting for the offshore price effect of gold, whereby EPU may cause a decline in the domestic currency resulting in the domestic currency gold price increasing to maintain parity with the offshore gold price.

The final objective of this study sought to expand on the European EPU model by using a more sophisticated ARIMAX approach. The results of this study not only confirmed the findings of the MLR approach but extended it substantially. The ARIMAX model explained 37.3% of the movement in the gold price, compared to 11.8% explained by the MLR model. Moreover, the ARIMAX study revealed a four-month mean reversion cycle in the gold prices response to EPU.

Moreover, this study revealed that gold was a near perfect hedge for the EUR and GBP: A 1% weakening of the EUR would result in a 1% strengthening of the EUR or GBP gold price, while the effect of any increase in the European EPUI would be marked into the gold price over and above the currency effect. Both the MLR model and the ARIMAX model estimated for European EPU appear to demonstrate the use of gold as a safe haven by European investors, to a significant level.

The ARIMAX model for European EPU's effect on gold was tested in an out of sample forecast with 2017 data and this revealed a 5% mean error, month to month. While the goal, ultimately, is to develop forecasting models that perfectly predict future prices (thus implying a 0% MAPE), market forces are in a constant state of flux, and thus the work to understand gold's role as a safe haven should be ongoing.

An area of focus for such and extension would appear to be the nexus of global demand for gold: China. It is a fact that in the second decade of the 21st century, China is both the world's largest producer and consumer of gold. In 2016 Chinese mines produced 453 of the total of 3,199 tonnes mined in that year, almost twice that of the next highest producers, Russia and Australia, with 289 tonnes (World Bank Group, 2017). In the same period, China accounted for 620 of the 1871 tonnes consumed globally by jewellery production (Thomson Reuters, 2017). That gold prices continue to be quoted in USD thus seems absurd, and this research provides the argument that the yellow metal should be priced in CNY. The argument is supported by the finding that the USD is inversely related to the price of gold, and that a 1% weakening of the USD results in a 1.5% increase in the USD price of gold (according to the ARIMAX model estimated in the process of investigating the second objective of this research). The converse is true of China, for when the CNY strengthens, the CNY price of gold is found to increase. Gold in China is positively correlated to Chinese currency. The effect is minor: a 1% strengthening of the CNY results in a 0.25% increase in the CNY gold price. The implication is a crucial expansion of the understanding of the dynamics of the gold market: Gold prices are a Chinese phenomenon, and the US is just another market (along with Europe) whose domestic gold prices fluctuate against the moves of its currency to eliminate arbitrage in accordance with efficient markets (Fama, 1970, 1991).

7.1.3 Alignment with the purpose of this study

This research was conducted using quantitative techniques, by taking a view of the effect of EPU on gold market. It made the following methodological contributions to the body of knowledge previously explored by Jones and Sackley (2016) relating to the role of gold as a safe haven against EPU:

- The set of variables relating to EPU was expanded to include EPU volatility. The effect of EPU volatility on the price of gold was tested in the US context, and it was found that there was no statistically significant relationship between US EPU volatility and the USD spot gold price or gold futures price. The implication of this finding was that gold is not used as a safe haven against EPU in the US.
- The geographical scope of the study was expanded to include China, Europe and Japan. No significant relationship was found between Japan and China EPU. The implication was that gold is not used as a safe haven against EPU in Japan, while methodological concerns resulted in the finding of gold as an EPU safe haven in China being inconclusive. In Europe, a statistically significant relationship was found between EPU and gold, and this showed evidence of the use of gold as a safe haven in that region.
- An ARIMAX approach was used to perform a more sophisticated investigation into the role of EPU as a safe haven in Europe, and this analysis not only confirmed the findings of the MLR approach, but it provided a deeper level of understanding insofar as mean reversion was concerned. The implication of the 4^{th} period mean reversion shown in the model is such that when European investors seek a safe haven in gold, they do so for four months before closing out that position. Moreover, this study revealed that a near-1:1 inverse correlation existed between gold priced in EUR or GBP, and the region's real exchange rates. The implication of this is the potential for a near-perfect hedge between gold and USD for European investors.

Finally, the ARIMAX model estimated for European EPU's effect on gold was used to conduct an out-of-sample forecast which deviated from observed gold prices on average of 5%. While this statistic high (a 5% variation on a gold price of $1300 implies a confidence band from $1235 to $1365), the model explained 37% of the movement in gold prices. This result, compared to the best model estimated by Jones and Sackley (2016) which explained 20.8%, is a significant expansion of the understanding of gold's role as a safe haven against EPU.

7.2 Implications for management

7.2.1 Implications for South African gold mining companies

7.2.1.1 Background

This study set out to enhance the analytical tools available to decisionmakers in the South African gold mining industry. As it stands the industry exists on a fine line between revival and oblivion. Gold production in South Africa has continually declined through the early 21st century (World Bank Group, 2017) thanks to a decline in the quality of deposits (Engineering & Mining Journal News, 2010) and historic tensions between mining companies on the one hand and communities and labour on the other, that are rooted in the apartheid era (Cropley & Flak, 2011). Mining's dark history in South Africa undoubtedly needs redress, however this has led to government striking a potential death blow to the South African gold industry through the proposed 2017 Mining charter (Chamber of Mines South Africa, 2018b).

Despite the pessimism hanging over the industry it remains a key driver of the South African economy. Moreover, Neal Froneman, the CEO of Sibanye-Stillwater, remains staunchly bullish about gold mining in South Africa, and he relishes the prospect of accessing the Witwatersrand's treasure of still-unmined gold (Creamer, 2018). Speaking at the 2018 Mining Indaba, Froneman proposed his vision of exploiting what is still the world's largest gold reserve (Chamber of Mines South Africa, 2017b) under a social and economic compact with workers and communities seeks to redress the injustices of the past (Creamer, 2018).

For Froneman's vision to come to fruition, he, and other mining CEO's who would invest shareholders money in new projects, need to be mindful of a harsh economic reality: shareholders expect a return that is consummate with the level of risk they expose themselves to. In a mining sector which is already under fire for value destruction (Bloomberg, 2017), raising capital for new gold mining operations faces a difficult task, especially given the lack of supplier pricing power that the homogenous nature of gold implies. Investors in South African operations need to see a sustained or increasing gold price to offset the high cost of deep level mining in South Africa's mature orebodies.

7.2.1.2 Recommendations to South African gold mining companies

This research can specifically guide South African mining investors to separate out short term fluctuation and long-term opportunity. This research found that EPU in Europe directly impacted the price of gold and that that impact was short lived. The research specifically showed that within four months of an excursion of European EPU, the resultant upswing in the price of gold would revert to its long-term trend. This research advises those looking to invest in mining projects to be well advised to dismiss upward moves in the gold price as temporary, if they are shown to emanate from safe haven seeking against EPU in Europe.

This research points to China as the nexus of global gold pricing, through the small, but significant direct relationship between CNY strength and gold priced in CNY. This is unsurprising given the scale of gold demand in China, which amounts to 70% of world consumption (World Gold Council, 2017a). While China is also currently the world's largest gold producer, this status may be surprisingly short lived. As of 2016 China only had 12,100 tonnes of proven gold reserves left (Reuters staff, 2017), while recent estimates of Witwatersrand basin proven reserves were approximately 36,000 tonnes in 2009 (Hartnady, 2009). This is potentially tantalising news for Neal Froneman and those who see a strong future for South African gold mining but for three considerations: the state of demand for gold in China, the rate at which China extracts the yellow metal from its deposits, and the cost of mining in South Africa.

Analysts hold that gold demand in China peaked in 2013 (Thomson Reuters, 2017) and that the market for both jewellery and investments has shifted. O'Connor et al. (2015) found a noticeable tapering in demand for gold ETF's in China following 2013. Simultaneously Chinese consumers are believed to have become less discerning over the past five years in terms of their preference for pure gold jewellery, with tastes shifting to jewellery of lower carats (Thomson Reuters, 2017). Nevertheless China remains a massive market which continues to grow its middle class (J. Liu, 2016).

China produced a little over 450 tonnes of gold in each of 2014, 2015 and 2016. At this rate it will be another 26 years before Chinese underground reserves are exhausted. Consideration must also be given to the definition of proven reserves which is inter alia reserves which are economically and operationally feasible to exploit. Thus, as gold prices rise, more of the deposit is economically exploitable. Nevertheless, South African miners will still be waiting for a considerable time for the bonanza that awaits when Chinese gold production grinds to a halt. A final consideration for South African gold miners was the finding that from 1836 to 2011 the growth in gold consumption did not correspond to growth in gold prices (Barro & Misra, 2016), however that research may not have been able to account for the recent unprecedented growth in China. Nevertheless, investors in gold mining infrastructure would do well to study Chinese gold demand and its effect on gold prices carefully.

South Africa's gold extraction costs are 33% higher than the world average (Thomson Reuters, 2017), making the country's operations less profitable and more sensitive to price shocks, production interruptions and cost escalations. New investments in South African gold operations must necessarily assume that gold prices will remain strong for many years into the future. This research points to the hypothesis that in the long-term China holds the key to these prices, not only in its demand and supply dynamics, but insofar as this research finds that long term investors in gold infrastructure should track the CNY price of gold. In addition to the long-term implications of Chinese demand, the finding of this research that gold is used as a safe haven against EPU in Europe has short term hedging implications for gold producers who would seek to maximise their profits by covering forward in futures markets.

7.2.2 Implications for the financial services industry

This study proposed that a better understanding of the effect of EPU's effect on gold prices could help to develop a more complete pricing model for investors, traders, and speculators.

The findings in the US, and Japan indicate that EPU does not induce safe haven seeking towards gold in those countries. Thus, the finding is that the EPUI in those countries is not a significant indicator for determining entry and exit points to gold markets. The China study showed no significant relationship between EPU and gold, however the narrow scope of the China EPUI raised doubts regarding its suitability for the research objective.

The findings of the European EPU study, and specifically the results of estimating the model for hypothesis 5 suggest the basis of a trading model for gold. The findings were such that a spike of 50% in the European EPUI would drive the gold price from $1300 to $1326, and at the same time the currency effect of this move would be hedged at a 1:1 ratio. Thus, the $26 increase in the gold price would be over and above from any effect specific to European investors resulting from fluctuations in the currency. The final finding of hypothesis 5's model was that the European EPU effect on gold reverts after four months.

The proposed trading strategy, from a European or UK perspective would be as follows:

1. At low EPU levels, hold a long position in gold and an equal short position in USD (the dollar borrow would be collateralised against the gold position). The short in dollars would hedge the investor against a strengthening of their home currency against the dollar, and the resulting lower gold price in the home currency.
2. Following a spike in European EPU beyond a determined level (which the research shows can lead to a corresponding move in the gold price beyond a 95% confidence level), the positions would be reversed to be short gold and long dollars.

3. After four months of the reverse position, the position can be reversed to the default long gold/short dollar. This trade would be on the basis that any move by gold driven by EPU is shown to reverse at the fourth lag, beyond a 95% confidence level.

Further research is required to determine the optimal entry and exit points for this strategy, however this research provides the theoretical basis.

7.3 The performance of this study in light of its motivation

The introduction to this study described a burning platform, being a world that is constantly under threat of a credit-fuelled economic calamity. It proposed that gold's immutability, fungibility, liquidity and scarcity had in the past provided a safe haven in times of economic uncertainty. It also proposed that in the future gold may fulfil a similar position in the universe of investment instruments, and it sought to investigate the contemporary role that gold played as such a safe haven.

Within the research scope, gold was only found to be used as a safe haven against EPU in Europe. Moreover, it was found that these defensive positions were reversed after four months. The US, China and Japan showed no significant use of gold as a safe haven against EPU.

Events of early February 2018 serve to illustrate the apparent lack of importance of gold in the US investment landscape. Gold, US stocks and USD returns are illustrated in *Figure 30*, along with the US EPUI.

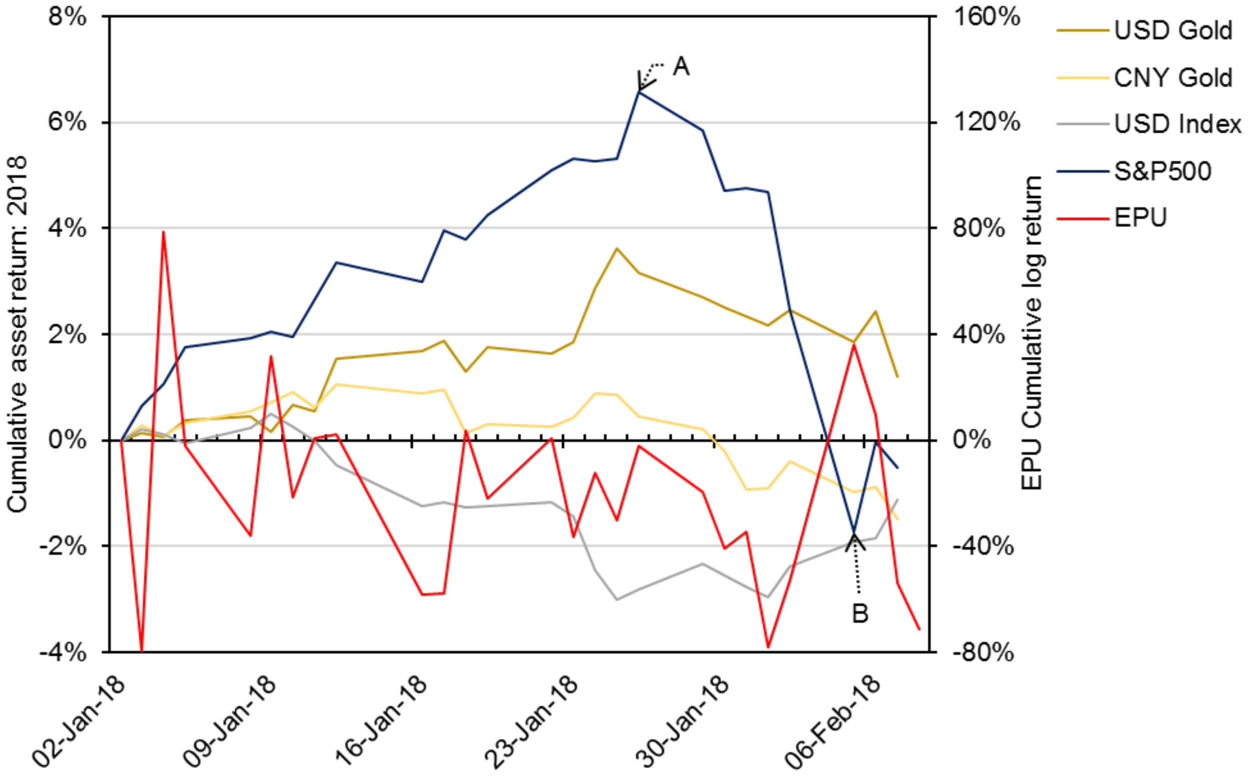


Figure 30 *2018 Asset cumulative returns for stocks, gold and EPU*

Data Source: Asset prices from US Federal Reserve, EPU data from http://www.policyuncertanity.com

On 26 January 2018 US stocks reached their highest ever level with the S&P 500 closing at 2872 points, up 6.57% in 2018 (point A on *Figure 30*). Ten days later a huge selloff saw US stocks down close to 2% for the year (point B on *Figure 30*). Not only did gold fail to react to this selloff, gold continued its decline from the year's high on 25 January 2018. The question then is: Is gold largely ignored by the US investors as a means of buffering themselves against negative trends, whether these occur in stocks (a view which would seems to contradict findings by other studies (C.-S. Liu et al., 2016)), or in the form of monetary and fiscal policy uncertainty.

The study was motivated by putting forward a reason to seek safe haven in gold. It showed that effects that may be a reason to seek safe haven do not result in such behaviour in the US and Japan. The result in China was inconclusive, while the study in Europe shows a link that suggests that such investor behaviour takes place.

7.4 A model for the drivers of the gold price

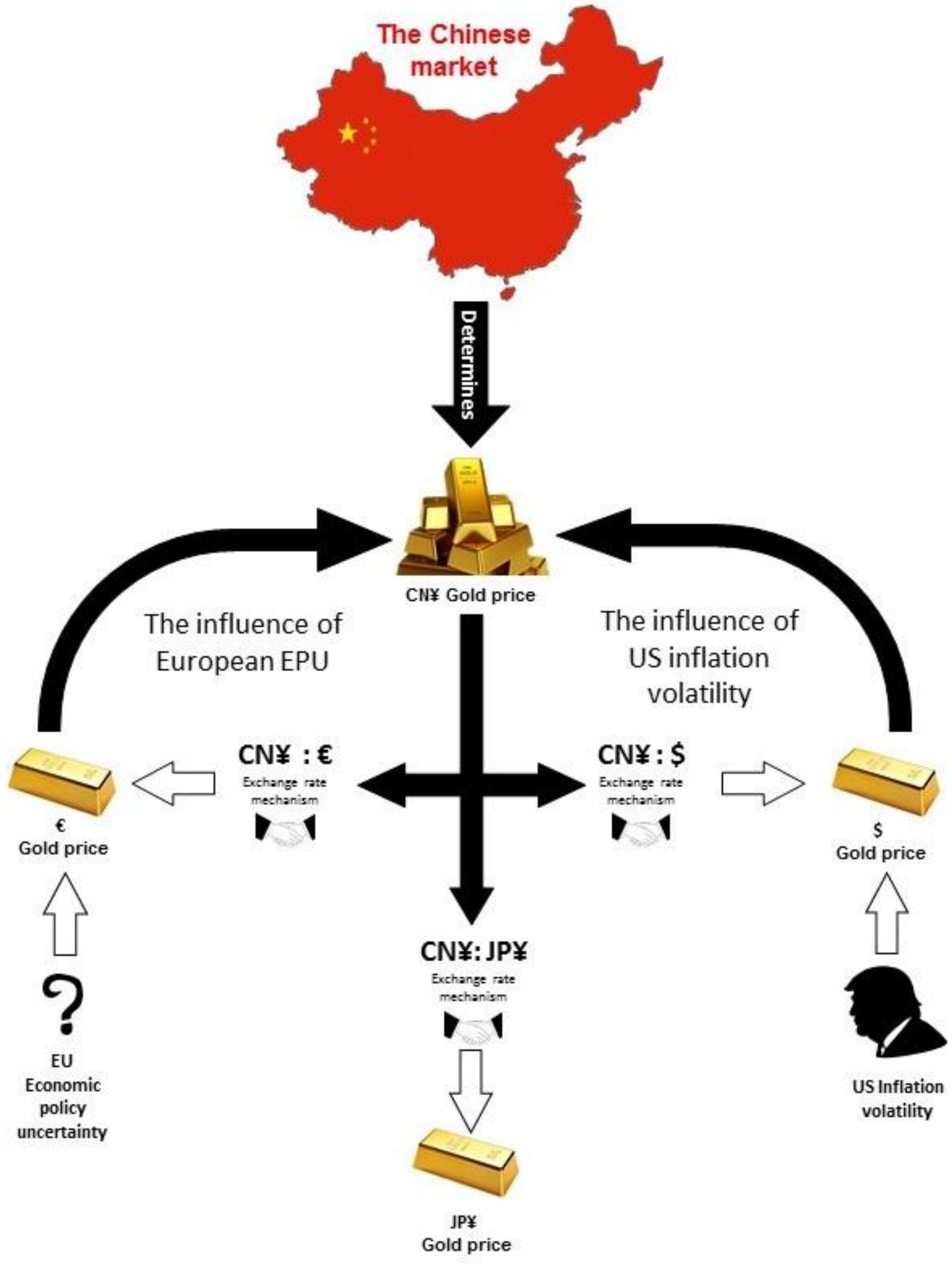


Figure 31 *Model of the gold pricing effects identified through the research*

Source: Own research

The key findings of this research are graphically represented in the model detailed in Figure 31. The model sets China at its centre, and shows that the USD, EUR, and JPY gold prices are a function of the CNY price and the respective exchange rates. Notwithstanding the dominance of China, the CNY gold price experiences weak feedback from European EPU, and US inflation volatility.

7.5 Limitations of the research exposed in the process of conducting the data analysis

The limitations foreseen prior to analysing the research data were enumerated in section 4.10. The following section details limitations which were unforeseen at the time of conceptualising and designing the study, but which became apparent while conducting the data analysis.

7.5.1 Limitations associated with multivariate linear regression, ARIMA and ARIMAX

None of the techniques used in this study are capable of modelling the effect of dynamic variances in the underlying series on the value of the variables. Other tools, including GARCH (Engle, 2002) and Markhov switching (Enders, 2004), may be explored to better understand the interaction between EPU and gold prices in extreme circumstances. Due to the limited time available for this research, these techniques were not explored.

A further technical limitation relates to the existence of cointegration, and the non-stationary nature of the variables in this study. MLR relies on input data being stationary, while ARIMA and ARIMAX models estimated using IBM SPSS v.25's expert modeller account for integration by stationarizing data during the analysis process.

Differencing data to ensure that it is stationary risks removing long term trends in the data, by showing only periodic returns. Future studies should apply techniques that integrate short term volatility with long run trends to build more comprehensive forecasting models for gold.

7.5.2 Lagged variables

Series were differenced using lags that corresponded to the lag scheme used by Jones and Sackley (2016). The opportunity existed to experiment with additional lag schemes and doing so may have developed a richer set of results, not only in terms of explanatory value of the models estimated, but also in terms of deciphering the causal nature of the relationships between variables.

7.5.3 Limitations in the measures of EPU

While the US EPUI is well developed and incorporates over 100 different daily news sources to model EPU in the US, the EPUI for other regions is not as well developed. This is particularly evident in the case of the Chinese EPUI.

The Chinese EPUI is constructed from articles in the South China Morning Post (Economic Policy Uncertainty, 2012a), an English language, Hong Kong based publication. The narrow scope of the index raises a concern that it does not reflect the full range of sentiment surrounding the government's role in the Chinese economy, and this may introduce a perception bias. Chinese language news services would potentially provide a more introspective reflection of the Chinese reality.

One may also question the utility of any broader survey of Chinese language news across mainland China: The Chinese government has a long history of censorship and filtering of opinion to suit their ends (King, Pan, & Roberts, 2013, 2014). An index of Chinese economic policy uncertainty would likely reflect the level of uncertainty the government wishes to espouse, rather than one which actually is the consensus of the Chinese people.

7.5.4 Causal inference was not determinable using the methodology employed

The models estimated in this study were not able to demonstrate causal links in the cases where significant relationships were found. The possibility exists therefore that European EPU and the gold price are spuriously correlated. The same concern exists with regard to the finding of the positive relationship between the gold price and the CNY real exchange rate.

7.6 Future research recommendations

7.6.1 Methodological advances on this research

The MLR and ARIMA modelling approaches used in this study necessitate that data are stationary, which risks removing important long-term trends from the model. Moreover, the models do not correctly account for volatility.

Multivariate generalised autoregressive heteroscedasticity (MGARCH) models are capable of integrating volatility information from multiple time series (Bauwens, Laurent, & Rombouts, 2006), and are less restrictive and easier to implement than vector error correction models (VECM).

With this in mind, VECM's are designed to account for cointegration (Enders, 2004), an effect which was found to be present in the hypothesis 4e MLR model. The adoption of a VECM approach may overcome the challenges of cointegration in the analysis of the effect of European EPU on gold and provide insight into the short and long-term trends. Error correction models are also found to perform better in Granger-causality tests than vector autoregressive models

(Toda & Phillips, 1993), and the VECM approach has been employed more recently in panel analysis to investigate the varying roles of different financial intermediaries behind economic growth (Peia & Roszbach, 2015).

7.6.2 Investigation of time-varying effects

This research considered a period from 1997 until 2016. Apart from confirming the stability of the coefficients for hypothesis 4e, the research did not address time varying effects of EPU on gold. The research sought to address, if overall, gold was used as a safe haven against EPU. Aside from including control variables to model other exogenous effects, it did not address finer variations due to different economic regimes.

The regime-switching approach developed by Hamilton (1989), better known as Markov-switching multifractal, is able to be applied to both MGARCH models (Augustyniak, Boudreault, & Morales, 2018) and vector autoregressive models (Bianchi & Melosi, 2017). Markov-switching has the potential to develop a substantially better forecasting model than that which was developed in hypothesis 5.

7.6.3 Varying lag lengths and trailing moving averages

This research used lags and moving averages which were aligned with Jones and Sackley's (2016) study to maintain comparability to that study. Further research into EPU and gold prices, regardless of whether it employs MGARCH, VECM, or ARIMAX, should vary the lags and periods for calculating moving averages.

7.6.4 The control variable set

The limitations evident at the conceptualisation stage of this study cited the omission of a measure of oil producer risk, and the gold lease, which had previously been included in Jones and Sackley's (2016) study. The oil producing country risk index was calculated by Jones and Sackley (2016) using proprietary country risk indices supplied by the PRS group, which were then weighted by those countries GDP. Future studies should include this measure however it is recommended that the ratings be weighted by the component countries' contribution to global oil supply.

The gold lease rate, being the interest rate charged to those who borrow gold for the purpose of short selling, was discontinued in January of 2015. Given that the cost associated with borrowing commodities directly impacts on the feasibility of short-selling them, future studies should include some measure of the borrowing cost of gold. The inclusion of such a measure may necessitate accessing proprietary data from institutions which are active in gold leasing.

Jones and Sackley (2016) incorporated a measure of corporate distress in their study, and this was based on the spread between US Aaa and Baa rated corporate bond rates. The same US measure was used in the China, Europe and Japan tests for this study. Future research should seek to quantify the market risk premium of corporate distress in each of these regions and include these as control variables.

7.6.5 Gold futures data

Three-month gold futures were used as the dependent variables to test hypotheses 2 and 3. Given that futures contracts are limited in their duration, it is necessary to average all the contemporaneous contracts to derive a single continuous time series. For this study, a continuous time series was obtained from http://www.quandl.com.

Future research may be improved in two ways. First, additional durations of futures contracts should be used to determine which contracts are most closely related to the independent variables. Secondly, future research should calculate the continuous time series for the research, to ensure this is done accurately and using the method that is best suited to the research.

7.6.6 Research in China and other large emerging markets

It was clear not only from the literature study, but from the reports of the World Gold Council and the World Bank, and the findings of this research that China plays a dominant role in the gold market. Another important market not considered in this study is India, where demand driven by gold jewellery matches that of China (Thomson Reuters, 2017).

Researching gold demand trends in China and India is crucial for South Africa's gold mining industry, as well as those seeking to hold gold as a safe haven. Gold demand trends in India and China, which together account for close to half the world's population and both boast a rapidly growing middle class, will be important determinants of gold prices for the foreseeable future. Research should focus on investigating a range of leading indicators of the growth of wealth in those countries.

7.6.7 Consolidating the future research recommendations

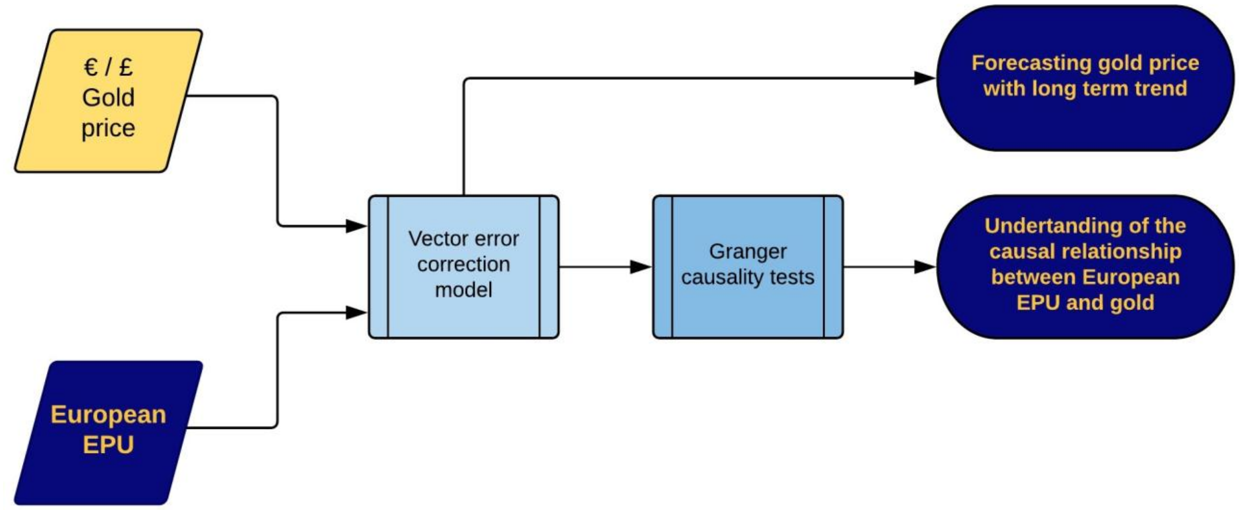


Figure 32 *Suggested research design for furthering the understanding of the role of gold as a safe haven against EPU in Europe*

Source: Own research

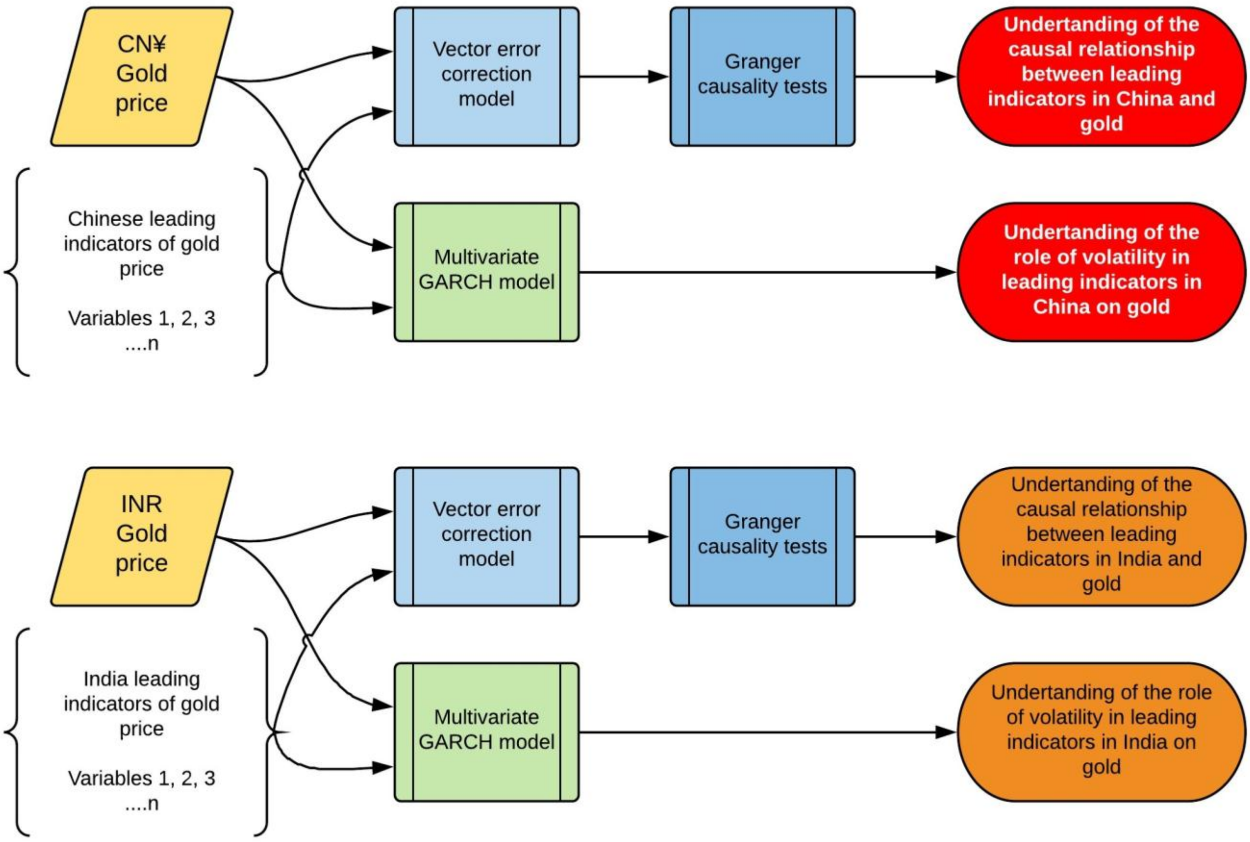


Figure 33 *Suggested research design for furthering the understanding of the effect of macroeconomic factors in India and China on gold*

Source: Own research

This section undertakes to suggest two research designs combining elements of the future research recommendations. The suggested studies are intended to build on this study with methodological contributions to the body of knowledge by using VECM and MGARCH analyses. They also undertake to make theoretical contributions by investigating causal relationships between gold, and EPU and other leading indicators.

Figure 32 suggests a research design for furthering the role of gold as a safe haven against EPU in Europe. Figure 33 suggests a research design to further the understanding of the effect of macroeconomic factors in China and India.

7.7 Conclusion

This study has contributed to the body of knowledge relating to gold's role as a safe haven in the US, Europe, and Japan. Moreover, it has also contributed to the erudition of the Chinese dragon as the main nexus of gold pricing. It is believed that this study will assist investors, both in gold mining operations, and in the financial services sector, to better forecast gold prices using its role as a safe haven in Europe. Finally, this study makes a call to action for future research of the supply and demand dynamics of gold in China. An understanding of the Chinese gold market is essential to expanding the forecasting power of existing models, as well as the academic understanding of gold price determinants.

Does gold still achieve a safe haven status in today's tumultuous geopolitical and economic universe? Only time would tell.

CHAPTER 8 References

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CHAPTER 9 Appendices

9.1 Data sources

Variable type indicates whether metrics were used to derive the main dependent or independent subject metrics of the study, or whether they were control variables identified by Jones and Sackley (2016). Conversion variables are those used to convert metrics which are available in USD to other currencies, and weighting variables are those used to derive weighted average indices.

The variables listed were downloaded and stored in individual Microsoft Excel workbooks.The full list of raw data and their sources are listed in Table 52.

Table 52

Data sources

Metric	Description	Period	Variable Type	Source	Download URL (where applicable)
P_{gold} 001	Gold spot price	Daily	Dependent	World Gold Council	https://www.gold.org/data/gold-price
F_{gold} 002	Gold 3-month NYMEX future price	Daily	Dependent	Quandl	https://www.quandl.com/data/CHRIS/CME_GC3-Gold-Futures-Continuous-Contract-3-GC3
$Rate_{cny}$ 003	USD / CNY exchange rate (1 USD = $Rate_{cny}$ X CNY)	Daily	Conversion	US Federal Reserve	https://fred.stlouisfed.org/series/DEXCHUS
$Rate_{eur}$ 004	USD / EUR exchange rate (1 USD = $Rate_{eur}$ X EUR)	Daily	Conversion	US Federal Reserve	https://fred.stlouisfed.org/series/DEXUSEU
$Rate_{gbp}$ 005	USD / GBP exchange rate	Daily	Conversion	US Federal Reserve	https://fred.stlouisfed.org/series/DEXUSUK
$Rate_{jpy}$ 006	USD / JPY exchange rate	Daily	Conversion	US Federal Reserve	https://fred.stlouisfed.org/series/DEXJPUS
EPU_{us} 007	US Economic policy uncertainty	Daily	Independent	Economic Policy Uncertainty	http://www.policyuncertainty.com/us_daily.html
EPU_{cn} 008	China economic policy uncertainty	Monthly	Independent	Economic Policy Uncertainty	http://www.policyuncertainty.com/china_monthly.html
EPU_{eu} 009	European economic policy uncertainty	Monthly	Independent	Economic Policy Uncertainty	http://www.policyuncertainty.com/europe_monthly.html

Metric	Description	Period	Variable Type	Source	Download URL (where applicable)
EPU_{jp} 011	Japan economic policy uncertainty	Monthly	Independent	Economic Policy Uncertainty	http://www.policyuncertainty.com/japan_monthly.html
Π_{world} 016	World inflation	Monthly	Control	IMF	Kindly provided by IMF staff via email
IDX_{usd} 017	USD Index	Daily	Control	US Federal Reserve	https://fred.stlouisfed.org/series/DTWEXB
IDX_{eur} 019	EUR Index	Daily	Control	European Central Bank	http://www.ecb.europa.eu/stats/balance_of_payments_and_external/eer/html/index.en.html
IDX_{jpy} 020	JPY Index	Monthly	Control	Bank of Japan	https://www.stat-search.boj.or.jp/ssi/cgi-bin/famecgi2?cgi=$graphwnd_en
IDX_{gbp} 021	GBP Index	Daily	Control	Bank of England	http://www.bankofengland.co.uk/boeapps/iadb/index.asp?Travel=NIxIRx&levels=2&XNotes=Y&A3951XNode3951.x=8&A3951XNode3951.y=6&Nodes=&SectionRequired=I&HideNums=-1&ExtraInfo=true#BM
$S\&P500$ 022	S&P500 index	Daily	Control	Chicago Board Options Exchange	https://fred.stlouisfed.org/series/SP500
$BOND_{us}$ 023	US 10 year government bond	Daily	Control	US Federal Reserve	https://fred.stlouisfed.org/series/DGS10
$Bond_{Aaa}$ 025	Yield on Aaa rated US corporate bonds	Daily	Control	US Federal Reserve	https://fred.stlouisfed.org/series/AAA/119
$Bond_{Baa}$ 026	Yield on Baa rated US corporate bonds	Daily	Control	US Federal Reserve	https://fred.stlouisfed.org/series/BAA
GDP_{us} 037	GDP - USA	Annual	Weighting	World Bank	https://data.worldbank.org/indicator/NY.GDP.MKTP.CD
GDP_{ru} 038	GDP - Russia	Annual	Weighting	World Bank	https://data.worldbank.org/indicator/NY.GDP.MKTP.CD
GDP_{sa} 039	GDP – Saudi Arabia	Annual	Weighting	World Bank	https://data.worldbank.org/indicator/NY.GDP.MKTP.CD
GDP_{ir} 040	GDP - Iran	Annual	Weighting	World Bank	https://data.worldbank.org/indicator/NY.GDP.MKTP.CD
GDP_{mx} 041	GDP - Mexico	Annual	Weighting	World Bank	https://data.worldbank.org/indicator/NY.GDP.MKTP.CD

Metric	Description	Period	Variable Type	Source	Download URL (where applicable)
GDP_{vz} 042	GDP - Venezuela	Annual	Weighting	World Bank	https://data.worldbank.org/indicator/NY.GDP.MKTP.CD
GDP_{cn} 043	GDP - China	Annual	Weighting	World Bank	https://data.worldbank.org/indicator/NY.GDP.MKTP.CD
GDP_{no} 044	GDP - Norway	Annual	Weighting	World Bank	https://data.worldbank.org/indicator/NY.GDP.MKTP.CD
GDP_{uk} 045	GDP - UK	Annual	Weighting	World Bank	https://data.worldbank.org/indicator/NY.GDP.MKTP.CD
GDP_{iq} 046	GDP - Iraq	Annual	Weighting	World Bank	https://data.worldbank.org/indicator/NY.GDP.MKTP.CD
GDP_{de} 047	GDP - Germany	Annual	Weighting	World Bank	https://data.worldbank.org/indicator/NY.GDP.MKTP.CD
GDP_{fr} 048	GDP - France	Annual	Weighting	World Bank	https://data.worldbank.org/indicator/NY.GDP.MKTP.CD
GDP_{es} 049	GDP - Spain	Annual	Weighting	World Bank	https://data.worldbank.org/indicator/NY.GDP.MKTP.CD
GDP_{it} 050	GDP - Italy	Annual	Weighting	World Bank	https://data.worldbank.org/indicator/NY.GDP.MKTP.CD
GDP_{jpn} 051	GDP - Japan	Annual	Weighting	World Bank	https://data.worldbank.org/indicator/NY.GDP.MKTP.CD
GDP_{eu} 052	GDP - EU	Annual	Weighting	World Bank	https://data.worldbank.org/indicator/NY.GDP.MKTP.CD
GDP_{world} 053	GDP - World	Annual	Weighting	World Bank	https://data.worldbank.org/indicator/NY.GDP.MKTP.CD
CPI_{us} 055	US CPI-U	Monthly	Control	US Federal Reserve	https://fred.stlouisfed.org/series/CPIAUCSL
CPI_{cn} 056	China CPI	Monthly	Control	US Federal Reserve	https://fred.stlouisfed.org/series/CHNCPIALLMINMEI
CPI_{eu} 057	Euro CPI	Monthly	Control	Eurostat	http://ec.europa.eu/eurostat/web/hicp/data/database
CPI_{jpn} 058	Japan CPI	Monthly	Control	US Federal Reserve	https://fred.stlouisfed.org/series/CPALTT01JPM661S

Metric	Description	Period	Variable Type	Source	Download URL (where applicable)
CPI_{uk} 059	UK CPI	Monthly	Control	US Federal Reserve	https://fred.stlouisfed.org/series/GBRCPIALLMINMEI

Note: at the time of writing the URL's were deemed to be correct. Raw data will be retained by the author for a period of 20 years.
Source: Own research

9.2 Jones and Sackley (2016) descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
$\%\Delta P_{gold}$	0.960	4.138	−11.734	17.366
$\%\Delta(P_g$ / S&P500)	0.849	6.79	−15.16	23.40
$\%\Delta P_{silver}$	1.18	9.22	−28.00	27.19
Δecon policy $uncert_{US}$	5.858	29.789	−55.631	144.396
π_{US}	2.448	1.227	−1.959	5.498
πVol_{US}	0.258	0.157	0.08	0.793
Δdollar index	−0.524	5.301	−11.82	17.366
Gold beta	−0.119	0.135	−0.744	0.095
Δdefault premium	8.795	36.922	−60.229	173.501
Δlease rate	11.438	261.828	−623.627	2683.819
Ecm	1.089	0.543	0.39	2.056
π_{world}	4.041	0.97	1.482	6.99
πVol_{World}	0.234	0.058	0.108	0.485
Δoil country uncert	−0.147	3.962	−27.007	35.961
Δecon policy $uncert_{EU}$	5.4	29.88	−48.526	103.414
N=178				

Figure 34 *Jones and Sackley (2016) descriptive statistics*

Source: Jones and Sackley (2016)

9.3 Procedure for the consolidation of datasets

The two-step process for deriving the two main datasets is illustrated in Figure 35.

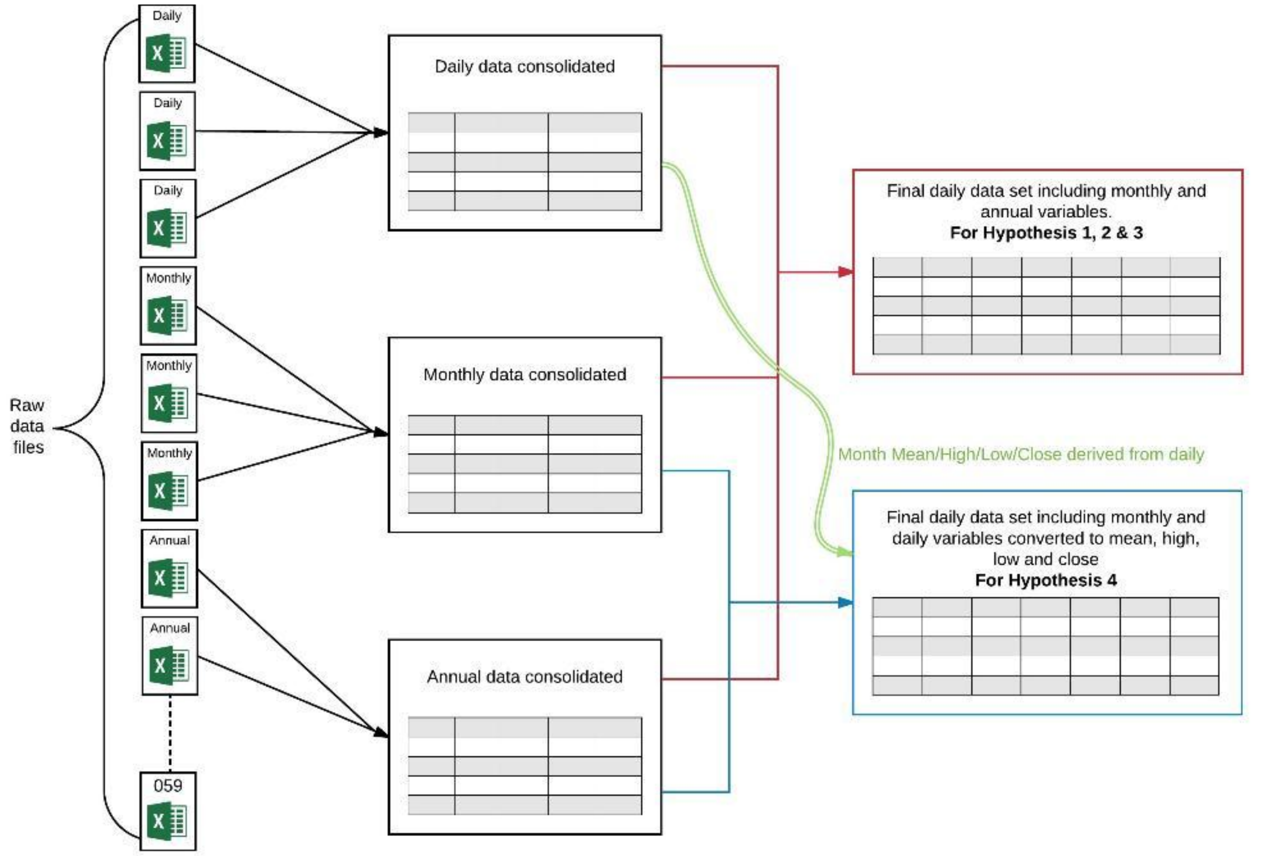

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Figure 35 *Data cleaning and consolidation process diagram*

Source: Own research.

Step 1: Individual datasets were organised into three tables, for daily, monthly and annual data. This was done by listing each period and cross-referencing the data into the table using Microsoft Excel's VLOOKUP function to ensure that each data point corresponded to its correct date. Simply copying the data into the table may have resulted in inconsistencies.

Inflation data were based on monthly CPI but were required in the daily dataset. Lagged moving averages and volatilities were created for inflation data prior to being consolidated into the final tables.

The formula for calculating inflation was as follows:

Equation 45 – Percent Inflation for x *country, in* t *month*

$$\Pi_x = \frac{CPI_{x,t} - CPI_{x,t-12}}{CPI_{x,t-12}} \times 100$$

Inflation and inflation volatility were calculated over a lagged 12 month period (Jones & Sackley, 2016).

Step 2: Daily and monthly tables were generated and once again data were cross-referenced into the tables using VLOOKUP. For the Daily dataset, monthly and annual data points were inserted where daily data were not available.

9.4 Chinese renminbi index weights

Table 53

Chinese renminbi index weights

Code	Currency	Weight	Code	Currency	Weight
AED	UAE dirham	1.87%	MYR	Malaysian ringgit	3.75%
AUD	Australian dollar	4.40%	NOK	Norwegian krona	0.27%
CAD	Canadian dollar	2.15%	NZD	New Zealand dollar	0.44%
CHF	Swiss franc	1.71%	PLN	Polish zloty	0.66%
DKK	Danish krona	0.40%	RUB	Russian ruble	2.63%
EUR	Euro	16.34%	SAR	Saudi riyal	1.99%
GBP	British pound	3.16%	SEK	Swedish krona	0.52%
HKD	Hong Kong dollar	4.28%	SGD	Singapore dollar	3.21%
HUF	Hungarian florint	0.31%	THB	Thai baht	2.91%
JPY	Japanese yen	11.53%	TRY	Turkish lira	0.83%
KRW	Korean won	10.77%	USD	United States dollar	22.40%
MXN	Mexican peso	1.69%	ZAR	South African rand	1.78%

Source: CFETS (2016)

9.5 Alphabetical key to variable names

Table 54

Alphabetical key to variable names: A to G

Variable Code	Variable Description
DefaultPremDly	Default Premium Daily
DefaultPremLRP20d	Default Premium 20 day %Δ
DefaultPremLRP6m	Default Premium 6 month % Log Return
ECMcn	China Spot ECM
ECMcnLRP1m	China Spot ECM 1 Month % Log Return
ECMeu	Europe Spot ECM
ECMeuLRP1m	Europe Spot ECM 1 Month % Log Return
ECMjp	Japan Spot ECM
ECMjpLRP1m	Japan Spot ECM 1 Month % Log Return
ECMusFut	USD Futures ECM
ECMusFutLRP1d	USD Futures ECM 1 day % Log Return
ECMusSpot	USD Spot ECM
ECMusSpotLRP1m	USD Spot ECM 1 month % Log Return
EPUcn	EPU China
EPUcnLRP6m	EPU China - 6 Month % Log Return
EPUeu	EPU EU
EPUeuLRP1m	EPU EU - 1 Month % Log Return
EPUeuLRP6m	EPU EU - 6 Month % Log Return
EPUjp	EPU Japan
EPUjpLRP6m	EPU Japan - 6 Month % Log Return
EPUus	EPU US
EPUusLRP20d	EPU US 20 day % Log Return
EPUusLRP6m	EPU US - 6 Month % Log Return
EPUusVol200d	EPU Volatility 200d
EPUusVol20d	EPU Volatility 20d
EPUusVol60d	EPU Volatility 60d
Fgold	3 Month Gold Futures Price - USD
FgoldLRP1d	3 Month Gold Futures Price - USD - 1 day % Log Return
GoldBeta200d	Gold Beta 200 Day
GoldBetaUS36m	Gold Beta 36m

Source: own research

Table 55

Alphabetical key to variable names: I to Z

Variable Code	Variable Description
IDXcny	CNY Index
IDXcnyLRP6m	CNY Index 6 Month % Log Return
IDXEurGbp	Euro-GBP Combined Index
IDXeurgbpLRP6m	Euro-GBP Combined Index 6 Month % Log Return
IDXjpy	JPY Index
IDXjpyLRP6m	JPY Index 6 Month % Log Return
IDXusd	USD Index
IDXusdLRP20d	USD Index 20 day %Δ
IDXusdLRP6m	USD Index - 6 Month % Log Return
INFLcn12	China Inflation (12 month trailing)
INFLcnVol	China inflation volatility
INFLeuuk12	Combined EU/UK Inflation (12 month trailing)
INFLeuukVol	EU-UK Inflation Volatility
INFLjpn12	Japan Inflation (12 month trailing)
INFLjpnVol	Japan inflation volatility
INFLus12m	US Inflation (12 month trailing)
INFLusVol	US Inflation Volatility
INFLworld	World Inflation
INFLWorldVol	World inflation volatility
Pgold	Gold Price - USD
Pgold_MClose	Gold Price - USD Month Close
PgoldCnyLRP1m	Gold Price - CNY 1 month % Log Return
PgoldCnyMClose	Gold Price - CNY Month Close
PgoldEurGbp	Gold spot price - EURO/GBP Combined Month close
PgoldEurGbpLRP1m	Gold spot price - EURO/GBP Combined 1 month % Log Return
PgoldJpyLRP1m	Gold Price - JPY 1 month % Log Return
PgoldJpyMClose	Gold Price - JPY Month Close
PgoldLRP1d	Gold Price - USD - 1 day % Log Return
PgoldLRP1m	Gold Price - USD - 1 Month % Log Return

Source: own research

9.6 Preliminary descriptive statistics tables

Table 56

Preliminary descriptive statistics: Hypothesis 1 and benchmark data

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Pgold	252	254.80	1813.50	765.8958	476.37064	0.545	0.153	-1.129	0.306
EPUus	252	9.91	626.03	99.2363	72.55955	2.532	0.153	11.741	0.306
IDXusd	252	93.9612	130.0723	110.150343	9.7273136	0.235	0.153	-1.126	0.306
DefaultPremium	252	.5300	3.4300	1.006230	0.4414686	3.041	0.153	12.046	0.306
PgoldLRP1m	251	-19.10	16.00	0.4138	4.89801	-0.099	0.154	1.156	0.306
EPUusLRP6m	246	-241.98	236.98	-0.5944	77.63752	0.011	0.155	0.483	0.309
EPUusVol1m	252	15.1267	199.1509	44.740941	23.0062999	2.299	0.153	9.224	0.306
DefaultPremLRP6m	246	-99.62	90.33	0.5717	28.63315	0.087	0.155	1.146	0.309
ECMusSpot	252	0.380	2.080	1.14575	0.526257	0.146	0.153	-1.468	0.306
GoldBetaUS36m	252	-0.724	1.662	0.10815	0.560186	0.981	0.153	0.525	0.306
IDXusdLRP6m	246	-9.48	14.65	0.5964	4.22282	0.565	0.155	0.790	0.309
INFLus12m	252	-2.097	5.600	2.05468	1.306951	-0.236	0.153	0.239	0.306
INFLusVol	252	0.000	2.752	0.62253	0.488901	2.149	0.153	5.578	0.306
INFLworld	252	1.361	10.403	4.24606	1.446968	1.474	0.153	2.912	0.306
INFLworldVol	252	0.000	1.979	0.43239	0.352751	1.815	0.153	4.255	0.306
EPUeuLRP6m	246	-116.34	121.20	2.4648	37.14927	0.043	0.155	0.485	0.309
Valid N (listwise)	246								

Source: Own research

Table 57

Preliminary descriptive statistics: Hypothesis 2 and 3 raw data

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Fgold	5196	254.20	1891.90	769.8756	476.57358	0.542	0.034	-1.136	0.068
EPUus	5196	3.32	719.07	94.0315	67.21993	2.114	0.034	8.108	0.068
EPUusLRP20d	5176	-383.922	377.546	-0.01886	76.356645	0.074	0.034	1.149	0.068
EPUusVol60d	5148	22.040	7677.975	52.53156	172.023720	41.231	0.034	1740.347	0.068
ECMusSpot	5196	0.369	2.123	1.14353	0.526536	0.154	0.034	-1.467	0.068
ECMusFut	5196	0.377	2.122	1.15230	0.522435	0.148	0.034	-1.465	0.068
GoldBeta200d	5196	-1.653	1.629	0.01894	0.533888	-0.384	0.034	1.808	0.068
IDXusd	5196	93.760	130.240	110.0894	9.63722	0.237	0.034	-1.143	0.068
IDXusdLRP20d	5176	-5.045	10.751	0.10854	1.474885	0.538	0.034	3.043	0.068
INFLus12m	5196	-2.10	5.60	2.0547	1.30870	-0.243	0.034	0.222	0.068
INFLusVol	5196	0.000	2.752	0.62292	0.490105	2.146	0.034	5.479	0.068
INFLworld	5196	1.36	10.40	4.2441	1.44448	1.455	0.034	2.794	0.068
INFLworldVol	5196	0.000	1.979	0.43244	0.353745	1.821	0.034	4.209	0.068
EPUeuLRP1m	5176	-80.817	107.083	0.29858	25.009797	0.269	0.034	1.354	0.068
Valid N (listwise)	5148								

Source: Own research

Table 58

Preliminary descriptive statistics: Hypothesis 4c raw data

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
PgoldCnyMClose	264	0.0000	11566.1403	5341.7357	2841.9158	0.356	0.150	-1.137	0.299
PgoldCnyLRP1m	259	-18.3800	16.0100	0.3625	4.8093	-0.108	0.151	1.202	0.302
EPUcn	261	9.0667	694.8494	133.3363	104.5365	2.258	0.151	6.782	0.300
IDXcny	225	55.1162	103.8013	83.6786	13.2584	-0.462	0.162	-1.019	0.323
INFLcn12	248	-2.1898	8.8009	1.9239	2.2242	0.633	0.155	0.343	0.308
INFLcnVol	236	0.3132	3.5459	0.9577	0.6123	1.786	0.158	4.190	0.316
IDXcnyLRP6m	219	-17.9500	11.6300	-1.0787	5.1927	-0.751	0.164	1.268	0.327
EPUcnLRP6m	255	-204.5600	263.2200	3.1517	69.4647	0.224	0.153	0.630	0.304
ECMcnLRP1m	259	-4.5100	4.1100	0.0494	1.1759	-0.087	0.151	0.991	0.302
Valid N (listwise)	211								

Source: Own research

Table 59

Preliminary descriptive statistics: Hypothesis 4e raw data

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	Kurtosis		N
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error		Statistic
PgoldEurGbpLRP1m	214	-15.86	15.02	0.6894	4.85790	0.112	0.166	0.622	0.331
EPUeu	261	47.6923	433.2775	136.591339	63.3660020	1.457	0.151	3.335	0.300
EPUeuLRP6m	255	-116.34	121.20	1.5805	37.16545	0.056	0.153	0.450	0.304
PgoldEurGBP	216	0.0000	1574.0137	755.609132	415.3952563	0.373	0.166	-1.365	0.330
IDXeurgbp	252	87.62	109.11	98.76	5.11	-0.054	0.153	-0.901	0.306
IDXeurgbpLRP6m	246	-9.67	7.74	-0.2247	3.00348	-0.409	0.155	-0.004	0.309
INFLeuuk12	240	-0.4240	4.1324	1.723871	0.8868531	-0.150	0.157	0.092	0.313
INFLeuukVol	228	0.0972	1.5035	0.340644	0.2498107	2.484	0.161	7.018	0.321
ECMeuLRP1m	214	-2.85	2.85	0.1022	0.77312	-0.084	0.166	1.021	0.331
Valid N (listwise)	211								

Source: Own research

Table 60

Preliminary descriptive statistics: Hypothesis 4j raw data

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	Kurtosis		N
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error		Statistic
PgoldJpyMClose	264	0.0000	151958.3800	78685.320430	43112.2683200	0.251	0.150	-1.485	0.299
PgoldJpyLRP1m	259	-26.60	13.70	0.4640	4.90158	-0.947	0.151	4.151	0.302
EPUjp	263	0.0000	237.3135	108.586056	37.2936175	1.166	0.150	1.879	0.299
EPUjpLRP6m	256	-68.75	97.96	0.0320	30.73443	0.521	0.152	0.507	0.303
IDXjpy	261	67.8600	130.9800	97.645249	15.2010917	-0.129	0.151	-0.776	0.300
IDXjpyLRP6m	255	-23.05	26.57	-0.9937	7.44131	0.484	0.153	1.846	0.304
INFLjpn12	248	-2.5151	3.7386	.123193	1.0833148	1.034	0.155	1.495	0.308
INFLjpnVol	248	0.1495	1.4834	.519334	0.3030397	1.132	0.155	0.371	0.308
ECMjpLRP1m	259	-3.97	2.37	0.0682	0.76150	-0.896	0.151	3.840	0.302
Valid N (listwise)	211								

Source: Own research

9.7 Detailed results of pre-estimation data quality tests

9.7.1 Hypothesis 1 and Benchmarking data

9.7.1.1 Hypothesis 1 and Benchmarking data: Tests for Normality

Table 62

Normality test: Hypothesis 1 and Benchmarking data

	Shapiro-Wilk			
	Statistic	df	Sig.	Conclusion
PgoldLRP1m	0.989	234	.059	Normal
EPUusLRP6m	0.996	234	.861	Normal
IDXusdLRP6m	0.974	234	.000	Non-normal
GoldBetaUS36m	0.899	234	.000	Non-normal
DefaultPremLRP6m	0.982	234	.004	Non-normal
INFLus12m	0.984	234	.008	Non-normal
INFLusVol	0.752	234	.000	Non-normal
INFLworld	0.951	234	.000	Non-normal
INFLworldVol	0.790	234	.000	Non-normal
ECMusSpot	0.901	234	.000	Non-normal
EPUeuLRP6m	0.994	234	.518	Normal

Source: Own research

The dependent and main independent variables are found to be normally distributed.

9.7.1.2 Hypothesis 1 and Benchmarking data: Tests for stationarity – 1st iteration

Stationarity test for PgoldLRP1m

Table 63

Stationarity test: Hypothesis 1 and Benchmark data, PgoldLRP1m

Dickey-Fuller test (ADF (stationary) / k: 6 / PgoldLRP1m):	
Tau (Observed value)	-5.114
Tau (Critical value)	-3.408
p-value (one-tailed)	.000
alpha	.05

KPSS test (Level / Lag Short / PgoldLRP1m):	
Eta (Observed value)	0.299
Eta (Critical value)	0.457
p-value (one-tailed)	.141
alpha	.05

Source: Own research

For variable PgoldLRP1m, the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for EPUusLRP6m

Table 64

Stationarity test: Hypothesis 1 and Benchmark data, EPUusLRP6m

Dickey-Fuller test (ADF (stationary) / k: 6 / EPUusLRP6m):	
Tau (Observed value)	-7.468
Tau (Critical value)	-3.408
p-value (one-tailed)	< .0001
alpha	.05

KPSS test (Level / Lag Short / EPUusLRP6m):	
Eta (Observed value)	0.034
Eta (Critical value)	0.457
p-value (one-tailed)	.972
alpha	.05

Source: Own research

For variable EPUusLRP6m, the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for IDXusdLRP6m

Table 65

Stationarity test: Hypothesis 1 and Benchmark data, IDXusdLRP6m

Dickey-Fuller test (ADF (stationary) / k: 6 / IDXusdLRP6m):	
Tau (Observed value)	-3.706
Tau (Critical value)	-3.408
p-value (one-tailed)	.021
alpha	.05

KPSS test (Level / Lag Short / IDXusdLRP6m):	
Eta (Observed value)	0.397
Eta (Critical value)	0.457
p-value (one-tailed)	.074
alpha	.05

Source: Own research

For variable EPUusLRP6m, the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for GoldBetaUS36m

Table 66

Stationarity test: Hypothesis 1 and Benchmark data, GoldBetaUS36m

Dickey-Fuller test (ADF (stationary) / k: 6 / GoldBetaUS36m):	
Tau (Observed value)	-3.417
Tau (Critical value)	-3.408
p-value (one-tailed)	.049
alpha	.05

KPSS test (Level / Lag Short / GoldBetaUS36m):	
Eta (Observed value)	0.502
Eta (Critical value)	0.457
p-value (one-tailed)	.037
alpha	.05

Source: Own research

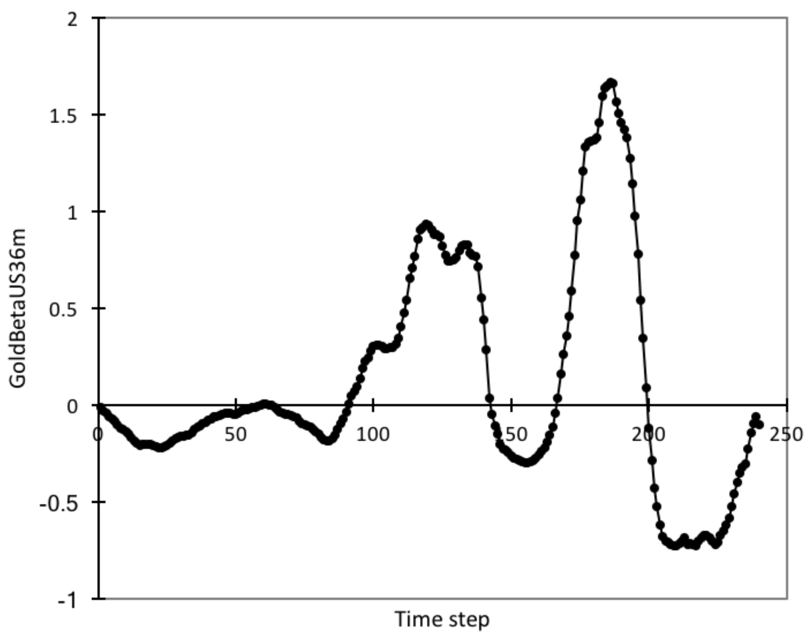


Figure 36 *Data plot indicating stationarity: GoldBeta36m*

Source: Own research

For variable GoldBetaUS36m, the KPSS test indicated that the data were non-stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for DefaultPremLRP6m

Table 67

Stationarity test: Hypothesis 1 and Benchmark data, DefaultPremLRP6m

Dickey-Fuller test (ADF (stationary) / k: 6 /DefaultPremLRP6m):	
Tau (Observed value)	-3.752
Tau (Critical value)	-3.408
p-value (one-tailed)	.018
alpha	.05

KPSS test (Level / Lag Short / DefaultPremLRP6m):	
Eta (Observed value)	0.075
Eta (Critical value)	0.457
p-value (one-tailed)	.738
alpha	.05

Source: Own research

For variable DefaultPremLRP6m, the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for INFLus12m

Table 68

Stationarity test: Benchmark data, INFLus12m

Dickey-Fuller test (ADF (stationary) / k: 6 / INFLus12m):	
Tau (Observed value)	-4.206
Tau (Critical value)	-3.408
p-value (one-tailed)	.005
alpha	.05

KPSS test (Level / Lag Short / INFLus12m):	
Eta (Observed value)	0.912
Eta (Critical value)	0.457
p-value (one-tailed)	.003
alpha	.05

Source: Own research

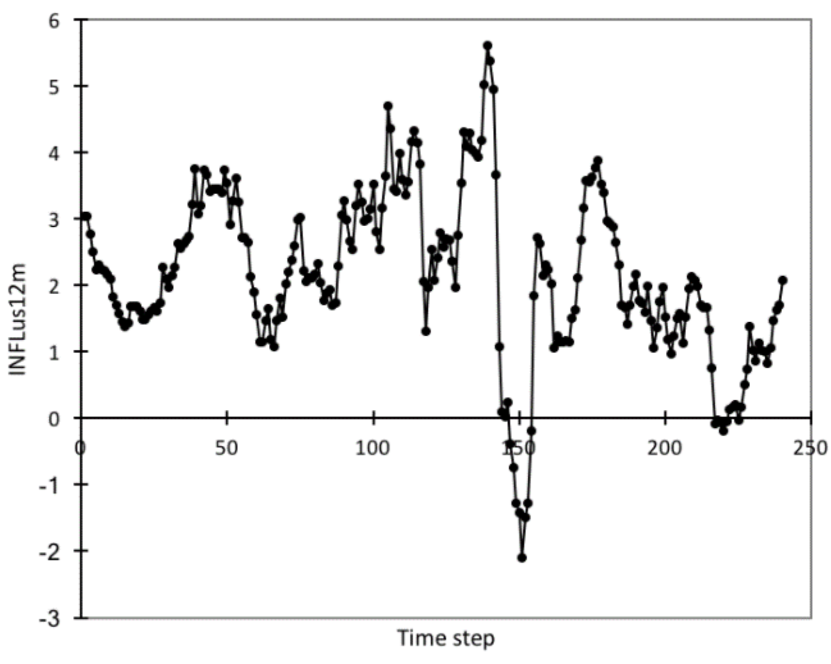


Figure 37 *Data plot indicating stationarity: INFLus12m*

Source: Own research

For variable INFLus12m, the KPSS test indicated that the data were non-stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for INFLusVol

Table 69

Stationarity test: Hypothesis 1 and Benchmark data, INFLusVol

Dickey-Fuller test (ADF (stationary) / k: 6 / INFLusVol):	
Tau (Observed value)	-2.360
Tau (Critical value)	-3.408
p-value (one-tailed)	.388
alpha	.05

KPSS test (Level / Lag Short / INFLusVol):	
Eta (Observed value)	1.077
Eta (Critical value)	0.457
p-value (one-tailed)	.001
alpha	.05

Source: Own research

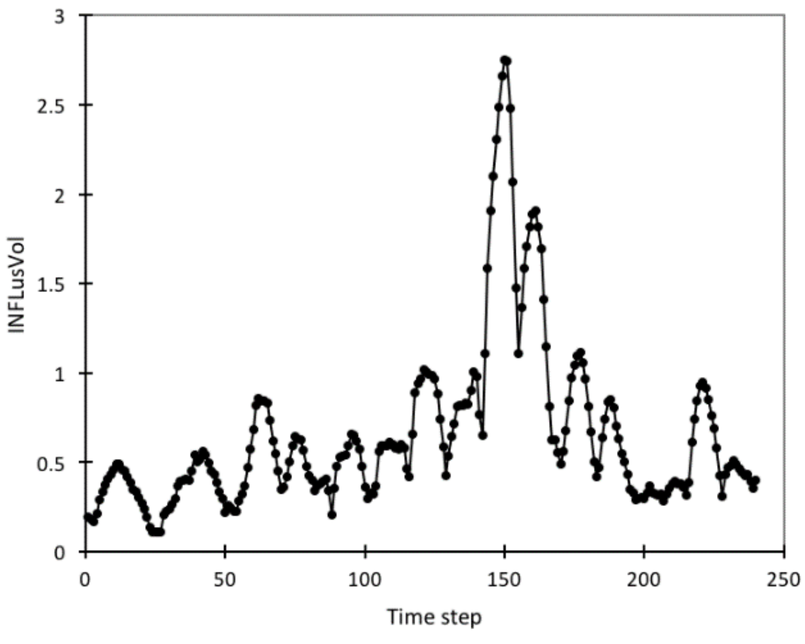


Figure 38 *Data plot indicating stationarity: INFLusVol*

Source: Own research

For variable INFLusVol, the KPSS test indicated is that the data were non-stationary, and the ADF test indicated that the data contained a unit root. Following visual inspection of the plot in Figure 38, the data were observed to be stationary. The conclusion was that the data were stationary.

Stationarity test for ECMusSpot

Table 70

Stationarity test: Hypothesis 1 and Benchmark data, ECMusSpot

Dickey-Fuller test (ADF (stationary) / k: 6 / ECMusSpot):	
Tau (Observed value)	-1.382
Tau (Critical value)	-3.408
p-value (one-tailed)	.851
alpha	.05

KPSS test (Level / Lag Short / ECMusSpot):	
Eta (Observed value)	5.490
Eta (Critical value)	0.457
p-value (one-tailed)	< .0001
alpha	.05

Source: Own research

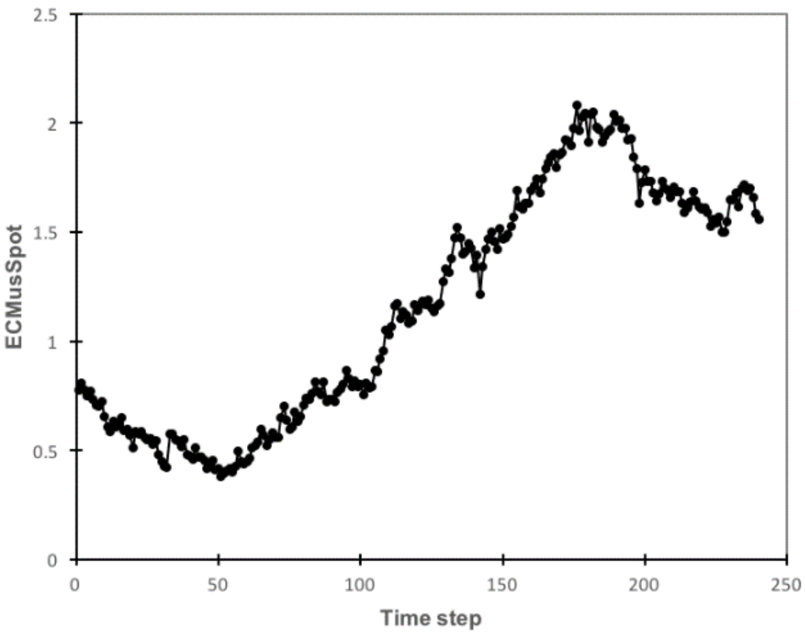


Figure 39 *Data plot indicating non-stationarity: ECMusSpot*

Source: Own research

For variable ECMusSpot, the KPSS test indicates is that the data were non-stationary, and the ADF test indicated that the data contained a unit root. Following the test results and the inspection of the data plot, the conclusion was that the data were non-stationary. It was decided to convert the data to a log return.

Stationarity test for EPUeuLRP6m

Table 71

Stationarity test: Hypothesis 1 ***and*** *Benchmark data, EPUeuLRP6m*

Dickey-Fuller test (ADF (stationary) / k: 6 / EPUeuLRP6m):	
Tau (Observed value)	-5.909
Tau (Critical value)	-3.408
p-value (one-tailed)	< .0001
alpha	.05

KPSS test (Level / Lag Short / EPUeuLRP6m):	
Eta (Observed value)	0.075
Eta (Critical value)	0.457
p-value (one-tailed)	.740
alpha	.05

Source: Own research

For the variable EPUeuLRP6m the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for INFLworld

Table 72

Stationarity test: Hypothesis 1 and Benchmark data, INFLworld

Dickey-Fuller test (ADF (stationary) / k: 6 / INFLworld):	
Tau (Observed value)	-4.304
Tau (Critical value)	-3.408
p-value (one-tailed)	.003
alpha	.05

KPSS test (Level / Lag Short / INFLworld):	
Eta (Observed value)	1.972
Eta (Critical value)	0.457
p-value (one-tailed)	< .0001
alpha	.05

Source: Own research

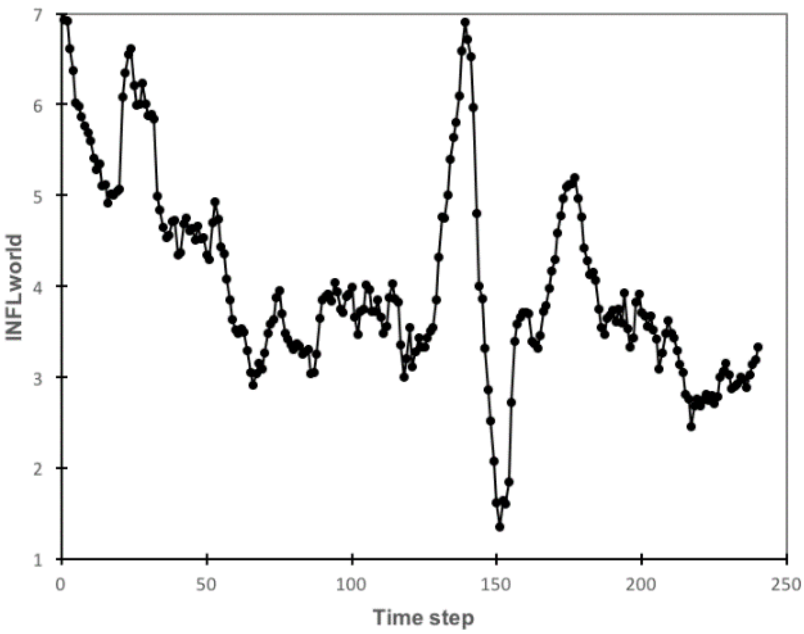


Figure 40 *Data plot indicating stationarity: INFLWorld*

Source: Own research

For the variable INFLworld, the KPSS test indicated that the data were non-stationary however the ADF test did not indicate the existence of a unit root. Following inspection of the data plot, it was concluded that the data were stationary.

Stationarity test for INFLworldVol

Table 73

Stationarity test: Hypothesis 1 and Benchmark data, INFLworldVol

Dickey-Fuller test (ADF (stationary) / k: 6 / INFLworldVol):	
Tau (Observed value)	-2.148
Tau (Critical value)	-3.408
p-value (one-tailed)	.506
alpha	.05

KPSS test (Level / Lag Short / INFLworldVol):	
Eta (Observed value)	0.421
Eta (Critical value)	0.457
p-value (one-tailed)	.064
alpha	.05

Source: Own research

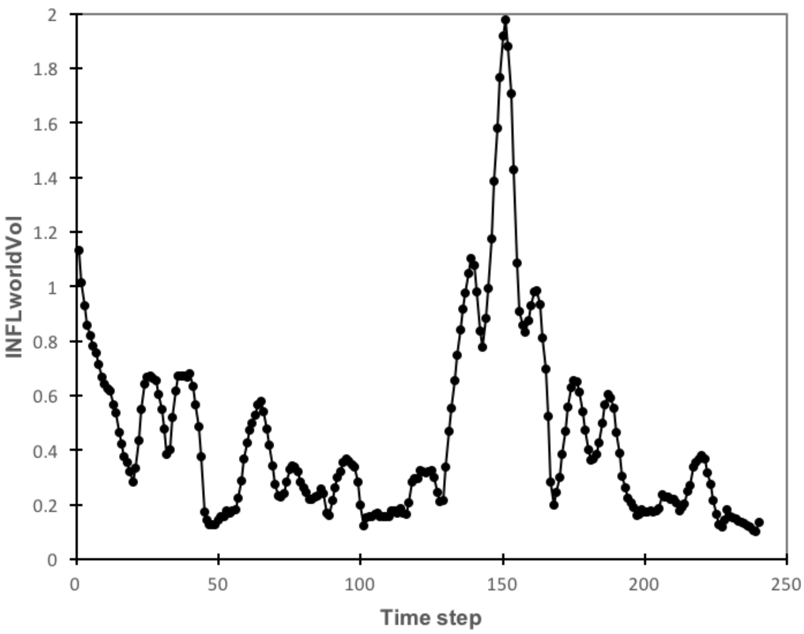


Figure 41 *Data plot indicating stationarity: INFLworldVol*

Source: Own research

For the variable INFLworldVol, the KPSS test indicated that the data were stationary however the ADF test indicated the existence of a unit root. Following inspection of the data plot, it was concluded that the data were stationary.

9.7.1.3 <u>Hypothesis 1 and Benchmarking data: Tests for stationarity – 2nd iteration</u>

Stationarity test for ECMusSpotLRP1m

Table 74

Stationarity test: Hypothesis 1 and Benchmark data, ECMusSpotLRP1m

Dickey-Fuller test (ADF (stationary) / k: 6 / ECMusSpotLRP1m):	
Tau (Observed value)	-6.026
Tau (Critical value)	-3.408
p-value (one-tailed)	< .0001
alpha	.05

KPSS test (Level / Lag Short / ECMusSpotLRP1m):	
Eta (Observed value)	0.291
Eta (Critical value)	0.457
p-value (one-tailed)	.148
alpha	.05

Source: Own research

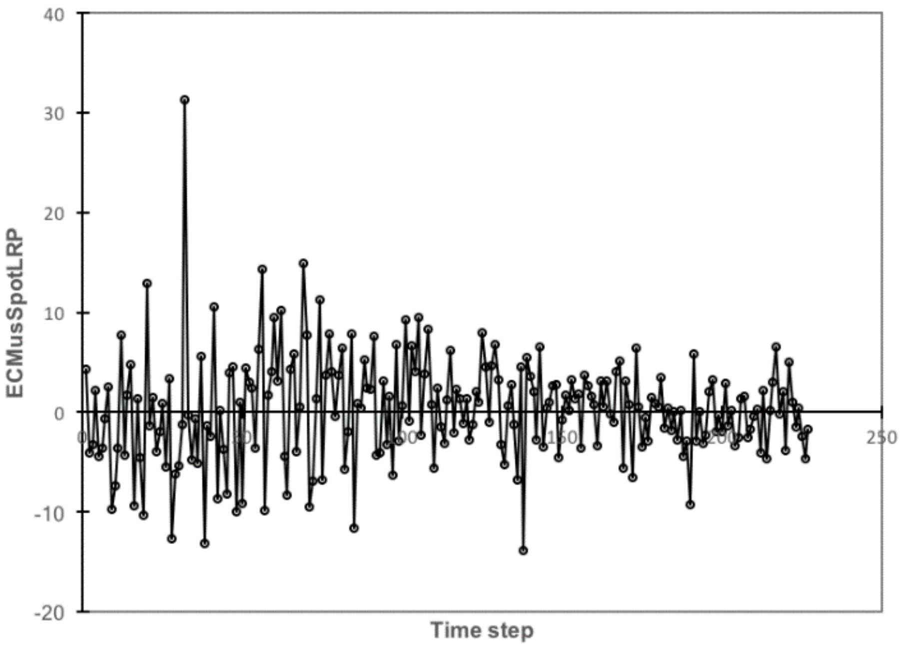


Figure 42 *Data plot indicating stationarity: ECMusSpotLRP1m*

Source: Own research

For the variable ECMusSpotLRP1m the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

9.7.1.4 <u>Hypothesis 1 and Benchmarking data: Tests for multicollinearity</u>

Table 75

Covariance matrix: Hypothesis 1 and Benchmark data

		EPUeu LRP6m	INFLusVol	GoldBeta US36m	ECMusSpot LRP1m	DefaultPrem LRP6m	EPUus LRP6m	INFLworld	INFLus12m	IDXusd LRP6m	INFLworld Vol
Correlations	EPUeuLRP6m	1.00000	-.07942	.03899	-.04859	-.06363	-.37634	-.02240	-.08717	-.07020	.06362
	INFLusVol	-.07942	1.00000	-.27464	-.08026	-.18870	-.05106	.66793	.13307	.02981	-.85300
	GoldBetaUS36m	.03899	-.27464	1.00000	.03336	-.08430	-.03520	-.18810	-.36686	.21810	.20098
	ECMusSpotLRP1m	-.04859	-.08026	.03336	1.00000	-.12497	-.00329	.03732	.00302	.16368	.07508
	DefaultPremLRP6m	-.06363	-.18870	-.08430	-.12497	1.00000	-.03690	-.21880	-.12020	-.51690	.18239
	EPUusLRP6m	-.37634	-.05106	-.03520	-.00329	-.03690	1.00000	-.01535	-.07492	-.10063	.04946
	INFLworld	-.02240	.66793	-.18810	.03732	-.21880	-.01535	1.00000	-.17934	-.07353	-.61561
	INFLus12m	-.08717	.13307	-.36686	.00302	-.12020	-.07492	-.17934	1.00000	.22067	-.00052
	IDXusdLRP6m	-.07020	.02981	.21810	.16368	-.51690	-.10063	-.07353	.22067	1.00000	.00420
	INFLworldVol	.06362	-.85300	.20098	.07508	.18239	.04946	-.61561	-.00052	.00420	1.00000
Covariances	EPUeuLRP6m	.00002	-.00025	.00006	-.00001	.00000	.00000	-.00002	-.00006	-.00001	.00024
	INFLusVol	-.00025	.47131	-.05980	-.00162	-.00086	-.00008	.08623	.01351	.00095	-.49592
	GoldBetaUS36m	.00006	-.05980	.10059	.00031	-.00018	-.00002	-.01122	-.01721	.00319	.05398
	ECMusSpotLRP1m	-.00001	-.00162	.00031	.00086	-.00002	.00000	.00021	.00001	.00022	.00187
	DefaultPremLRP6m	.00000	-.00086	-.00018	-.00002	.00004	.00000	-.00027	-.00012	-.00016	.00103
	EPUusLRP6m	.00000	-.00008	-.00002	.00000	.00000	.00000	-.00001	-.00002	-.00001	.00009
	INFLworld	-.00002	.08623	-.01122	.00021	-.00027	-.00001	.03536	-.00499	-.00064	-.09803
	INFLus12m	-.00006	.01351	-.01721	.00001	-.00012	-.00002	-.00499	.02187	.00151	-.00006
	IDXusdLRP6m	-.00001	.00095	.00319	.00022	-.00016	-.00001	-.00064	.00151	.00213	.00016
	INFLworldVol	.00024	-.49592	.05398	.00187	.00103	.00009	-.09803	-.00006	.00016	.71718

a. Dependent Variable: PgoldLRP1m

Source: Own research

Table 76

Pairwise regression result - INFLworld : INFLusVol

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.457[a]	.209	.206	.435713

a. Predictors: (Constant), INFLworld

b. Dependent Variable: INFLusVol

Source: Own research

Table 77

Pairwise regression result - INFLworldVol : INFLusVol

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.760[a]	.578	.576	.318389

a. Predictors: (Constant), INFLworldVol

b. Dependent Variable: INFLusVol

Source: Own research

Table 78

Pairwise regression result - IDXusdLRP6m : DefaultPremLRP6m

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.514[a]	.265	.262	3.62859

a. Predictors: (Constant), DefaultPremLRP6m

b. Dependent Variable: IDXusdLRP6m

Source: Own research

Table 79

Pairwise regression result - INFLworldVol : INFLworld

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.089[a]	.008	.004	.352063

a. Predictors: (Constant), INFLworld

b. Dependent Variable: INFLworldVol

Source: Own research

9.7.1.5 *Hypothesis 1 and Benchmarking data:* ACF's for seasonality inspection

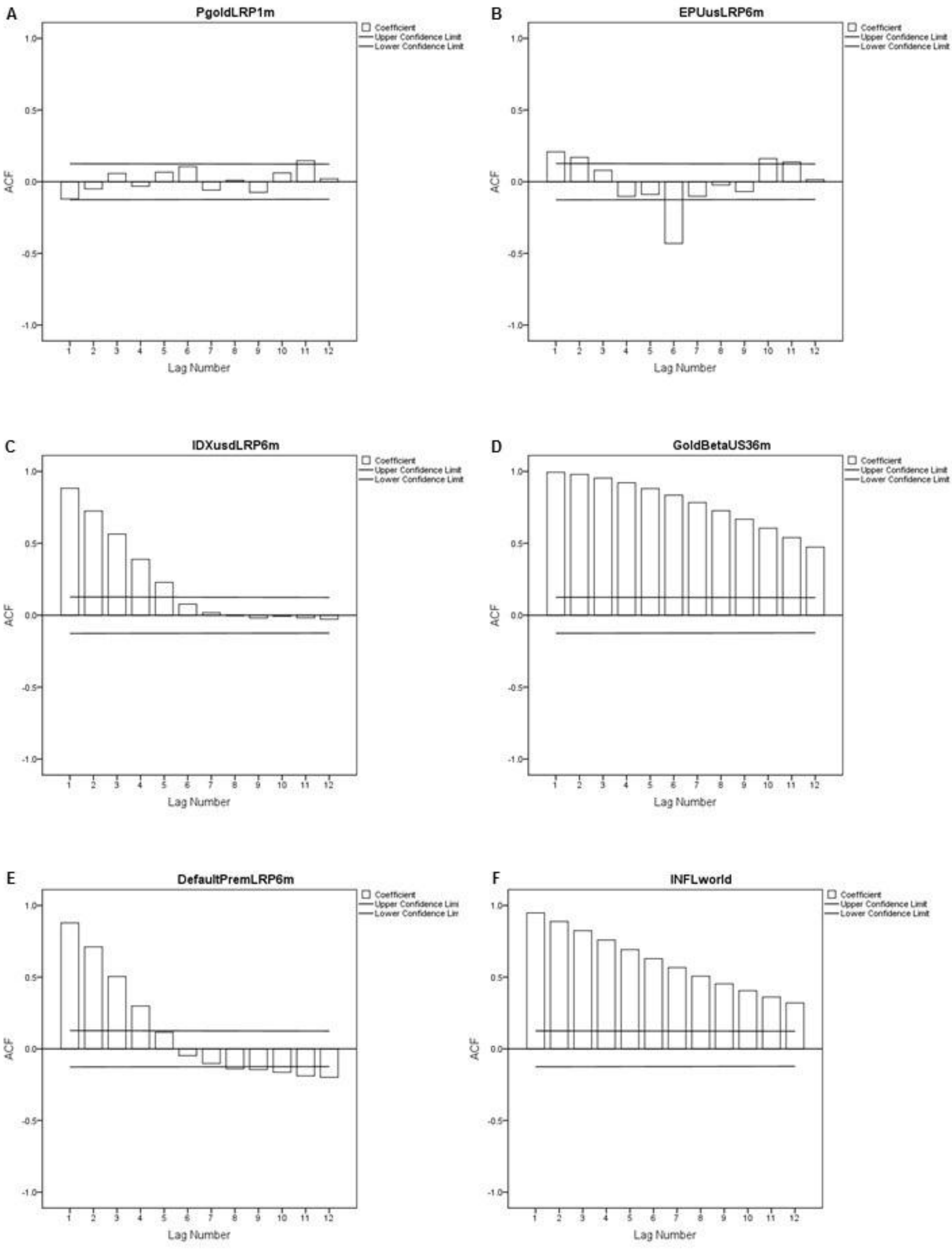


Figure 43 *Hypothesis 1 and Benchmark data: Seasonality ACF plots part 1*

Source: own research

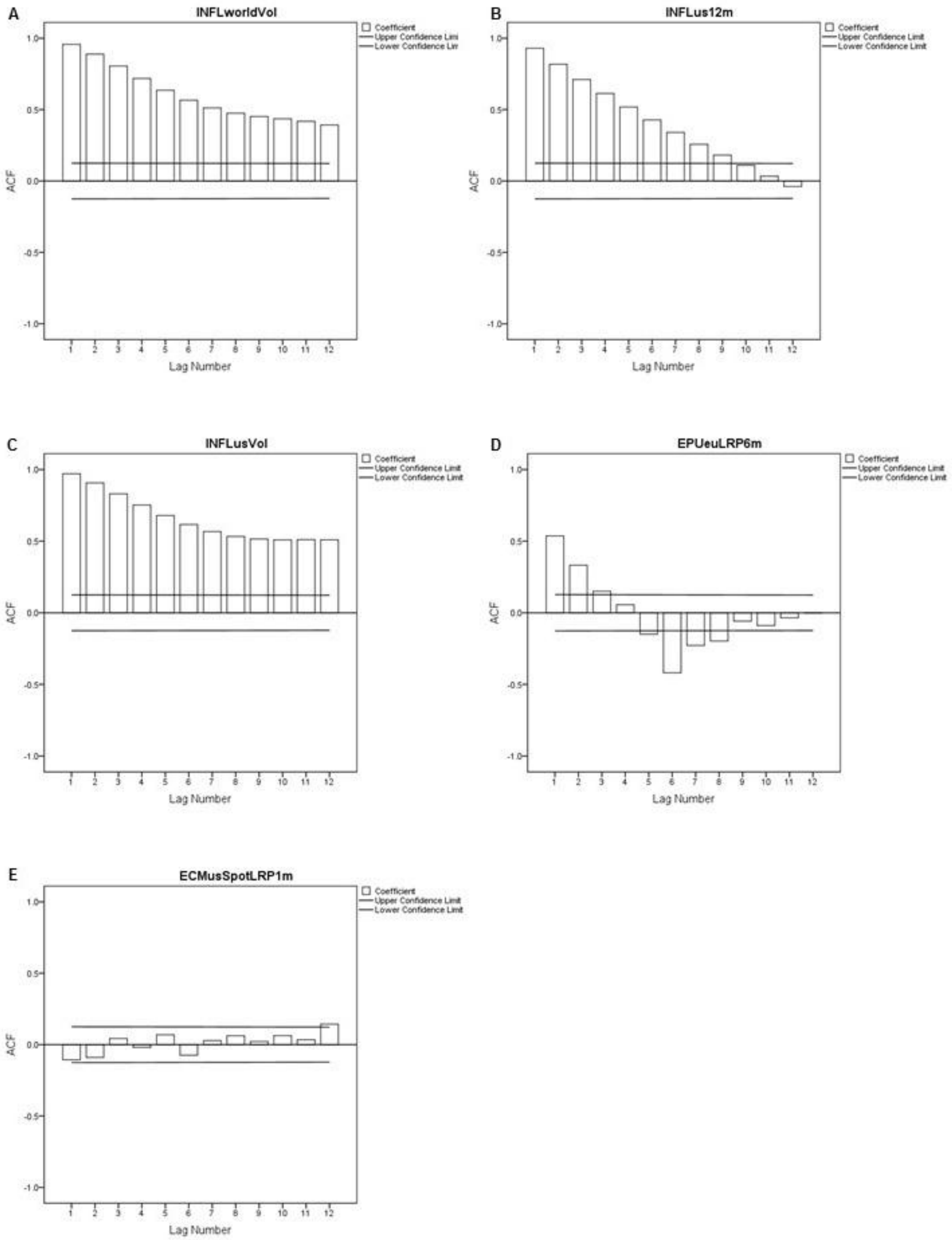
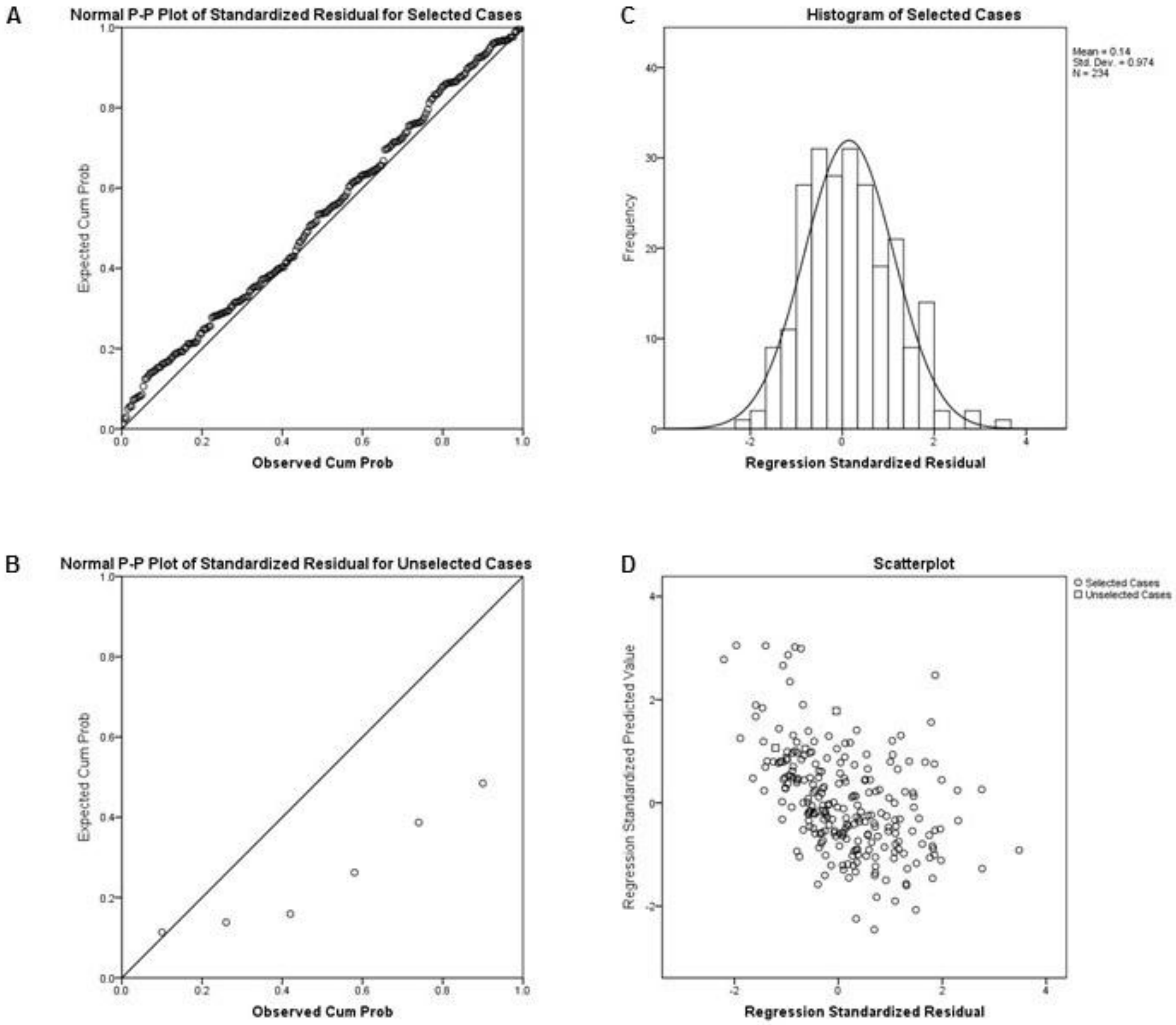


Figure 44 *Hypothesis 1 and Benchmark data: Seasonality ACF plots part 2*

Source: own research

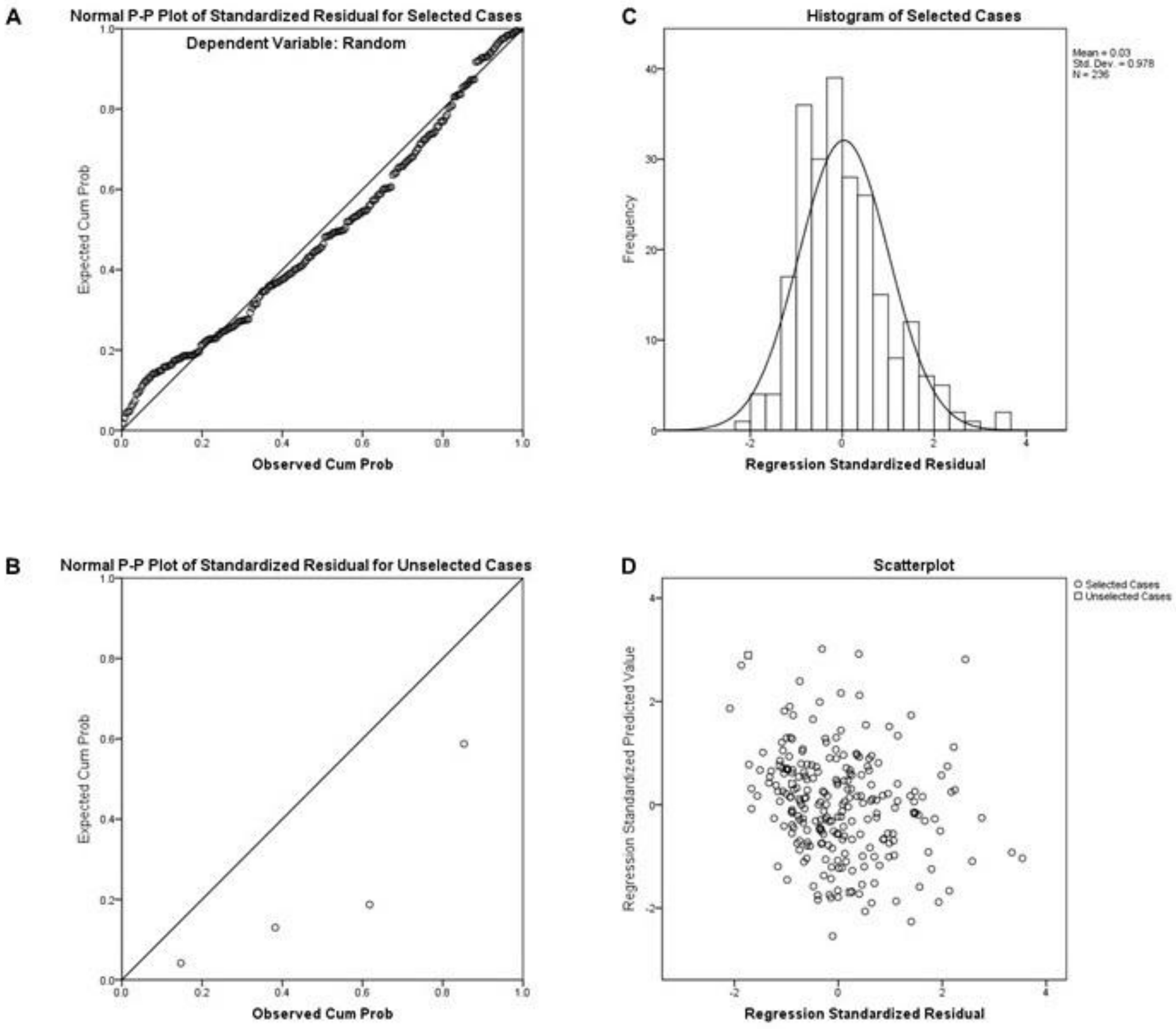
9.7.1.6 Benchmarking data: Test for outliers



Panel A shows the P-P plot of the retained cases; Panel B shows the P-P plot of the removed cases; Panel C shows the histogram of retained cases; Panel D shows the scatterplot, with retained cases marked as o and removed cases marked as ☐

Figure 45 *Benchmark data - Domestic: Plots following Mahalanobis test*

Source: own research

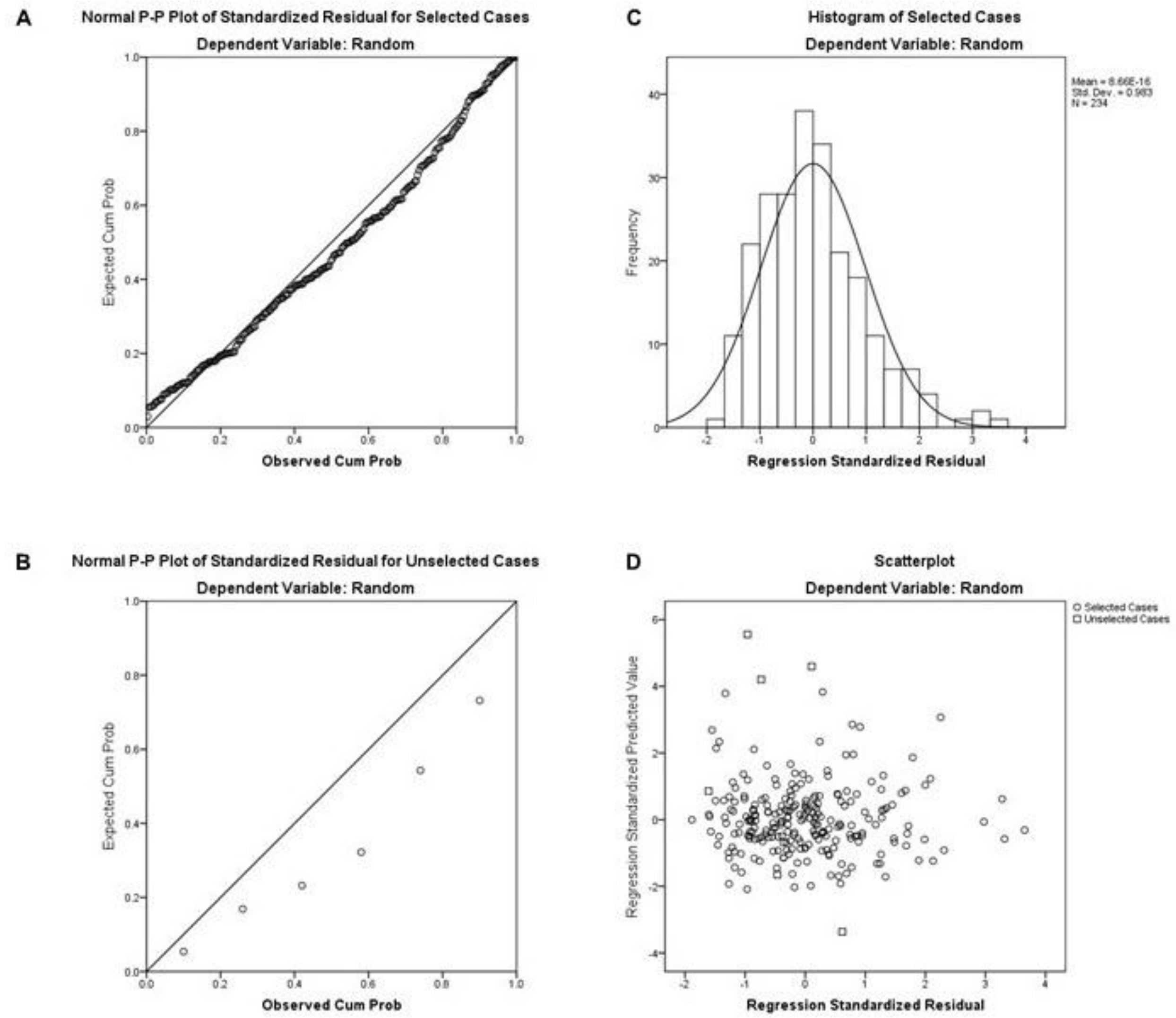


Panel A shows the P-P plot of the retained cases; Panel B shows the P-P plot of the removed cases; Panel C shows the histogram of retained cases; Panel D shows the scatterplot, with retained cases marked as o and removed cases marked as □

Figure 46 *Benchmark data - International: Plots following Mahalanobis test*

Source: own research

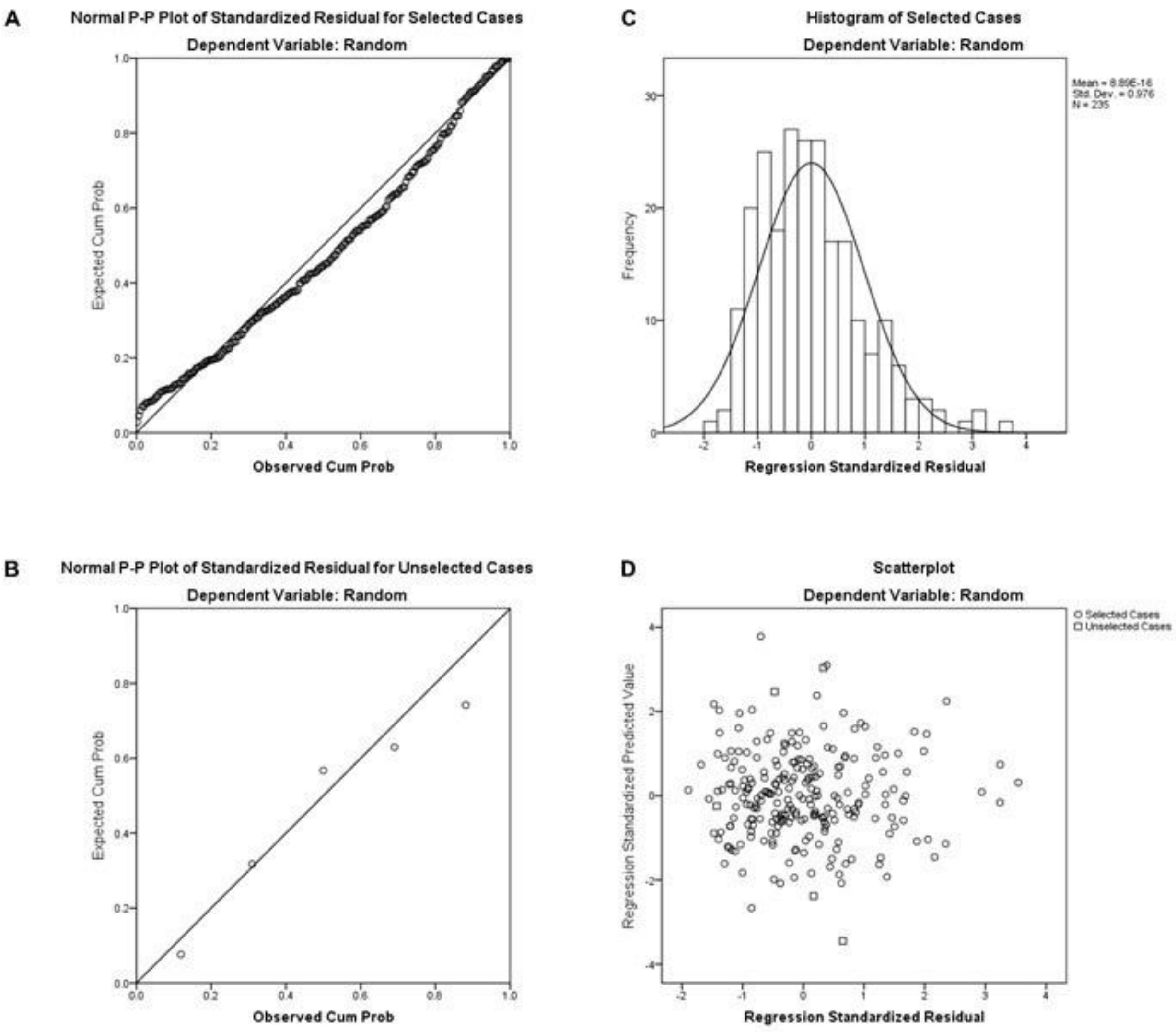
9.7.1.7 <u>Hypothesis 1 data: Test for outliers</u>



Panel A shows the P-P plot of the retained cases; Panel B shows the P-P plot of the removed cases; Panel C shows the histogram of retained cases; Panel D shows the scatterplot, with retained cases marked as o and removed cases marked as ☐

Figure 47 *Hypothesis 1d data: Plots following Mahalanobis test*

Source: own research



Panel A shows the P-P plot of the retained cases; Panel B shows the P-P plot of the removed cases; Panel C shows the histogram of retained cases; Panel D shows the scatterplot, with retained cases marked as o and removed cases marked as □

Figure 48 *Hypothesis 1i data: Plots following Mahalanobis test*

Source: own research

9.7.2 Hypotheses 2 and 3

9.7.2.1 Hypotheses 2 and 3 data: Tests for Normality

Table 80

Normality test: Hypothesis 2 and 3 data

	Shapiro-Wilk		
	Statistic	df	Sig.
PgoldLRP1d	0.937	4949	.000
FgoldLRP1d	0.944	4949	.000
EPUusLRP20d	0.990	4949	.000
EPUusVol20d	0.846	4949	.000
EPUusVol60d	0.846	4949	.000
EPUusVol200d	0.922	4949	.000
IDXusdLRP20d	0.977	4949	.000
GoldBeta200d	0.942	4949	.000
DefaultPremLRP20d	0.953	4949	.000
INFLus12	0.982	4949	.000
INFLusVol	0.751	4949	.000
INFLworld	0.944	4949	.000
INFLworldVol	0.804	4949	.000
ECMusSpot	0.901	4949	.000
ECMusFut	0.902	4949	.000
EPUeuLRP1m	0.981	4949	.000

Source: Own research

9.7.2.2 Hypotheses 2 and 3 data: Tests for stationarity – 1st iteration

Stationarity test for PgoldLRP1d

Table 81

Stationarity test: H2 & 3, PgoldLRP1d

Dickey-Fuller test (ADF (stationary) / k: 17 / PgoldLRP1d):	
Tau (Observed value)	-17.002
Tau (Critical value)	-3.390
p-value (one-tailed)	< .0001
alpha	.05

KPSS test (Level / Lag Short / PgoldLRP1d):	
Eta (Observed value)	0.235
Eta (Critical value)	0.472
p-value (one-tailed)	.206
alpha	.05

Source: Own research

For variable PgoldLRP1d the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for FgoldLRP1d

Table 82

Stationarity test: H2 & 3, FgoldLRP1d

Dickey-Fuller test (ADF (stationary) / k: 17 / FgoldLRP1d):	
Tau (Observed value)	-16.885
Tau (Critical value)	-3.390
p-value (one-tailed)	< .0001
alpha	.05

KPSS test (Level / Lag Short / FgoldLRP1d):	
Eta (Observed value)	0.229
Eta (Critical value)	0.472
p-value (one-tailed)	.213
alpha	.05

Source: Own research

For variable FgolLRP1d the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for EPUusLRP20d

Table 83

Stationarity test: H2 & 3, EPUusLRP20d

Dickey-Fuller test (ADF (stationary) / k: 17 / EPUusLRP20d):	
Tau (Observed value)	-15.443
Tau (Critical value)	-3.390
p-value (one-tailed)	< .0001
alpha	.05

KPSS test (Level / Lag Short / EPUusLRP20d):	
Eta (Observed value)	0.012
Eta (Critical value)	0.472
p-value (one-tailed)	1.000
alpha	.05

Source: Own research

For variable EPUusLRP20d the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for EPUusVol20d

Table 84

Stationarity test: H2 & 3, EPUusVol20d

Dickey-Fuller test (ADF (stationary) / k: 17 / EPUusVol20d):	
Tau (Observed value)	-10.004
Tau (Critical value)	-3.390
p-value (one-tailed)	< .0001
alpha	.05

KPSS test (Level / Lag Short / EPUusVol20d):	
Eta (Observed value)	1.204
Eta (Critical value)	0.472
p-value (one-tailed)	.002
alpha	.05

Source: Own research

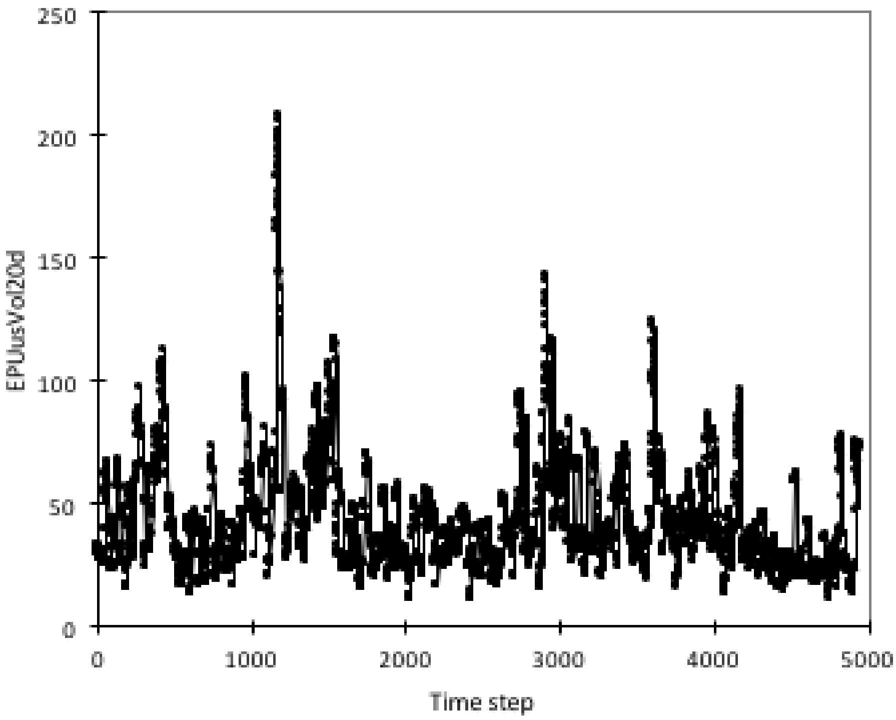


Figure 49 *Data plot indicating stationarity: EPUusVol20d*

Source: Own research

For variable EUPusVol20d the KPSS test indicated is that the data were non-stationary, however the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for EPUusVol60d

Table 85

Stationarity test: H2 & 3, EPUusVol60d

Dickey-Fuller test (ADF (stationary) / k: 17 / EPUusVol60d):	
Tau (Observed value)	-6.007
Tau (Critical value)	-3.390
p-value (one-tailed)	< .0001
alpha	.05

KPSS test (Level / Lag Short / EPUusVol60d):	
Eta (Observed value)	1.138
Eta (Critical value)	0.472
p-value (one-tailed)	.002
alpha	.05

Source: Own research

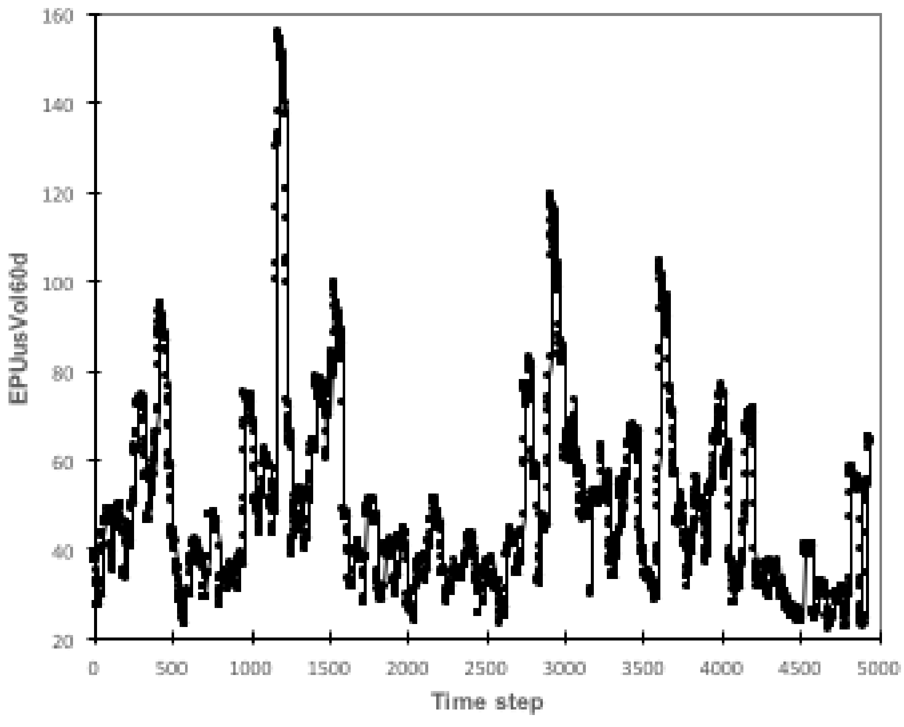


Figure 50 *Data plot indicating stationarity: EPUusVol60d*

Source: Own research

For variable EUPusVol60d the KPSS test indicated is that the data were non-stationary, however the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for EPUusVol200d

Table 86

Stationarity test: H2 & 3, EPUusVol200d

Dickey-Fuller test (ADF (stationary) / k: 17 / EPUusVol200d):

Tau (Observed value)	-2.626
Tau (Critical value)	-3.390
p-value (one-tailed)	.261
Alpha	.05

KPSS test (Level / Lag Short / EPUusVol200d):

Eta (Observed value)	1.407
Eta (Critical value)	0.472
p-value (one-tailed)	.000
Alpha	.05

Source: Own research

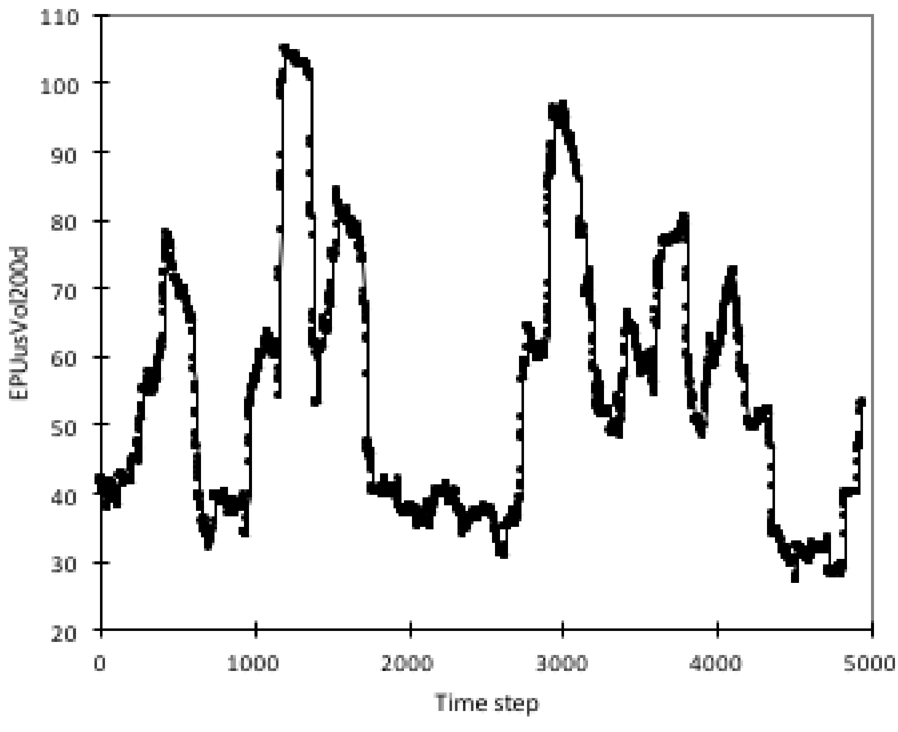


Figure 51 *Data plot indicating stationarity: EPUusVol200d*

Source: Own research

For variable EUPusVol200d the KPSS test indicated is that the data were non-stationary, however the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for IDXusdLRP20d

Table 87

Stationarity test: H2 & 3, IDXusdLRP20d

Dickey-Fuller test (ADF (stationary) / k: 17 / IDXusdLRP20d):	
Tau (Observed value)	-14.067
Tau (Critical value)	-3.390
p-value (one-tailed)	< .0001
alpha	.05

KPSS test (Level / Lag Short / IDXusdLRP20d):	
Eta (Observed value)	0.497
Eta (Critical value)	0.472
p-value (one-tailed)	.044
alpha	.05

Source: Own research

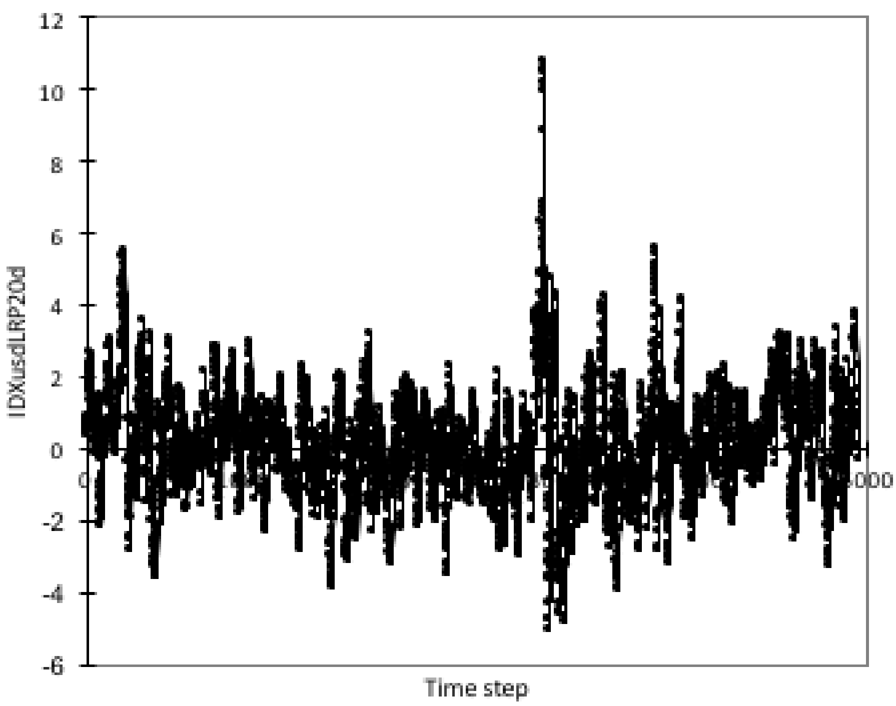


Figure 52 *Data plot indicating stationarity: IDXusLRP20d*

Source: Own research

For variable IDXusdLRP20d the KPSS test indicated is that the data were non-stationary, however the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for GoldBeta200d

Table 88

Stationarity test: H2 & 3, GoldBeta200d

Dickey-Fuller test (ADF (stationary) / k: 17 / GoldBeta200d):	
Tau (Observed value)	-5.638
Tau (Critical value)	-3.390
p-value (one-tailed)	< .0001
alpha	.05

KPSS test (Level / Lag Short / GoldBeta200d):	
Eta (Observed value)	1.229
Eta (Critical value)	0.472
p-value (one-tailed)	.002
alpha	.05

Source: Own research

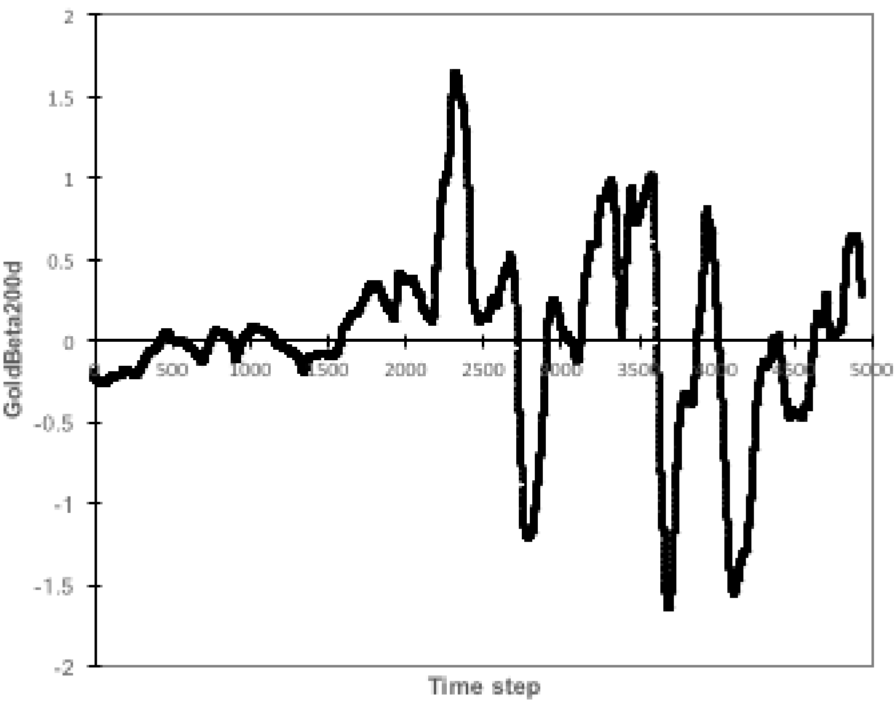


Figure 53 *Data plot indicating stationarity: GoldBeta200d*

Source: Own research

For variable GoldBeta200d the KPSS test indicated is that the data were non-stationary, however the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for DefaultPremLRP20d

Table 89

Stationarity test: H2 & 3, DefaultPremLRP20d

Dickey-Fuller test (ADF (stationary) / k: 17 / DefaultPremLRP20d):	
Tau (Observed value)	-12.334
Tau (Critical value)	-3.390
p-value (one-tailed)	< .0001
alpha	.05

KPSS test (Level / Lag Short / DefaultPremLRP20d):	
Eta (Observed value)	0.109
Eta (Critical value)	0.472
p-value (one-tailed)	.537
alpha	.05

Source: Own research

Stationarity test for ECMusSpot

Table 90

Stationarity test: H2 & 3, ECMusSpot

Dickey-Fuller test (ADF (stationary) / k: 17 / ECMusSpot):	
Tau (Observed value)	-1.742
Tau (Critical value)	-3.390
p-value (one-tailed)	.723
alpha	.05

KPSS test (Level / Lag Short / ECMusSpot):	
Eta (Observed value)	26.507
Eta (Critical value)	0.472
p-value (one-tailed)	< .0001
alpha	.05

Source: Own research

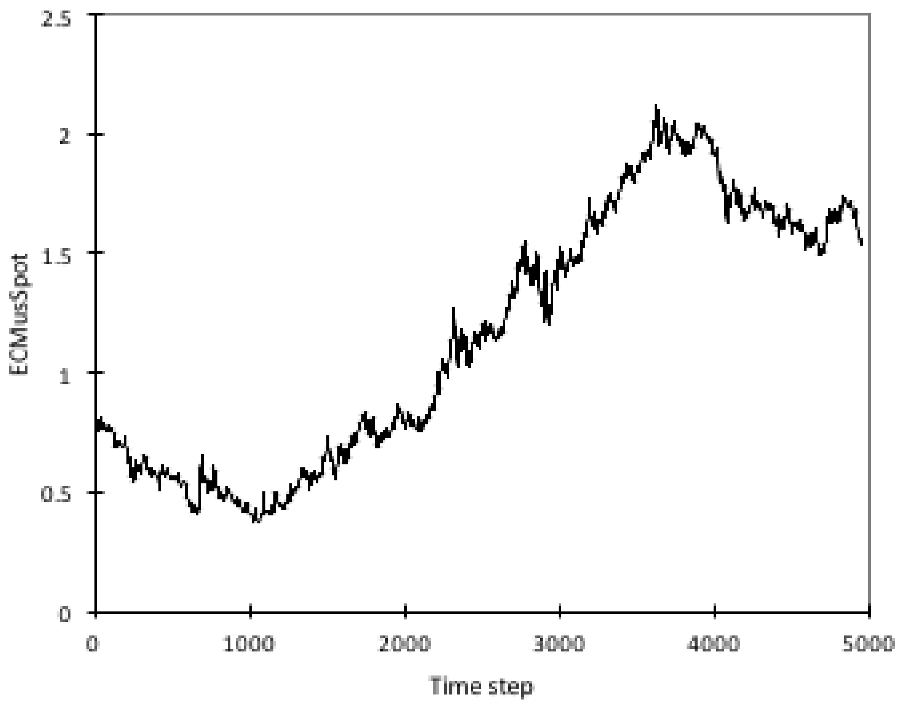


Figure 54 *Data plot indicating non-stationarity: ECMusSpot*

Source: Own research

For variable ECMusSpot the KPSS test indicated is that the data were non-stationary, and the ADF test indicated that the data contained a unit root. The conclusion was that the data were non-stationary.

The data were transformed to log returns and re-tested for stationarity.

Stationarity test for ECMusFut

Table 91

Stationarity test: H2 & 3, ECMusFut

Dickey-Fuller test (ADF (stationary) / k: 17 / ECMusFut):	
Tau (Observed value)	-1.745
Tau (Critical value)	-3.390
p-value (one-tailed)	.721
alpha	.05

KPSS test (Level / Lag Short / ECMusFut):	
Eta (Observed value)	26.451
Eta (Critical value)	0.472
p-value (one-tailed)	< .0001
alpha	.05

Source: Own research

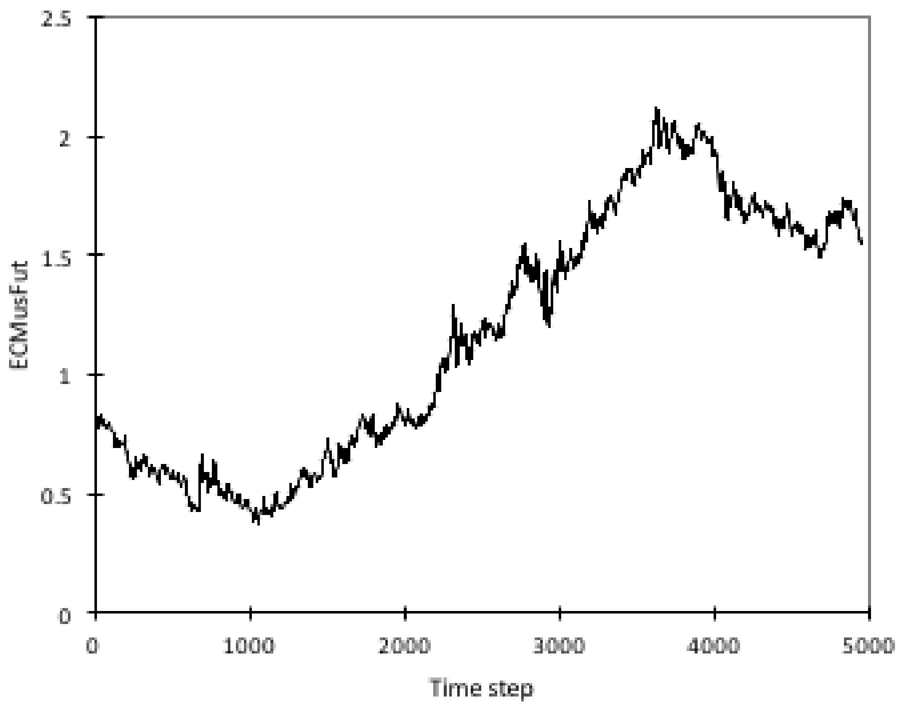


Figure 55 *Data plot indicating non-stationarity: ECMusFut*

Source: Own research

For variable ECMusFut the KPSS test indicated is that the data were non-stationary, and the ADF test indicated that the data contained a unit root. The conclusion was that the data were non-stationary.

The data were transformed to log returns and re-tested for stationarity.

9.7.2.3 *Hypotheses 2 and 3 data: Tests for stationarity – 2nd iteration*

Stationarity test for ECMusSpotLRP1d

Table 92

Stationarity test: H2 & 3, ECMusSpotLRP1d

Dickey-Fuller test (ADF (stationary) / k: 17 / ECMusSpotLRP1d):	
Tau (Observed value)	-17.017
Tau (Critical value)	-3.390
p-value (one-tailed)	< .0001
alpha	.05

KPSS test (Level / Lag Short / ECMusSpotLRP1d):	
Eta (Observed value)	0.207
Eta (Critical value)	0.472
p-value (one-tailed)	.247
alpha	.05

Source: Own research

For variable ECMusSpotLRP1d the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for ECMusFutLRP1d

Table 93

Stationarity test: H2 & 3, ECMusFutLRP1d

Dickey-Fuller test (ADF (stationary) / k: 17 / ECMusFutLRP1d):	
Tau (Observed value)	-16.876
Tau (Critical value)	-3.390
p-value (one-tailed)	< .0001
alpha	.05

KPSS test (Level / Lag Short / ECMusFutLRP1d):	
Eta (Observed value)	0.206
Eta (Critical value)	0.472
p-value (one-tailed)	.247
alpha	.05

Source: Own research

For variable ECMusFutLRP1d the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

9.7.2.4 Hypothesis 2 and 3 data: Tests for multicollinearity

Table 94

Covariance matrix: Hypothesis 2 and 3 data

		EPUeu LRP1m	INFLworld Vol	ECMusFut LRP1d	GoldBeta 200d	DefaultPrem LRP20d	EPUus LRP20d	EPUus Vol20d	INFLworld	IDXusd LRP20d	ECMusSpot LRP1d	INFLus12	INFLusVol
Correlations	EPUeuLRP1m	1.00000	-.01533	-.00372	-.04339	-.01128	-.14031	-.07935	.02251	-.11520	-.02523	-.04335	.01419
	INFLworldVol	-.01533	1.00000	.00428	.16268	.16006	-.01309	.09773	-.72753	-.00856	.00614	.39520	-.87567
	ECMusFutLRP1d	-.00372	.00428	1.00000	-.00082	-.00893	-.00636	.00088	.00296	.02915	-.60223	-.00082	-.00520
	GoldBeta200d	-.04339	.16268	-.00082	1.00000	.00983	-.00702	.06567	.04177	.04888	.00139	-.16936	-.20661
	DefaultPremLRP20d	-.01128	.16006	-.00893	.00983	1.00000	-.00538	-.04403	-.15830	-.24852	-.01757	-.02200	-.13664
	EPUusLRP20d	-.14031	-.01309	-.00636	-.00702	-.00538	1.00000	-.08558	.02507	-.03635	.00952	-.03151	.01498
	EPUusVol20d	-.07935	.09773	.00088	.06567	-.04403	-.08558	1.00000	-.17929	.06635	.00192	.07537	-.15023
	INFLworld	.02251	-.72753	.00296	.04177	-.15830	.02507	-.17929	1.00000	-.05513	.00220	-.61895	.69991
	IDXusdLRP20d	-.11520	-.00856	.02915	.04888	-.24852	-.03635	.06635	-.05513	1.00000	.05146	.07502	.03987
	ECMusSpotLRP1d	-.02523	.00614	-.60223	.00139	-.01757	.00952	.00192	.00220	.05146	1.00000	-.00108	-.00662
	INFLus12	-.04335	.39520	-.00082	-.16936	-.02200	-.03151	.07537	-.61895	.07502	-.00108	1.00000	-.24738
	INFLusVol	.01419	-.87567	-.00520	-.20661	-.13664	.01498	-.15023	.69991	.03987	-.00662	-.24738	1.00000
Covariances	EPUeuLRP1m	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	INFLworldVol	.00000	.00241	.00000	.00012	.00001	.00000	.00000	-.00047	.00000	.00000	.00016	-.00156
	ECMusFutLRP1d	.00000	.00000	.00006	.00000	.00000	.00000	.00000	.00000	.00000	-.00004	.00000	.00000
	GoldBeta200d	.00000	.00012	.00000	.00022	.00000	.00000	.00000	.00001	.00000	.00000	-.00002	-.00011
	DefaultPremLRP20d	.00000	.00001	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	EPUusLRP20d	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	EPUusVol20d	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	INFLworld	.00000	-.00047	.00000	.00001	.00000	.00000	.00000	.00017	.00000	.00000	-.00007	.00033
	IDXusdLRP20d	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00003	.00000	.00000	.00001
	ECMusSpotLRP1d	.00000	.00000	-.00004	.00000	.00000	.00000	.00000	.00000	.00000	.00006	.00000	.00000
	INFLus12	.00000	.00016	.00000	-.00002	.00000	.00000	.00000	-.00007	.00000	.00000	.00007	-.00008
	INFLusVol	.00000	-.00156	.00000	-.00011	.00000	.00000	.00000	.00033	.00001	.00000	-.00008	.00132

a. Dependent Variable: PgoldLRP1d

Source: Own research

Table 95

Pairwise regression result - INFLworld : INFLus12

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.572[a]	.328	.327	.89694

a. Predictors: (Constant), INFLus12

b. Dependent Variable: INFLworld

Source: own research

9.7.2.5 Hypotheses 2 and 3: ACF’s for seasonality inspection

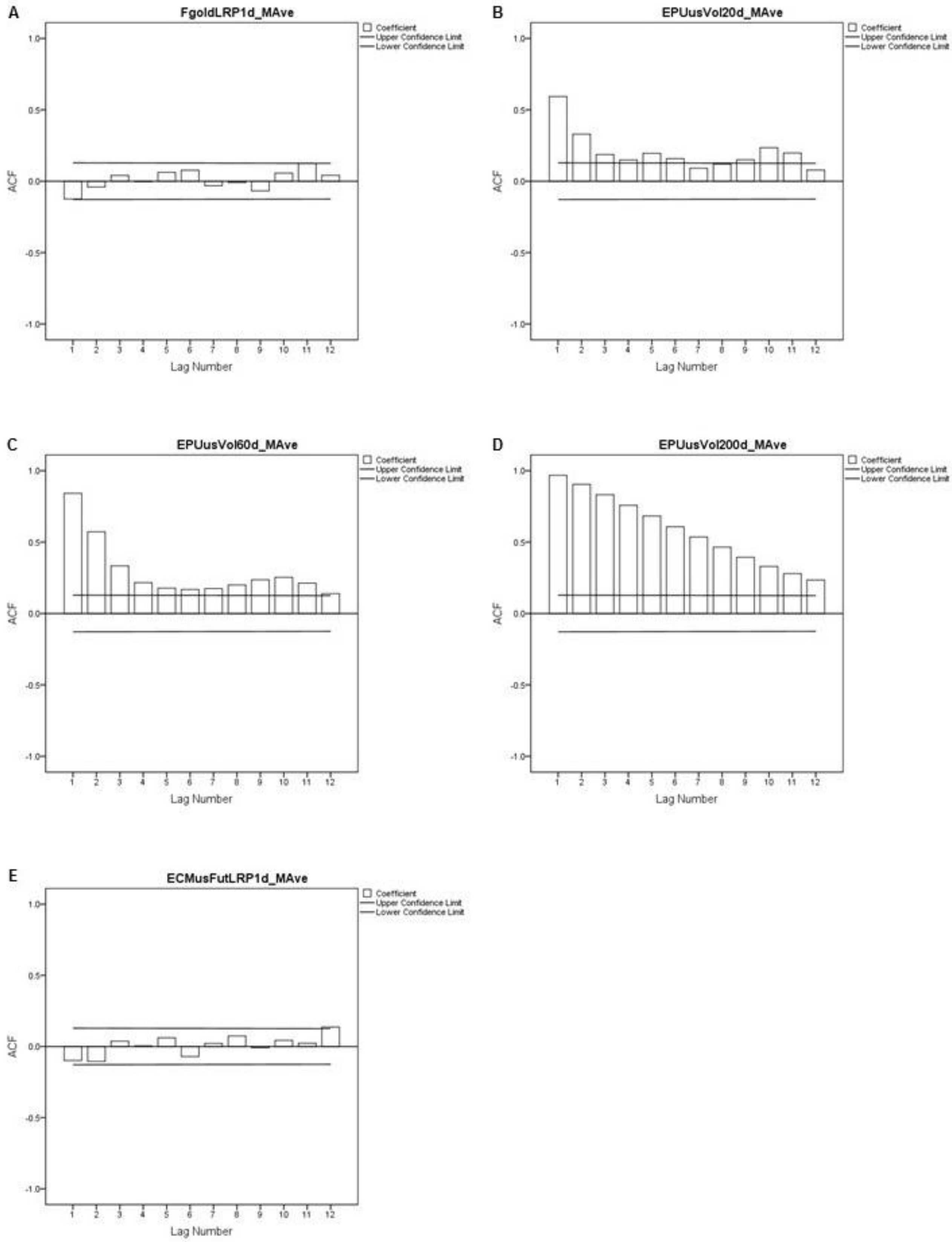
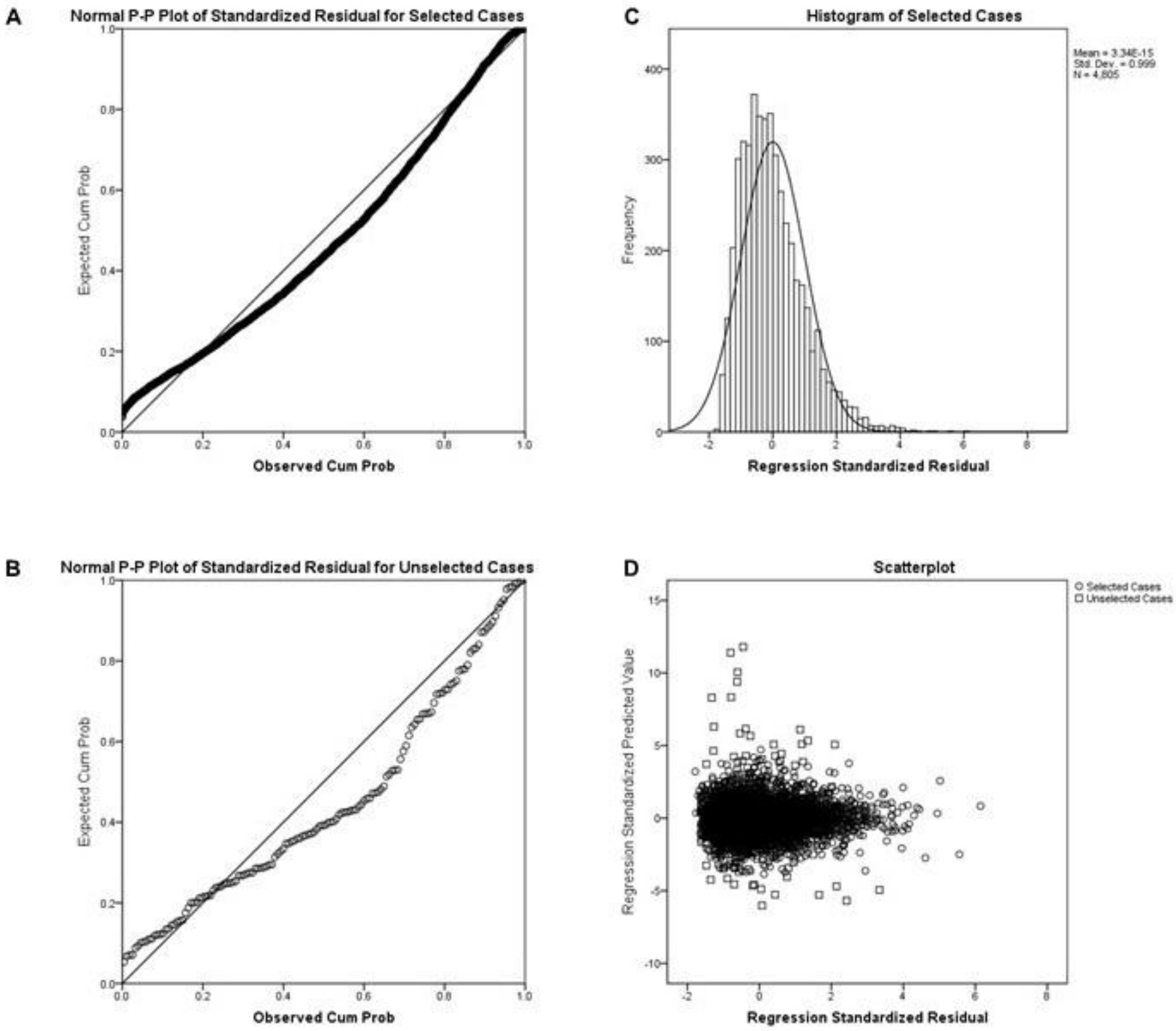


Figure 56 *Hypothesis 1, 2 and 3: ACF’s for seasonality inspection*

Source: own research

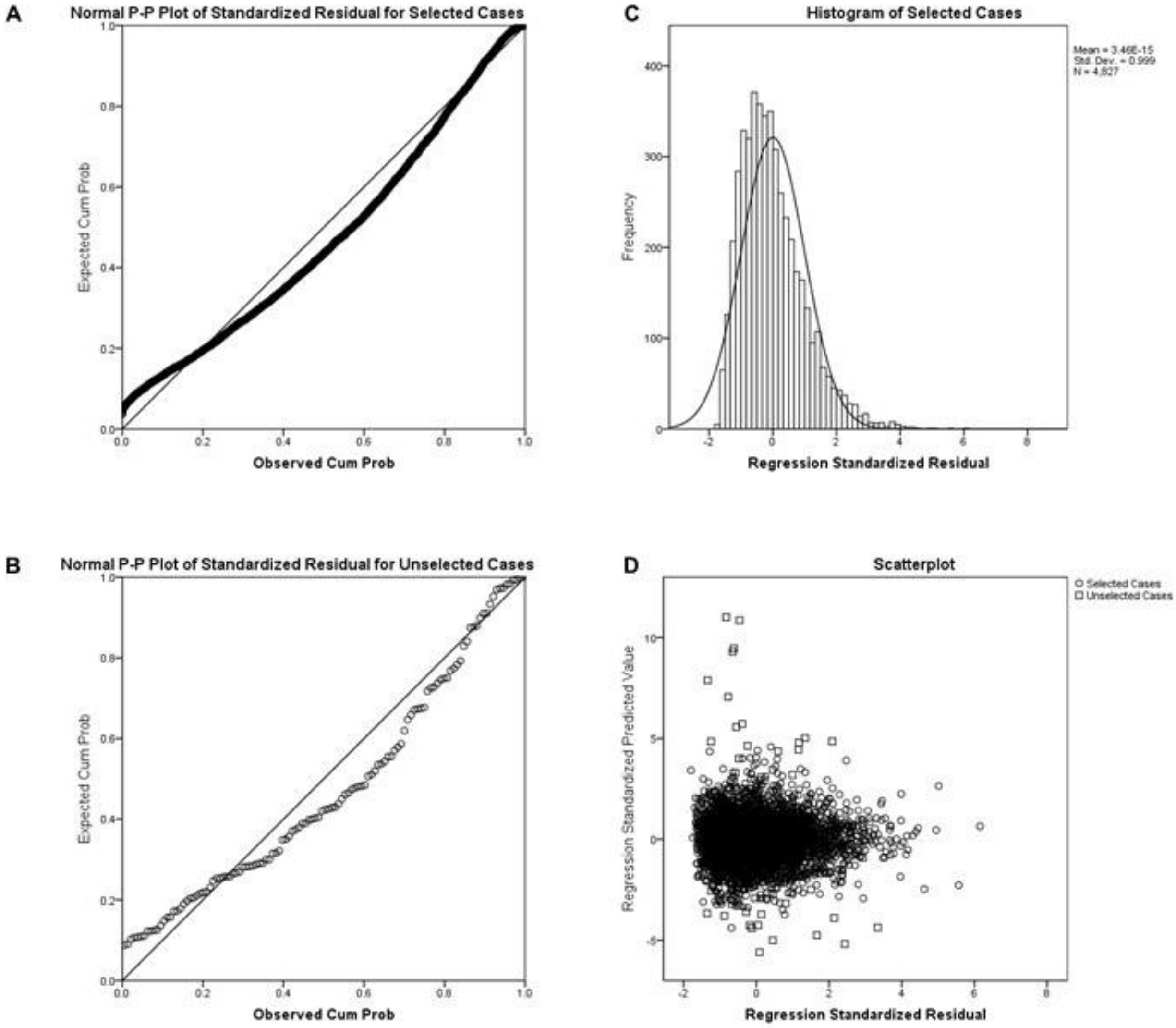
9.7.2.6 Hypotheses 2 and 3: Test for outliers



Panel A shows the P-P plot of the retained cases; Panel B shows the P-P plot of the removed cases; Panel C shows the histogram of retained cases; Panel D shows the scatterplot, with retained cases marked as o and removed cases marked as □

Figure 57 *Hypothesis 2d data: Plots following Mahalanobis test*

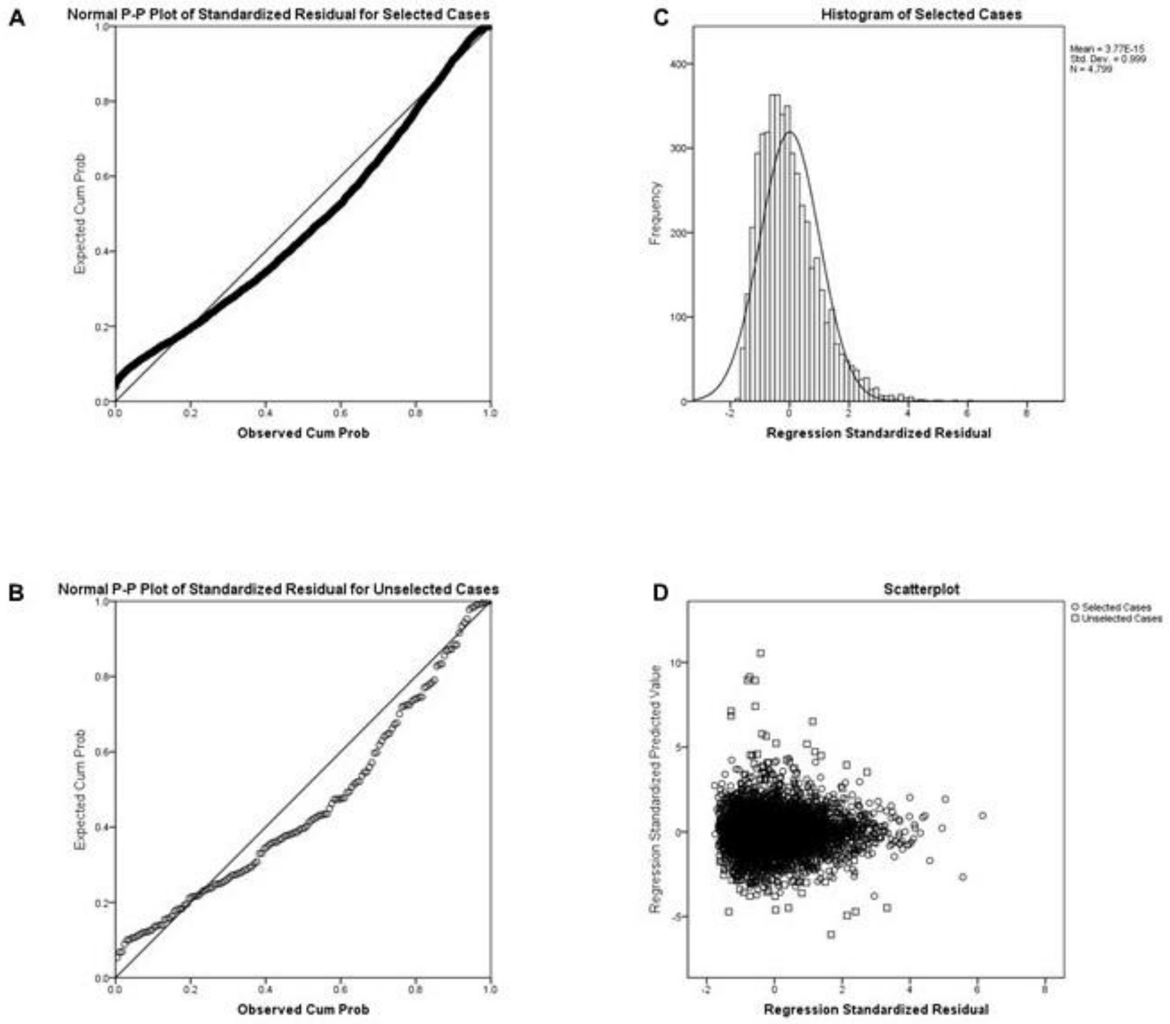
Source: own research



Panel A shows the P-P plot of the retained cases; Panel B shows the P-P plot of the removed cases; Panel C shows the histogram of retained cases; Panel D shows the scatterplot, with retained cases marked as o and removed cases marked as □

Figure 58 *Hypothesis 2i data: Plots following Mahalanobis test*

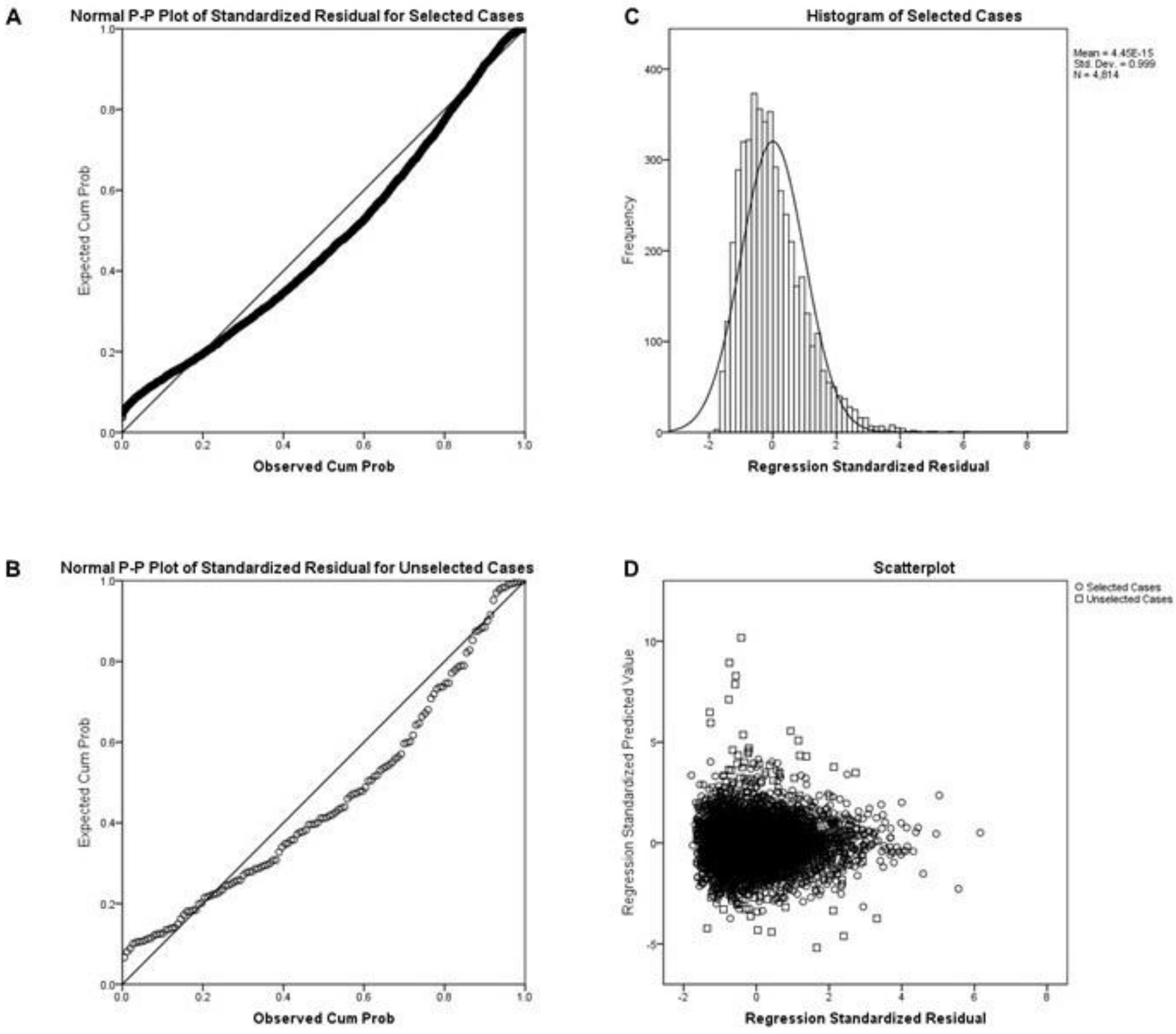
Source: own research



Panel A shows the P-P plot of the retained cases; Panel B shows the P-P plot of the removed cases; Panel C shows the histogram of retained cases; Panel D shows the scatterplot, with retained cases marked as o and removed cases marked as □

Figure 59 *Hypothesis 3d data: Plots following Mahalanobis test*

Source: own research



Panel A shows the P-P plot of the retained cases; Panel B shows the P-P plot of the removed cases; Panel C shows the histogram of retained cases; Panel D shows the scatterplot, with retained cases marked as o and removed cases marked as □

Figure 60 *Hypothesis 3i data: Plots following Mahalanobis test*

Source: own research

9.7.3 Hypothesis 4

9.7.3.1 Tests for Normality

Table 96

Normality test: Hypothesis 4c data

	Shapiro-Wilk		
	Statistic	df	Sig.
PgoldCnyLRPerc1m	0.985	204	.029
EPUcnLRP6m	0.987	204	.059
IDXcnyLRP6m	0.967	204	.000
INFLcn12	0.953	204	.000
INFLcnVol	0.836	204	.000
ECMcn	0.939	204	.000
GoldBetaUS36m	0.925	204	.000
DefaultPremLRP6m	0.984	204	.018

Source: Own research

Table 97

Normality test: Hypothesis 4e data

	Shapiro-Wilk		
	Statistic	df	Sig.
PgoldEurGbpLRP1m	0.989	204	.141
EPUeuLRP6m	0.994	204	.597
IDXeurgbpLRP6m	0.980	204	.005
INFLeuuk12	0.954	204	.000
INFLeuukVol	0.734	204	.000
ECMeu	0.901	204	.000
GoldBetaUS36m	0.925	204	.000
DefaultPremLRP6m	0.984	204	.018

Source: Own research

Table 98

Normality test: Hypothesis 4c data

	Shapiro-Wilk		
	Statistic	df	Sig.
PgoldJpyLRPerc1m	0.951	240	.000
EPUjpLRP6m	0.980	240	.002
IDXjpyLRP6m	0.971	240	.000
INFLjpn12	0.910	240	.000
INFLjpnVol	0.862	240	.000
ECMjp	0.880	240	.000
GoldBetaUS36m	0.895	240	.000
DefaultPremLRP6m	0.980	240	.002

Source: Own research

9.7.3.2 Hypotheses 4c data: Tests for stationarity – 1st iteration

Stationarity test for PgoldCnyLRPerc1m

Table 99

Stationarity test: Hypothesis 4c, PgoldCnyLRP1m

Dickey-Fuller test (ADF (stationary) / k: 5 / PgoldCnyLRPerc1m):	
Tau (Observed value)	-5.127
Tau (Critical value)	-3.412
p-value (one-tailed)	.000
alpha	.05

KPSS test (Level / Lag Short / PgoldCnyLRPerc1m):	
Eta (Observed value)	0.243
Eta (Critical value)	0.453
p-value (one-tailed)	.201
alpha	.05

Source: Own research

For variable PgoldCnyLRPerc1m the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for EPUcnLRP6m

Table 100

Stationarity test: Hypothesis 4c, EPUcnLRP6m

Dickey-Fuller test (ADF (stationary) / k: 5 / EPUcnLRP6m):	
Tau (Observed value)	-7.678
Tau (Critical value)	-3.412
p-value (one-tailed)	< .0001
alpha	.05

KPSS test (Level / Lag Short / EPUcnLRP6m):	
Eta (Observed value)	0.085
Eta (Critical value)	0.453
p-value (one-tailed)	.681
alpha	.05

Source: Own research

For variable EPUcnLRP6m the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for IDXcnyLRP6m

Table 101

Stationarity test: Hypothesis 4c, IDXcnyLRP6m

Dickey-Fuller test (ADF (stationary) / k: 5 / IDXcnyLRP6m):	
Tau (Observed value)	-5.852
Tau (Critical value)	-3.412
p-value (one-tailed)	< .0001
alpha	.05

KPSS test (Level / Lag Short / IDXcnyLRP6m):	
Eta (Observed value)	0.180
Eta (Critical value)	0.453
p-value (one-tailed)	.317
alpha	.05

Source: Own research

For variable IDXcnyLRP6m the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for INFLcn12

Table 102

Stationarity test: Hypothesis 4c, INFLcn12

Dickey-Fuller test (ADF (stationary) / k: 5 / INFLcn12):	
Tau (Observed value)	-3.582
Tau (Critical value)	-3.412
p-value (one-tailed)	.033
alpha	.05

KPSS test (Level / Lag Short / INFLcn12):	
Eta (Observed value)	0.680
Eta (Critical value)	0.453
p-value (one-tailed)	.012
alpha	.05

Source: Own research

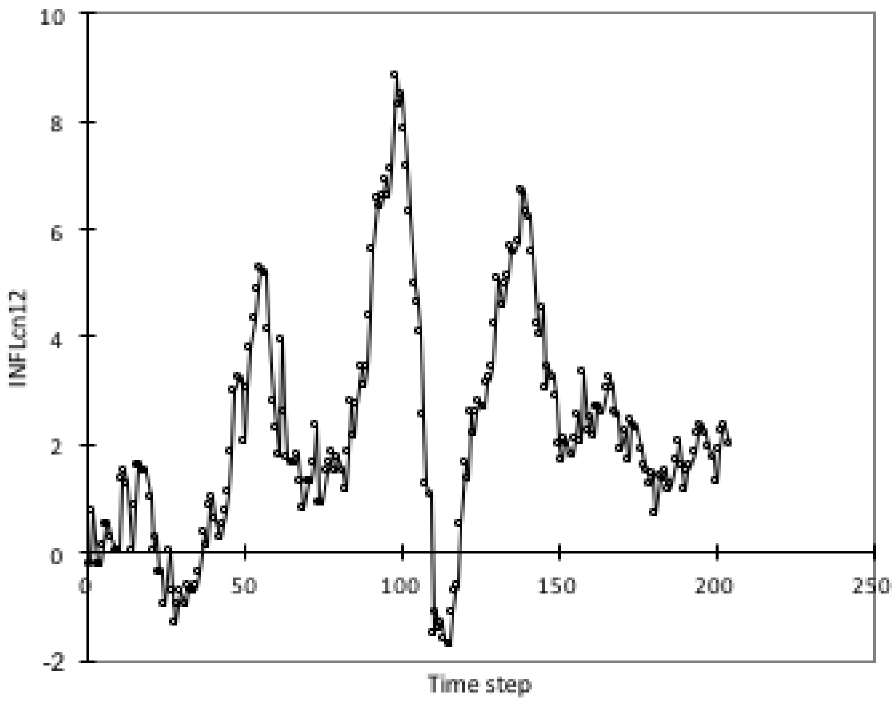


Figure 61 *Data plot indicating stationarity: INFLcn12*

For variable INFLcn12 the KPSS test indicated is that the data were non-stationary, however the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for INFLcnVol

Table 103

Stationarity test: Hypothesis 4c, INFLcnVol

Dickey-Fuller test (ADF (stationary) / k: 5 / INFLcnVol):	
Tau (Observed value)	-2.437
Tau (Critical value)	-3.412
p-value (one-tailed)	.354
alpha	.05
KPSS test (Level / Lag Short / INFLcnVol):	
Eta (Observed value)	0.657
Eta (Critical value)	0.453
p-value (one-tailed)	.013
alpha	.05

Source: Own research

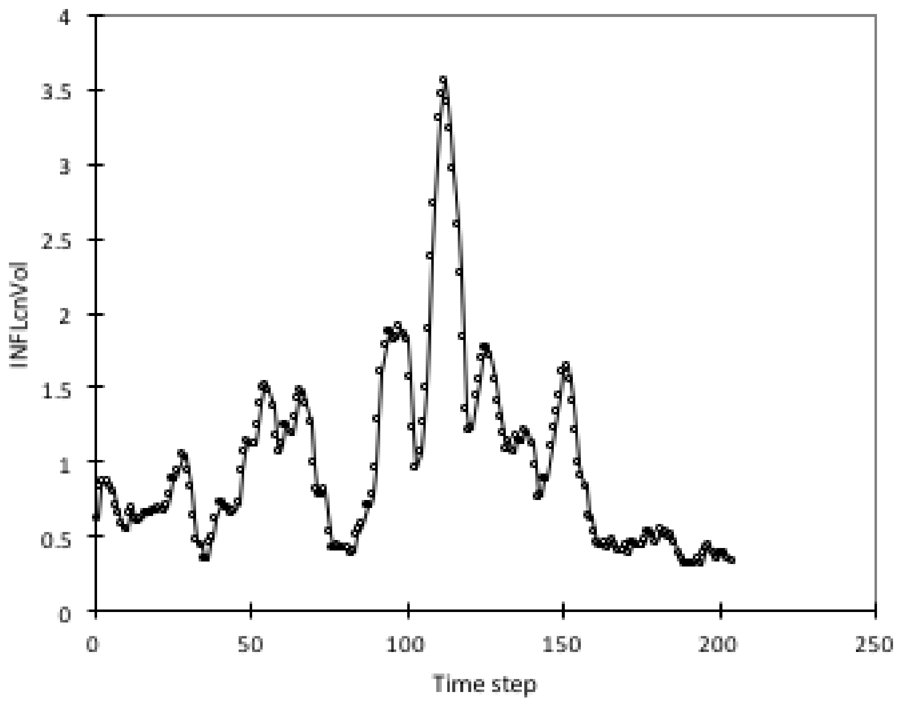


Figure 62 *Data plot indicating stationarity: INFLcnVol*

For variable INFLcnVol the KPSS test indicated is that the data were non-stationary, and the ADF test indicated that the data contained a unit root. Visual inspection of the data plot indicates no major trend. The conclusion was that the data were stationary.

Stationarity test for ECMcn

Table 104

Stationarity test: Hypothesis 4c, ECMcn

Dickey-Fuller test (ADF (stationary) / k: 5 / ECMcn):	
Tau (Observed value)	-0.700
Tau (Critical value)	-3.412
p-value (one-tailed)	.963
alpha	.05

KPSS test (Level / Lag Short / ECMcn):	
Eta (Observed value)	4.215
Eta (Critical value)	0.453
p-value (one-tailed)	< .0001
alpha	.05

Source: Own research

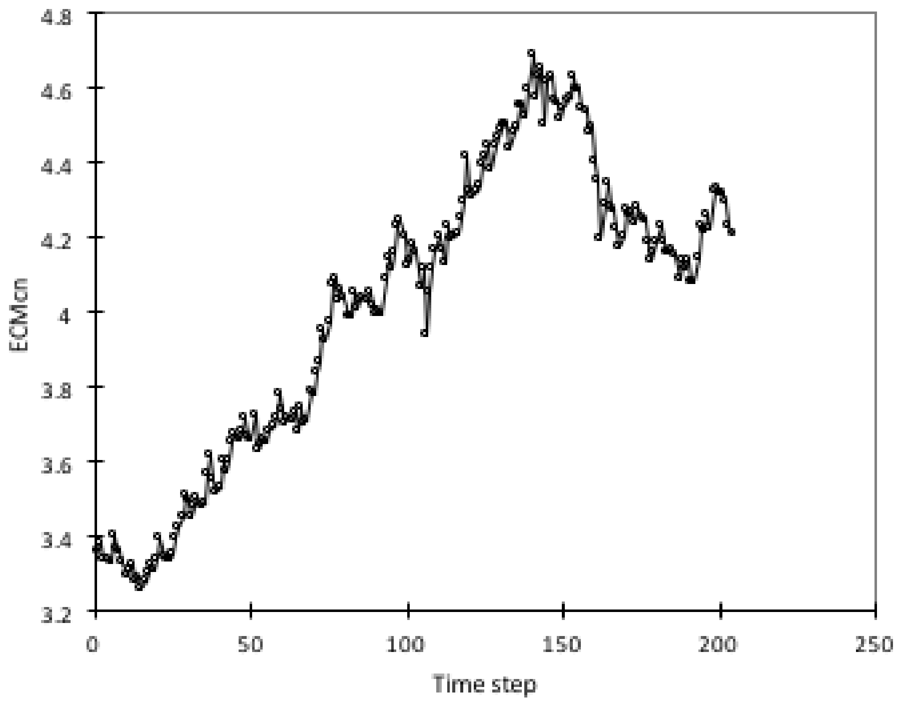


Figure 63 *Data plot indicating non-stationarity: ECMcn*

For variable ECMcn the KPSS test indicated is that the data were non-stationary, and the ADF test indicated that the data contained a unit root. The conclusion was that the data were non-stationary.

The data were transformed to log returns and re-tested for stationarity.

9.7.3.3 *Hypotheses 4c data: Tests for stationarity – 2nd iteration*

Stationarity test for ECMcnLRP1m

Table 105

Stationarity test: Hypothesis 4c, ECMcnLRP1m

Dickey-Fuller test (ADF (stationary) / k: 5 / ECMcnLRP1m):	
Tau (Observed value)	-5.213
Tau (Critical value)	-3.412
p-value (one-tailed)	< .0001
alpha	.05

KPSS test (Level / Lag Short / ECMcnLRP1m):	
Eta (Observed value)	0.279
Eta (Critical value)	0.453
p-value (one-tailed)	.156
alpha	.05

Source: Own research

For variable ECMcnLRP1m the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

9.7.3.4 *Hypotheses 4e data: Tests for stationarity – 1st iteration*

Stationarity test for PgoldEurGbpLRP1m

Table 106

Stationarity test: Hypothesis 4e,PgoldEurGbpLRP1m

Dickey-Fuller test (ADF (stationary) / k: 5 / PgoldEurGbpLR1m):	
Tau (Observed value)	-5.179
Tau (Critical value)	-3.412
p-value (one-tailed)	< .0001
alpha	.05

KPSS test (Level / Lag Short / PgoldEurGbpLR1m):	
Eta (Observed value)	0.150
Eta (Critical value)	0.453
p-value (one-tailed)	.399
alpha	.05

Source: Own research

For variable PgoldEurGbpLRP1m the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for EPUeuLRP6m

Table 107

Stationarity test: Hypothesis 4e, EPUeuLRP6m

Dickey-Fuller test (ADF (stationary) / k: 5 / EPUeuLRP6m):	
Tau (Observed value)	-9.324
Tau (Critical value)	-3.412
p-value (one-tailed)	< .0001
alpha	.05

KPSS test (Level / Lag Short / EPUeuLRP6m):	
Eta (Observed value)	0.073
Eta (Critical value)	0.453
p-value (one-tailed)	.754
alpha	.05

Source: Own research

For variable EPUeuLRP6m the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for IDXeurgbpLRP6m

Table 108

Stationarity test: Hypothesis 4e, IDXeurgbpLRP6m

Dickey-Fuller test (ADF (stationary) / k: 5 / IDXeurgbpLRP6m):	
Tau (Observed value)	-5.181
Tau (Critical value)	-3.412
p-value (one-tailed)	< .0001
Alpha	.05

KPSS test (Level / Lag Short / IDXeurgbpLRP6m):	
Eta (Observed value)	0.330
Eta (Critical value)	0.453
p-value (one-tailed)	.109
alpha	.05

Source: Own research

For variable IDXeurgbpLRP6m the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for INFLeuuk12

Table 109

Stationarity test: Hypothesis 4e, INFLeuuk12

Dickey-Fuller test (ADF (stationary) / k: 5 / INFLeuuk12):	
Tau (Observed value)	-2.868
Tau (Critical value)	-3.412
p-value (one-tailed)	.171
alpha	.05
KPSS test (Level / Lag Short / INFLeuuk12):	
Eta (Observed value)	1.219
Eta (Critical value)	0.453
p-value (one-tailed)	<.0001
alpha	.05

Source: Own research

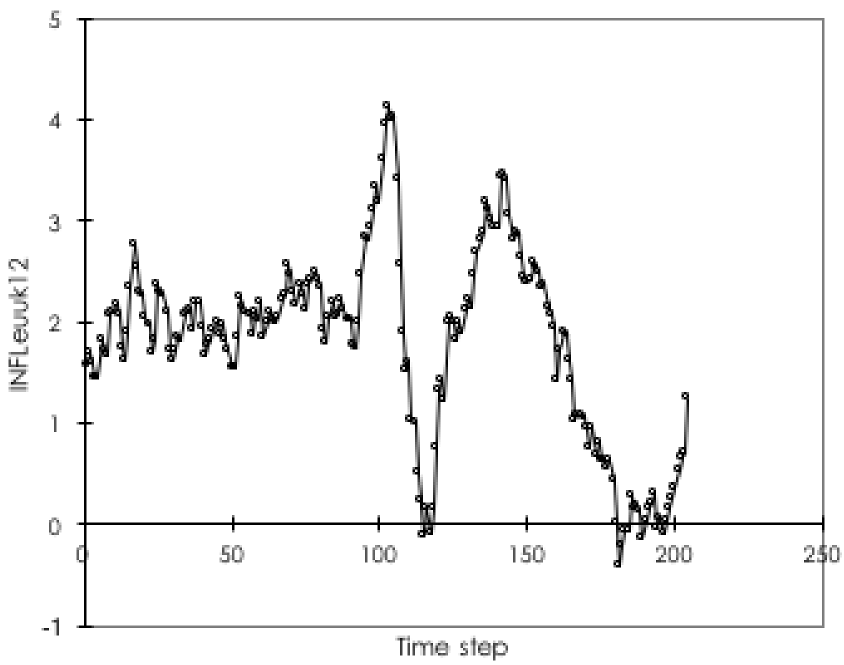


Figure 64 *Data plot indicating stationarity: INFLeuuk12*

For variable INFLeuuk12 the KPSS test indicated is that the data were non-stationary, and the ADF test indicated that the data contained a unit root. Visual inspection of the data plot indicated no major trend. The conclusion was that the data were stationary.

Stationarity test for INFLeuukVol

Table 110

Stationarity test: Hypothesis 4e, INFLeuukVol

Dickey-Fuller test (ADF (stationary) / k: 5 / INFLeuukVol):	
Tau (Observed value)	-1.912
Tau (Critical value)	-3.412
p-value (one-tailed)	.640
alpha	.05

KPSS test (Level / Lag Short / INFLeuukVol):	
Eta (Observed value)	0.720
Eta (Critical value)	0.453
p-value (one-tailed)	.009
alpha	.05

Source: Own research

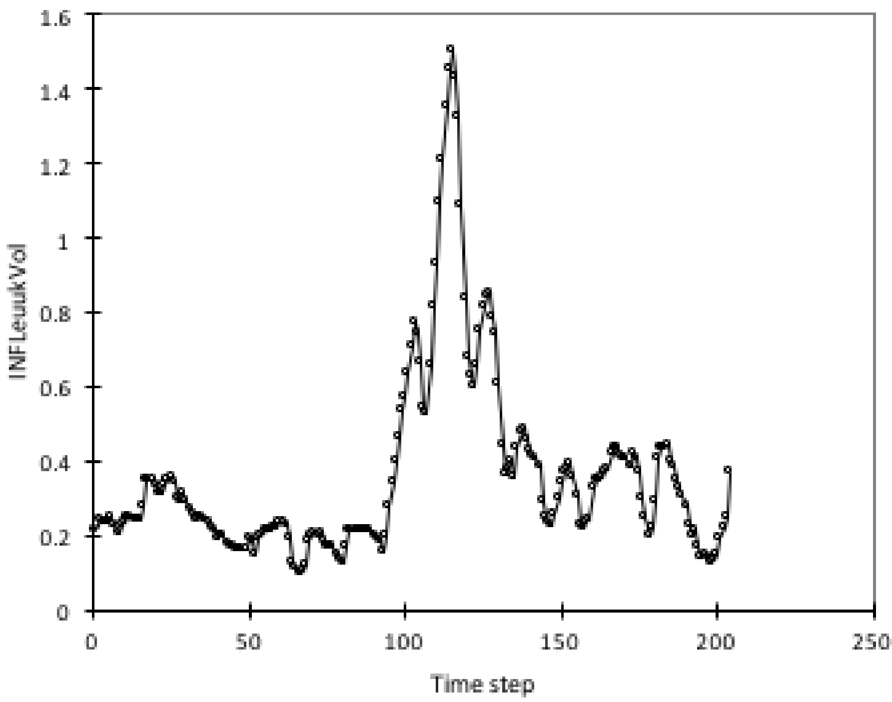


Figure 65 *Data plot indicating stationarity: INFLeuukVol*

For variable INFLeuukVol the KPSS test indicated is that the data were non-stationary, and the ADF test indicated that the data contained a unit root. Visual inspection of the data plot indicated no major trend. The conclusion was that the data were stationary.

Stationarity test for ECMeu

Table 111

Stationarity test: Hypothesis 4e,ECMeu

Tau (Observed value)	-0.177
Tau (Critical value)	-3.412
p-value (one-tailed)	.990
alpha	.05
Eta (Observed value)	4.788
Eta (Critical value)	0.453
p-value (one-tailed)	< .0001
alpha	.05

Source: Own research

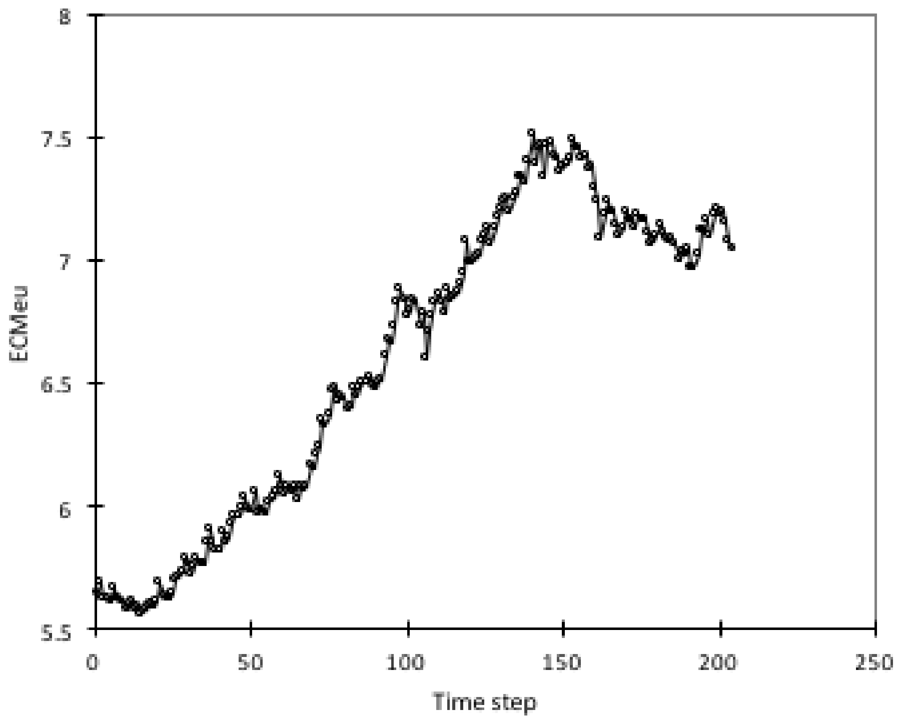


Figure 66 *Data plot indicating non-stationarity: ECMeu*

For variable ECMeu the KPSS test indicated is that the data were non-stationary, and the ADF test indicated that the data contained a unit root. Visual inspection of the data plot indicated a major trend. The conclusion was that the data were non-stationary. Data were transformed to log returns.

9.7.3.5 Hypotheses 4e data: Tests for stationarity – 2nd iteration

Stationarity test for ECMeuLRP1m

Table 112

Stationarity test: Hypothesis 4e, ECMeuLRP1m

Dickey-Fuller test (ADF (stationary) / k: 5 / ECMeuLRP1m):	
Tau (Observed value)	-5.062
Tau (Critical value)	-3.412
p-value (one-tailed)	<.0001
Alpha	.05

KPSS test (Level / Lag Short / ECMeuLRP1m):	
Eta (Observed value)	0.380
Eta (Critical value)	0.453
p-value (one-tailed)	.080
alpha	.05

Source: Own research

For variable ECMeuLRP1m the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

9.7.3.6 Hypotheses 4j data: Tests for stationarity – 1st iteration

Stationarity test for PgoldJpyLRPerc1m

Table 113

Stationarity test: Hypothesis 4j,PgoldJpyLRPerc1m

Dickey-Fuller test (ADF (stationary) / k: 5 / PgoldJpyLRPerc1m):	
Tau (Observed value)	-6.302
Tau (Critical value)	-3.412
p-value (one-tailed)	< .0001
alpha	.05

KPSS test (Level / Lag Short / PgoldJpyLRPerc1m):	
Eta (Observed value)	.200
Eta (Critical value)	.453
p-value (one-tailed)	.272
alpha	.05

Source: Own research

For variable PgoldJpyLRPerc1m the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for EPUjpLRP6m

Table 114

Stationarity test: Hypothesis 4j, EPUjpLRP6m

Dickey-Fuller test (ADF (stationary) / k: 5 / EPUjpLRP6m):	
Tau (Observed value)	-7.234
Tau (Critical value)	-3.412
p-value (one-tailed)	< .0001
alpha	.05

KPSS test (Level / Lag Short / EPUjpLRP6m):	
Eta (Observed value)	0.065
Eta (Critical value)	0.453
p-value (one-tailed)	.802
alpha	.05

Source: Own research

For variable EPUjpnLRP6m the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for IDXjpyLRP6m

Table 115

Stationarity test: Hypothesis 4j, IDXjpyLRP6m

Dickey-Fuller test (ADF (stationary) / k: 5 / IDXjpyLRP6m):	
Tau (Observed value)	-4.442
Tau (Critical value)	-3.412
p-value (one-tailed)	.002
alpha	.05

KPSS test (Level / Lag Short / IDXjpyLRP6m):	
Eta (Observed value)	.131
Eta (Critical value)	.453
p-value (one-tailed)	.461
alpha	.05

Source: Own research

For variable IDXjpyLRP6m the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for INFLjpn12

Table 116

Stationarity test: Hypothesis 4j,INFLjpn12

Dickey-Fuller test (ADF (stationary) / k: 5 / INFLjpn12):	
Tau (Observed value)	-3.611
Tau (Critical value)	-3.412
p-value (one-tailed)	.031
alpha	.05

KPSS test (Level / Lag Short / INFLjpn12):	
Eta (Observed value)	1.037
Eta (Critical value)	0.453
p-value (one-tailed)	.001
alpha	.05

Source: Own research

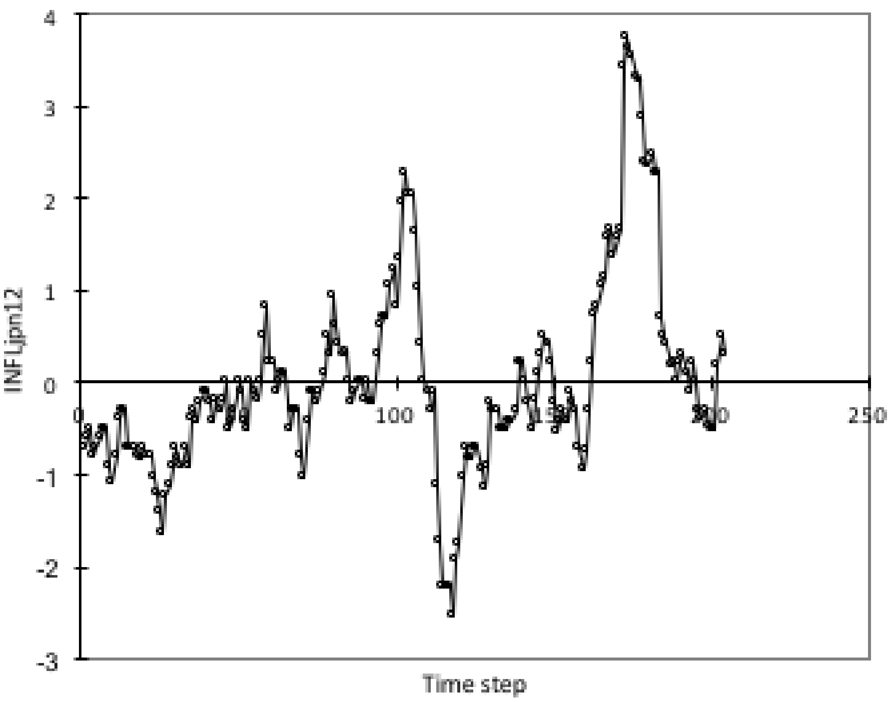


Figure 67 *Data plot indicating stationarity: INFLjpn12*

For variable INFLjpn12 the KPSS test indicated is that the data were non-stationary, however the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

Stationarity test for INFLjpnVol

Table 117

Stationarity test: Hypothesis 4j,INFLjpnVol

Dickey-Fuller test (ADF (stationary) / k: 5 / INFLjpnVol):	
Tau (Observed value)	-3.050
Tau (Critical value)	-3.412
p-value (one-tailed)	.118
alpha	.05

KPSS test (Level / Lag Short / INFLjpnVol):	
Eta (Observed value)	1.501
Eta (Critical value)	0.453
p-value (one-tailed)	< .0001
alpha	.05

Source: Own research

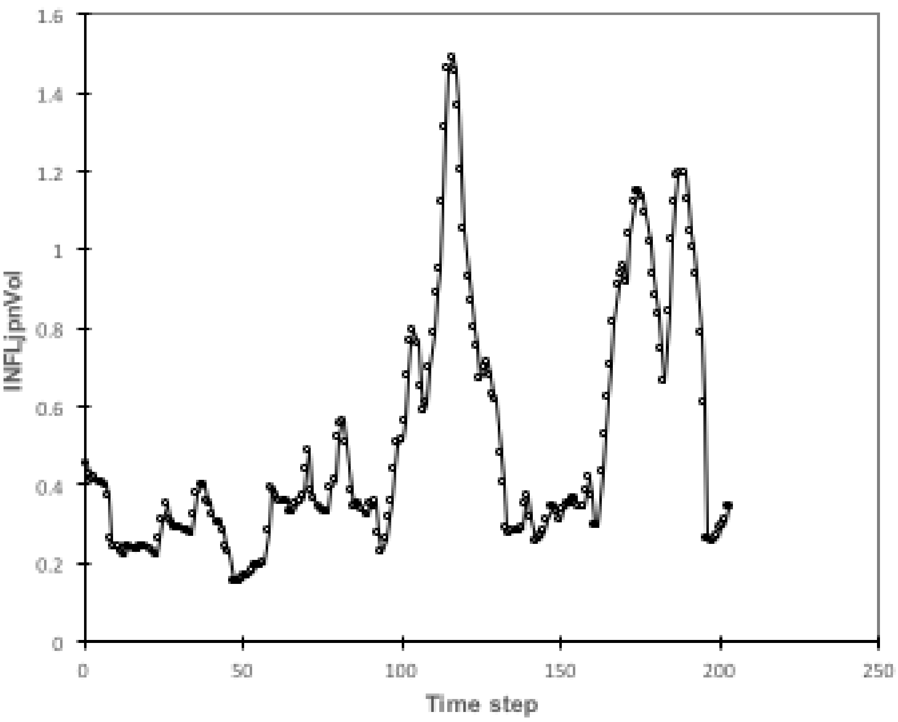


Figure 68 *Data plot indicating stationarity: INFLjpnVol*

For variable INFLjpnVol the KPSS test indicated is that the data were non-stationary, and the ADF test indicated that the data contained a unit root. Visual inspection of the data plot indicated no major trend. The conclusion was that the data were stationary.

Stationarity test for ECMjp

Table 118

Stationarity test: Hypothesis 4j, ECMjp

Tau (Observed value)	-0.681
Tau (Critical value)	-3.412
p-value (one-tailed)	.965
alpha	.05
Eta (Observed value)	4.969
Eta (Critical value)	0.453
p-value (one-tailed)	< .0001
alpha	.05

Source: Own research

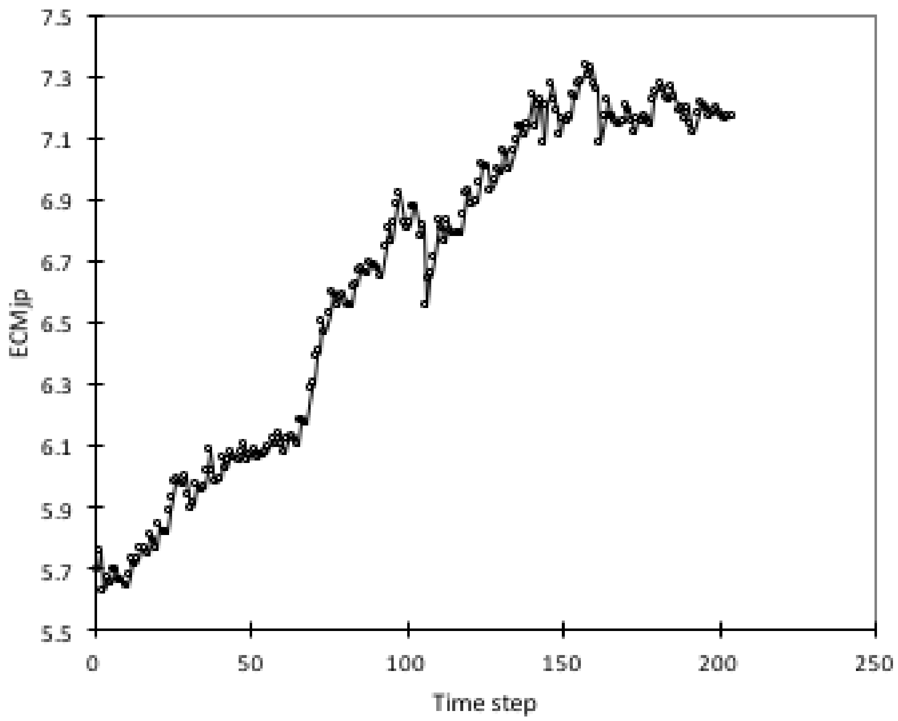


Figure 69 *Data plot indicating non-stationarity: ECMjp*

For variable ECMjp the KPSS test indicated is that the data were non-stationary, and the ADF test indicated that the data contained a unit root. Visual inspection of the data plot indicated a major trend. The conclusion was that the data were non-stationary.

Data were transformed to log returns.

9.7.3.7 Hypotheses 4j data: Tests for stationarity – 2nd iteration

Stationarity test for ECMjpLRP1m

Table 119

Stationarity test: Hypothesis 4j, ECMjpLRP1m

Dickey-Fuller test (ADF (stationary) / k: 6 / ECMjpLRP1m):	
Tau (Observed value)	-5.754
Tau (Critical value)	-3.408
p-value (one-tailed)	< .0001
alpha	.05

KPSS test (Level / Lag Short / ECMjpLRP1m):	
Eta (Observed value)	0.216
Eta (Critical value)	0.457
p-value (one-tailed)	.246
alpha	.05

Source: Own research

For variable ECMjpLRP1m the KPSS test indicated is that the data were stationary, and the ADF test indicated that the data did not contain a unit root. The conclusion was that the data were stationary.

9.7.3.8 Hypothesis 4c data: Tests for multicollinearity

Table 120

Covariance matrix: Hypothesis 4c data

		DefaultPrem LRP6m	ECMcn LRP1m	GoldBeta US36m	INFLcnVol	EPUcn LRP6m	INFLcn12	IDXcny LRP6m
Correlations	DefaultPremLRP6m	1.000000	-.108411	-.055342	.004429	-.268336	.026544	.685226
	ECMcnLRP1m	-.108411	1.000000	.037479	-.119935	-.024054	.028312	-.163514
	GoldBetaUS36m	-.055342	.037479	1.000000	-.130255	.039899	-.419836	-.028920
	INFLcnVol	.004429	-.119935	-.130255	1.000000	.138953	-.052542	.077303
	EPUcnLRP6m	-.268336	-.024054	.039899	.138953	1.000000	-.171195	-.102071
	INFLcn12	.026544	.028312	-.419836	-.052542	-.171195	1.000000	.069824
	IDXcnyLRP6m	.685226	-.163514	-.028920	.077303	-.102071	.069824	1.000000
Covariances	DefaultPremLRP6m	.000006	-.000012	-.000014	.000001	-.000001	.000002	.000024
	ECMcnLRP1m	-.000012	.001984	.000164	-.000460	-.000001	.000036	-.000102
	GoldBetaUS36m	-.000014	.000164	.009667	-.001103	.000003	-.001167	-.000040
	INFLcnVol	.000001	-.000460	-.001103	.007418	.000010	-.000128	.000093
	EPUcnLRP6m	-.000001	-.000001	.000003	.000010	.000001	-.000004	-.000001
	INFLcn12	.000002	.000036	-.001167	-.000128	-.000004	.000799	.000028
	IDXcnyLRP6m	.000024	-.000102	-.000040	.000093	-.000001	.000028	.000196

a. Dependent Variable: PgoldCnyLRPerc1m

Source: Own research

Table 121

Pairwise regression result: IDXcnyLRP6m : DefaultPrem

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.685[a]	.469	.467	3.84648

a. Predictors: (Constant), DefaultPremLRP6m

b. Dependent Variable: IDXcnyLRP6m

Source: Own research

Table 122

Pairwise regression result: INFLcn12 : GoldBeta

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.434[a]	.188	.185	1.8999193

a. Predictors: (Constant), GoldBetaUS36m

b. Dependent Variable: INFLcn12

Source: Own research

9.7.3.9 Hypothesis 4e data: Tests for multicollinearity

Table 123

Covariance matrix: Hypothesis 4e

		DefaultPremLRP6m	ECMeuLRP1m	GoldBetaUS36m	INFLeuukVol	EPUeuLRP6m	IDXeurgbpLRP6m	INFLeuuk12
Correlations	DefaultPremLRP6m	1.000000	-.000333	.154807	.195489	-.157244	.436740	-.295439
	ECMeuLRP1m	-.000333	1.000000	.017927	-.046911	-.097673	-.053927	-.037905
	GoldBetaUS36m	.154807	.017927	1.000000	.124381	-.028815	.011221	-.714041
	INFLeuukVol	.195489	-.046911	.124381	1.000000	.042810	.179715	-.042042
	EPUeuLRP6m	-.157244	-.097673	-.028815	.042810	1.000000	.067499	.039843
	IDXeurgbpLRP6m	.436740	-.053927	.011221	.179715	.067499	1.000000	-.085300
	INFLeuuk12	-.295439	-.037905	-.714041	-.042042	.039843	-.085300	1.000000
Covariances	DefaultPremLRP6m	.000044	.000000	.000408	.000877	-.000005	.000179	-.000521
	ECMeuLRP1m	.000000	.048947	.001572	-.007002	-.000099	-.000734	-.002225
	GoldBetaUS36m	.000408	.001572	.157171	.033268	-.000052	.000274	-.075124
	INFLeuukVol	.000877	-.007002	.033268	.455160	.000132	.007460	-.007527
	EPUeuLRP6m	-.000005	-.000099	-.000052	.000132	.000021	.000019	.000048
	IDXeurgbpLRP6m	.000179	-.000734	.000274	.007460	.000019	.003786	-.001393
	INFLeuuk12	-.000521	-.002225	-.075124	-.007527	.000048	-.001393	.070427

a. Dependent Variable: PgoldEurGbpLR1m

Source: Own research

Table 124

Pairwise regress: IDXeurgbpLRP6m : DefaultPremLRP6m

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.423[a]	.179	.175	2.78885

a. Predictors: (Constant), DefaultPremLRP6m

b. Dependent Variable: IDXeurgbpLRP6m

Source: Own research

Table 125

Pairwise regression: INFLeuuk12 : GoldBeta

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.712[a]	.507	.505	0.6599984

a. Predictors: (Constant), GoldBetaUS36m

b. Dependent Variable: INFLeuuk12

Source: Own research

9.7.3.10 Hypothesis 4j data: Tests for multicollinearity

Table 126

Covariance matrix: Hypothesis 4j

		DefaultPrem LRP6m	ECMjp LRP1m	GoldBeta US36m	EPUjp LRP6m	IDXjpy LRP6m	INFLjpn12	INFLjpnVol
Correlations	DefaultPremLRP6m	1.000000	-.000059	-.099422	-.224787	-.256908	-.225292	.078344
	ECMjpLRP1m	-.000059	1.000000	-.011577	-.066547	-.011381	.102463	.037699
	GoldBetaUS36m	-.099422	-.011577	1.000000	.007079	.161682	.049545	.460358
	EPUjpLRP6m	-.224787	-.066547	.007079	1.000000	.073209	-.074152	-.014832
	IDXjpyLRP6m	-.256908	-.011381	.161682	.073209	1.000000	.036635	-.033420
	INFLjpn12	-.225292	.102463	.049545	-.074152	.036635	1.000000	-.248120
	INFLjpnVol	.078344	.037699	.460358	-.014832	-.033420	-.248120	1.000000
Covariances	DefaultPremLRP6m	.000002	.000000	-.000010	.000000	-.000002	-.000011	.000015
	ECMjpLRP1m	.000000	.002105	-.000039	-.000004	-.000003	.000166	.000241
	GoldBetaUS36m	-.000010	-.000039	.005337	.000001	.000059	.000128	.004680
	EPUjpLRP6m	.000000	-.000004	.000001	.000001	.000000	-.000003	-.000002
	IDXjpyLRP6m	-.000002	-.000003	.000059	.000000	.000025	.000006	-.000023
	INFLjpn12	-.000011	.000166	.000128	-.000003	.000006	.001249	-.001220
	INFLjpnVol	.000015	.000241	.004680	-.000002	-.000023	-.001220	.019367

a. Dependent Variable: PgoldJpyLRPerc1m

Source: Own research

Table 126

Covariance matrix: Hypothesis 4j

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.503[a]	.253	.250	0.2659877

a. Predictors: (Constant), GoldBetaUS36m

Source: Own research

9.7.3.11 <u>*Hypothesis 4: ACF's for seasonality inspection*</u>

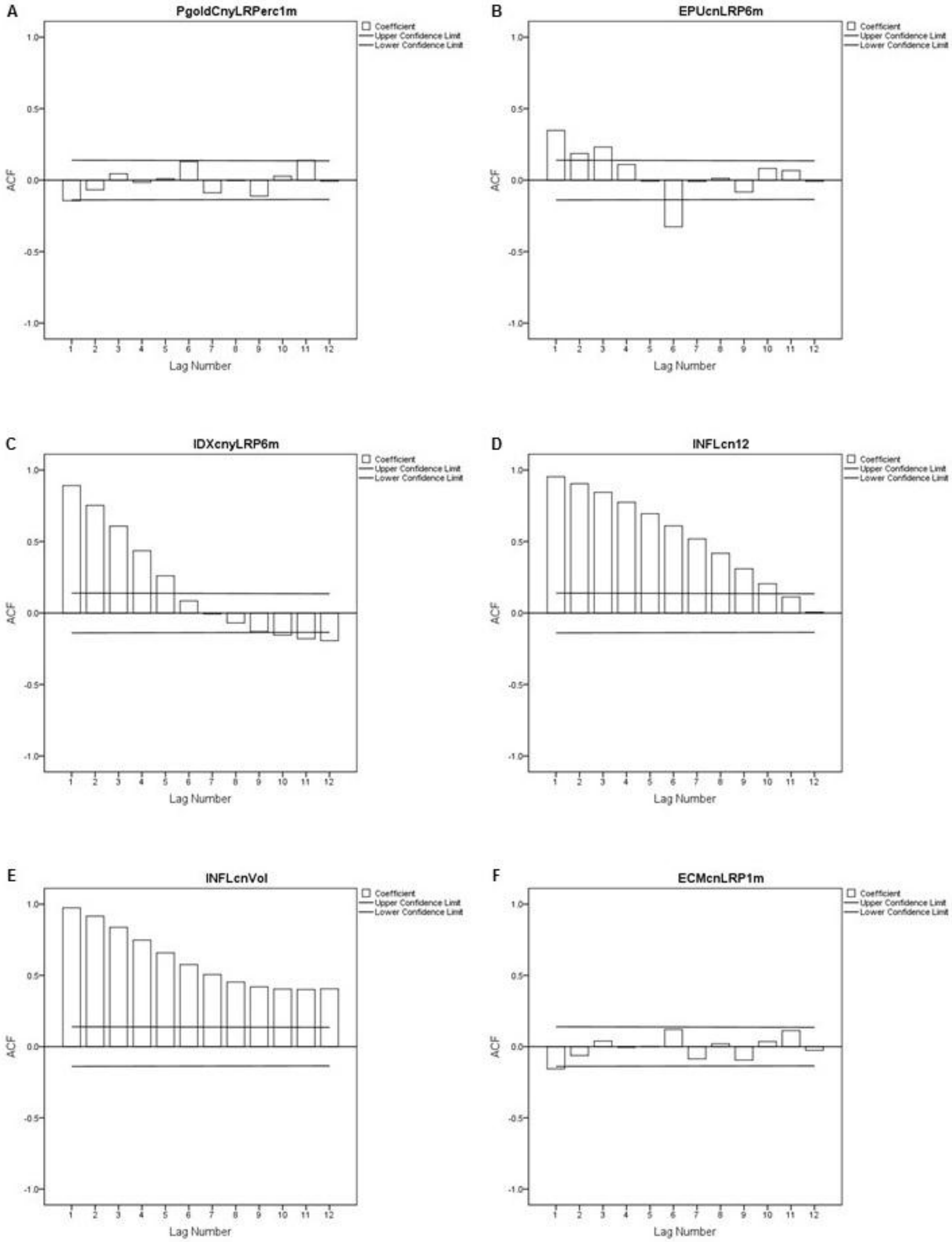


Figure 70 *Hypothesis 4c data: Seasonality ACF plots*

Source: Own research

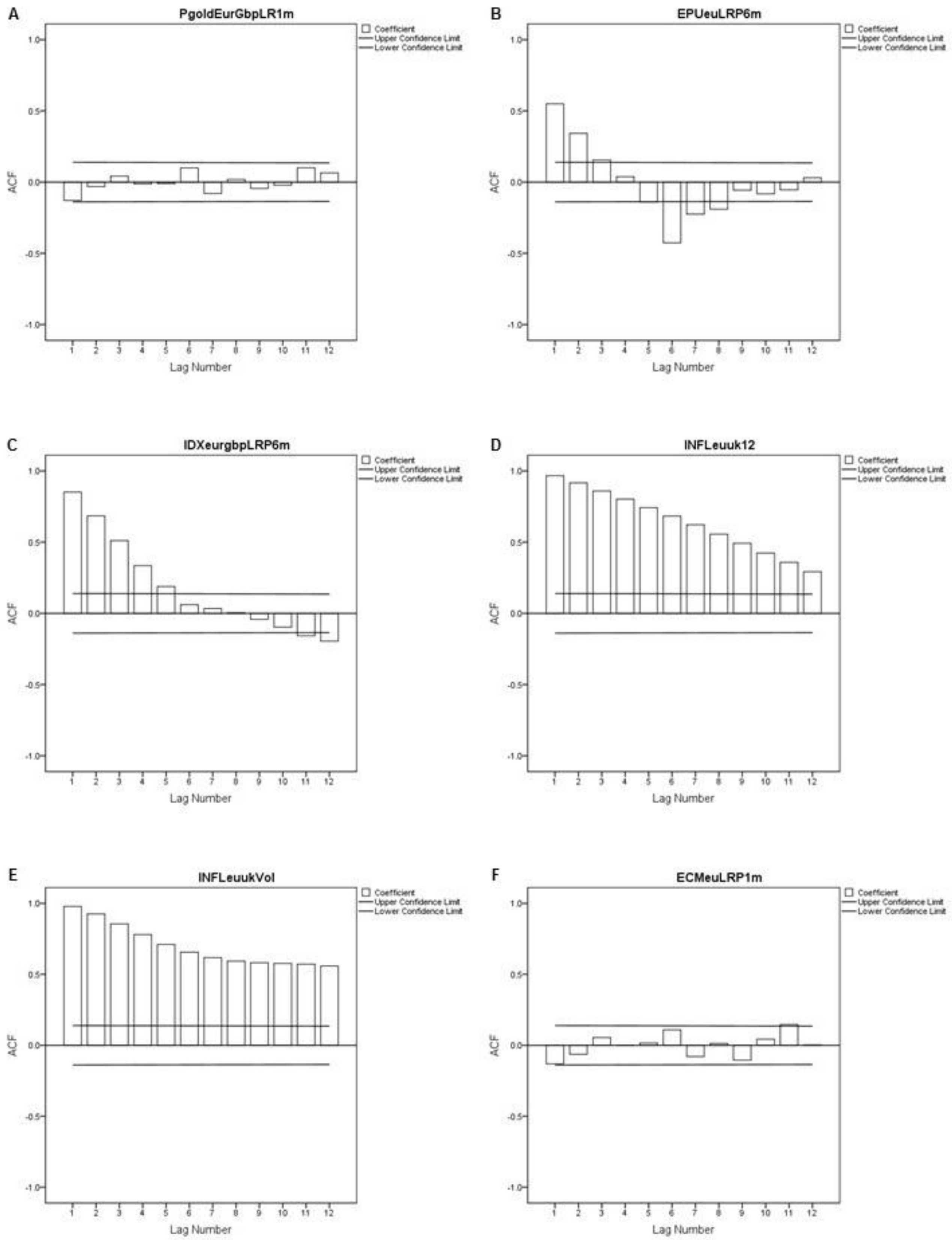


Figure 71 *Hypothesis 4e data: Seasonality ACF plots*

Source: Own research

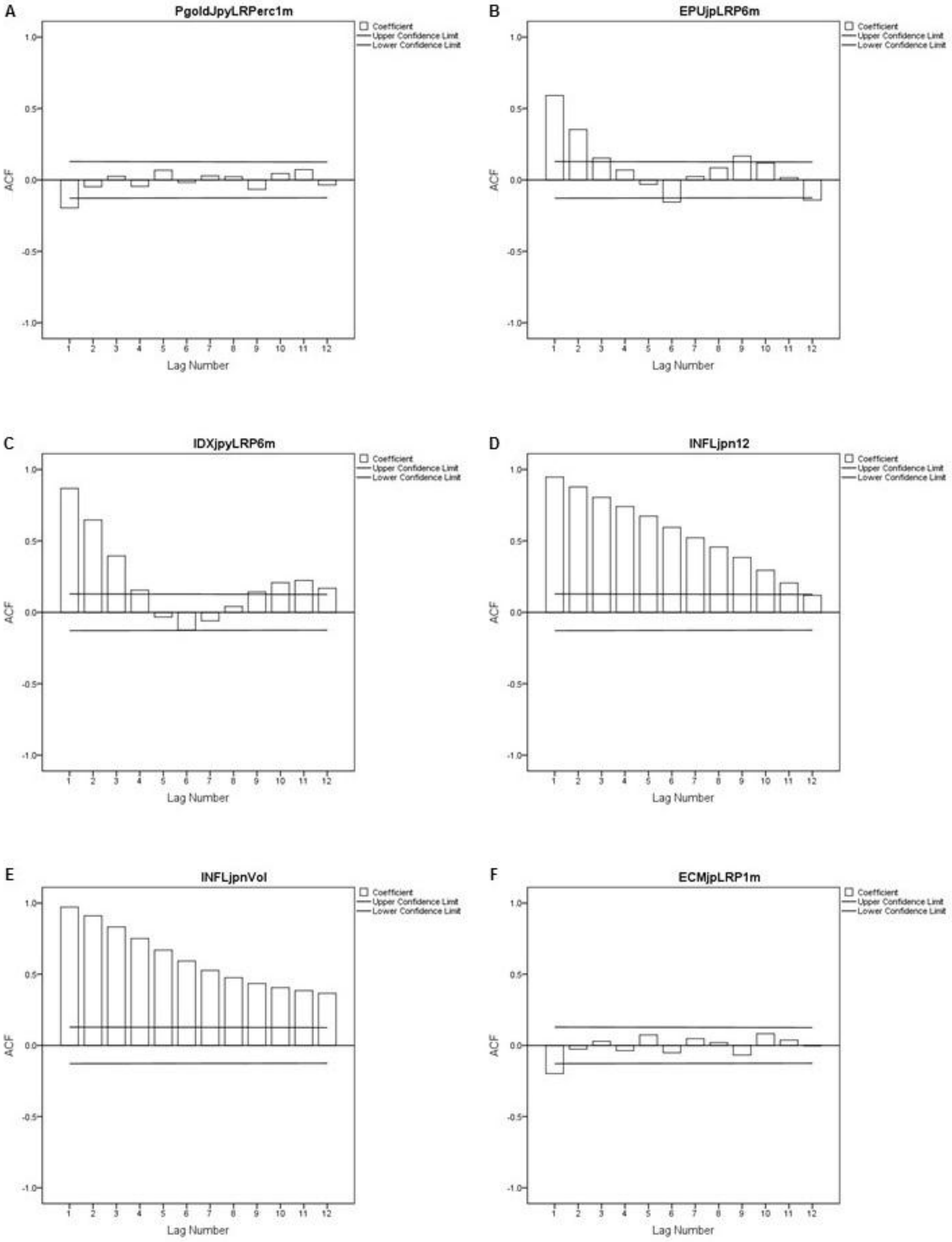
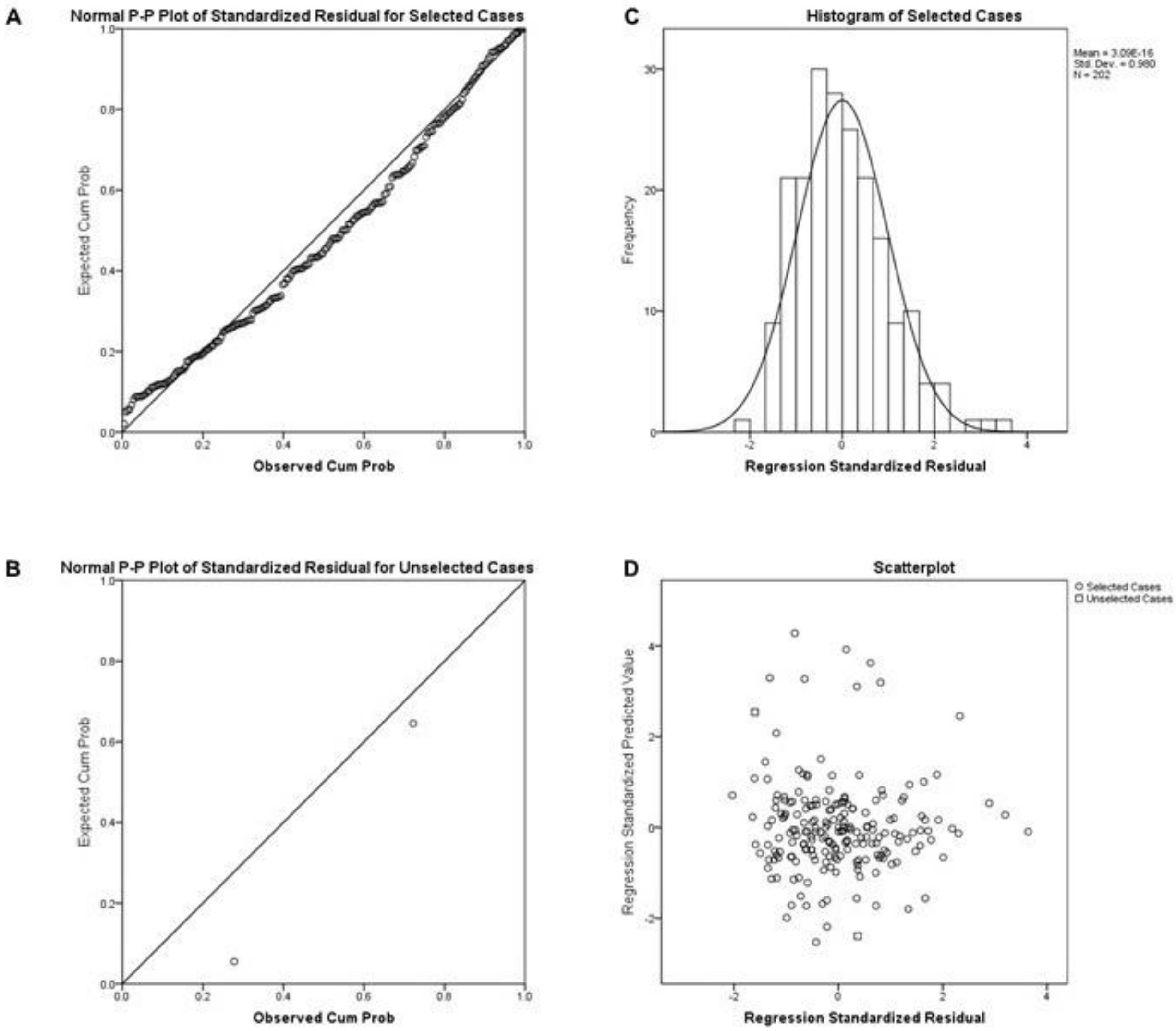


Figure 72 *Hypothesis 4j data: Seasonality ACF plots*

Source: Own research

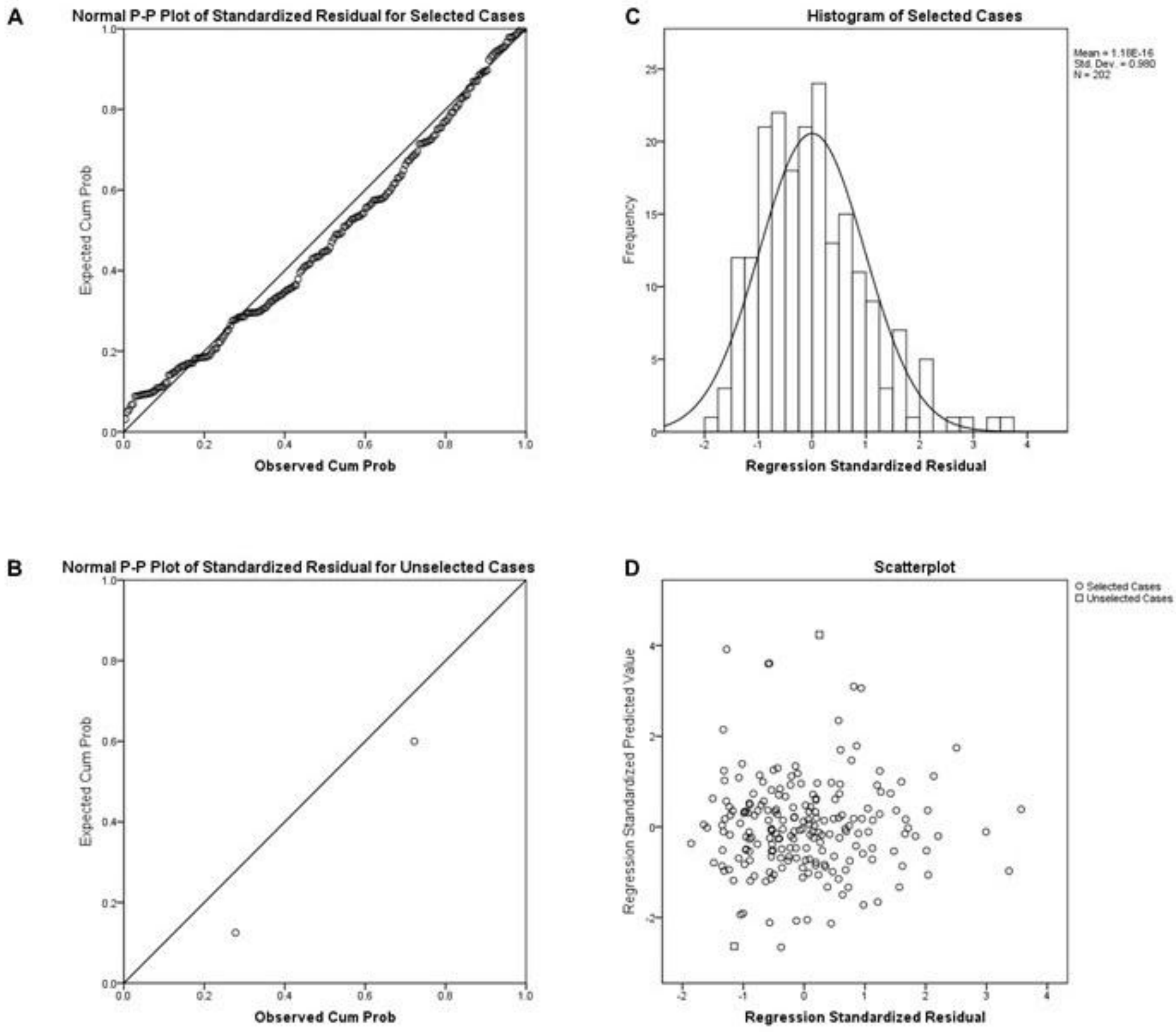
9.7.3.12 <u>Hypothesis 4: Test for outliers</u>



Panel A shows the P-P plot of the retained cases; Panel B shows the P-P plot of the removed cases; Panel C shows the histogram of retained cases; Panel D shows the scatterplot, with retained cases marked as o and removed cases marked as □

Figure 73 *Hypothesis 4c data: Plots following Mahalanobis test*

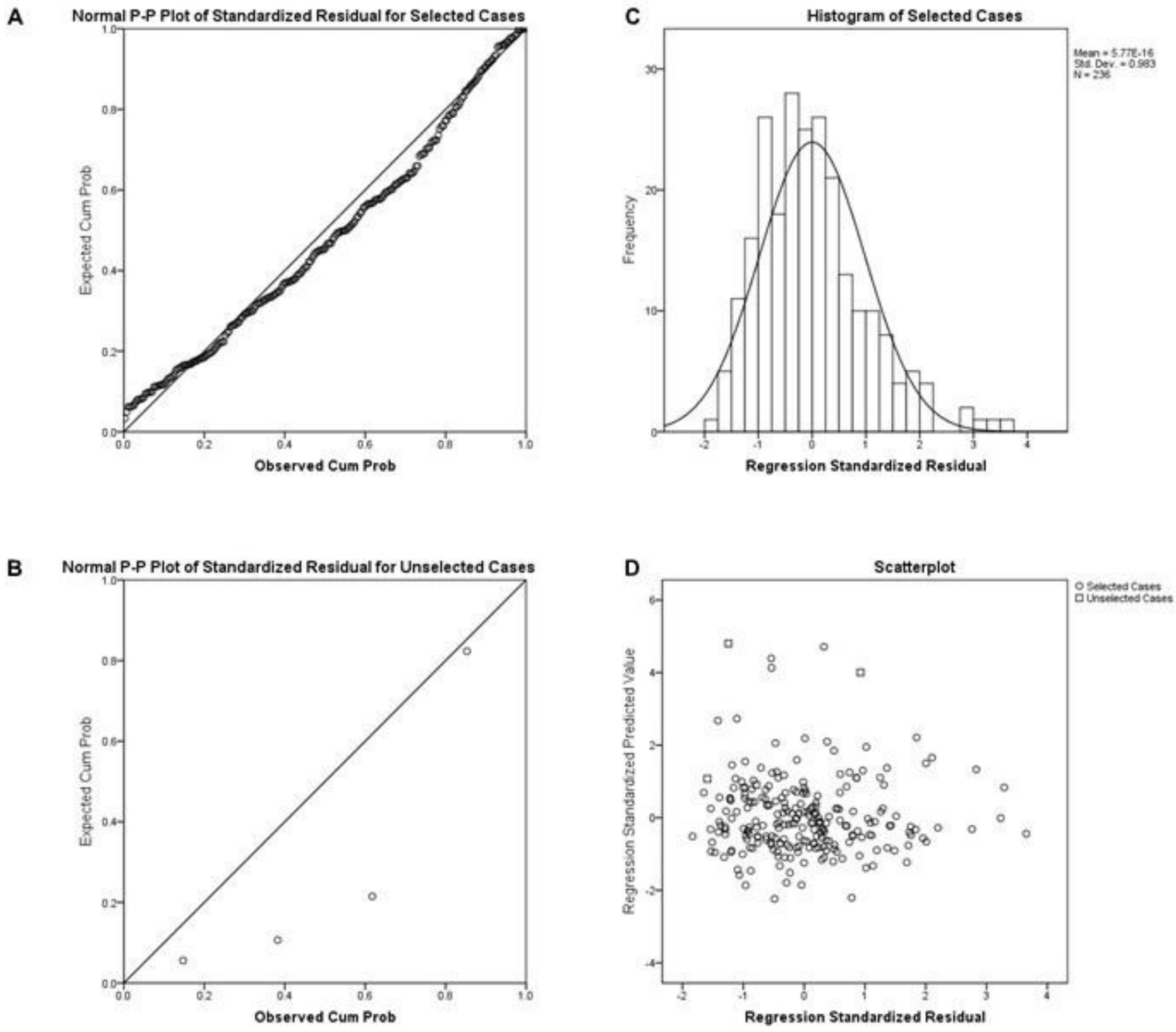
Source: own research



Panel A shows the P-P plot of the retained cases; Panel B shows the P-P plot of the removed cases; Panel C shows the histogram of retained cases; Panel D shows the scatterplot, with retained cases marked as o and removed cases marked as □

Figure 74 *Hypothesis 4e data: Plots following Mahalanobis test*

Source: own research



Panel A shows the P-P plot of the retained cases; Panel B shows the P-P plot of the removed cases; Panel C shows the histogram of retained cases; Panel D shows the scatterplot, with retained cases marked as o and removed cases marked as □

Figure 75 *Hypothesis 4j data: Plots following Mahalanobis test*

Source: own research

9.8 Descriptive statistics of finalised input variables

Table 128

Descriptive statistics: Benchmark domestic final input data

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
PgoldLRP1m	234	-15.69	12.27	0.4504	4.70749	-0.069	0.159	0.183	0.317
EPUusLRP6m	234	-241.98	236.98	1.0841	76.52175	0.070	0.159	0.563	0.317
IDXusdLRP6m	234	-8.62	14.65	0.6141	4.16255	0.594	0.159	0.724	0.317
GoldBetaUS36m	234	-.724	1.662	.11118	.573382	0.927	0.159	0.333	0.317
DefaultPremLRP6m	234	-99.62	90.33	0.9501	27.62686	0.174	0.159	1.130	0.317
INFLus12m	234	-1.286	5.600	2.19478	1.186392	-0.032	0.159	0.268	0.317
INFLusVol	234	0.108	2.658	0.62912	0.428437	2.143	0.159	5.450	0.317
ECMusSpotLRP1m	234	-13.15	14.95	0.1679	4.89608	0.037	0.159	0.369	0.317
Valid N (listwise)	234								

Source: Own research

Table 129

Descriptive statistics: Benchmark international final input data

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
PgoldLRP1m	236	-15.69	13.03	0.4836	4.76859	-0.012	0.158	0.210	0.316
EPUusLRP6m	236	-241.98	236.98	0.2137	76.78681	0.082	0.158	0.516	0.316
IDXusdLRP6m	236	-8.62	14.65	0.6216	4.15746	0.589	0.158	0.711	0.316
GoldBetaUS36m	236	-0.724	1.662	.011498	0.577411	0.924	0.158	0.289	0.316
DefaultPremLRP6m	236	-99.62	90.33	0.8388	27.92729	0.139	0.158	1.053	0.316
INFLus12m	236	-1.427	5.600	2.18253	1.205602	-0.115	0.158	0.386	0.316
INFLusVol	236	0.108	2.752	0.63829	0.448439	2.247	0.158	5.976	0.316
ECMusSpotLRP1m	236	-13.15	14.95	0.1788	4.89763	0.037	0.158	0.347	0.316
INFLworld	236	1.615	6.927	4.04332	1.068793	0.799	0.158	0.238	0.316
INFLworldVol	236	0.104	1.918	0.44011	0.321738	1.734	0.158	3.765	0.316
EPUeuLRP6m	236	-116.34	121.20	3.1657	36.66934	0.028	0.158	0.573	0.316
Valid N (listwise)	236								

Source: Own research

Table 130

Descriptive statistics: Hypothesis 1 domestic data

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
PgoldLRP1m	234	-15.69	16.00	0.4977	4.81871	0.074	0.159	0.462	0.317
EPUusLRP6m	234	-241.98	236.98	-0.0621	76.59666	0.084	0.159	0.555	0.317
EPUusVol1m	234	15.1267	141.2941	43.826298	20.7975266	1.492	0.159	2.797	0.317
DefaultPremLRP6m	234	-99.62	85.03	0.7315	27.10835	0.065	0.159	0.956	0.317
ECMusSpotLRP1m	234	-13.15	31.32	0.2248	5.19795	0.820	0.159	4.997	0.317
GoldBetaUS36m	234	-0.724	1.662	0.11667	0.579469	0.914	0.159	0.260	0.317
IDXusdLRP6m	234	-8.62	14.65	0.5708	4.07194	0.499	0.159	0.496	0.317
INFLus12m	234	-1.286	5.600	2.20262	1.185008	-0.048	0.159	0.282	0.317
INFLusVol	234	0.108	2.658	0.62723	0.427273	2.168	0.159	5.575	0.317
Valid N (listwise)	234								

Source: Own research

Table 131

Descriptive statistics: Hypothesis 1i final input data

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
PgoldLRP1m	235	-15.69	16.00	0.4979	4.85258	0.103	0.159	0.438	0.316
EPUusLRP6m	235	-241.98	236.98	-0.8444	75.77508	0.033	0.159	0.466	0.316
EPUusVol1m	235	15.1267	122.9063	43.699587	20.4135967	1.363	0.159	1.924	0.316
DefaultPremLRP6m	235	-99.62	90.33	0.7357	27.93776	0.147	0.159	1.064	0.316
ECMusSpotLRP1m	235	-13.15	31.32	0.2326	5.22409	0.824	0.159	4.851	0.316
GoldBetaUS36m	235	-0.724	1.662	0.11365	0.578740	0.928	0.159	0.282	0.316
IDXusdLRP6m	235	-8.62	14.65	0.5974	4.15339	0.602	0.159	0.745	0.316
INFLus12m	235	-1.427	5.600	2.17072	1.194592	-0.142	0.159	0.400	0.316
INFLusVol	235	0.108	2.752	0.63773	0.449313	2.247	0.159	5.957	0.316
INFLworld	235	1.615	6.927	4.03664	1.060459	0.789	0.159	0.248	0.316
INFLworldVol	235	0.104	1.918	0.43857	0.320181	1.762	0.159	3.927	0.316
EPUeuLRP6m	235	-116.34	121.20	2.7884	36.50746	0.035	0.159	0.610	0.316
Valid N (listwise)	235								

Source: Own research

Table 132

Descriptive statistics: Hypothesis 2d final input data

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
FgoldLRP1d	4805	-4.069	4.357	0.02758	0.991759	-0.208	0.035	1.181	0.071
EPUusLRP20d	4805	-335.254	329.932	0.19252	75.036054	0.088	0.035	0.986	0.071
DefaultPremLRP20d	4805	-35.364	43.193	-0.09903	9.012045	0.214	0.035	1.298	0.071
ECMusFutLRP1d	4805	-5.11	5.09	0.0039	1.07065	-0.256	0.035	2.230	0.071
GoldBeta200d	4805	-1.653	1.629	0.02132	0.548505	-0.388	0.035	1.548	0.071
IDXusdLRP20d	4805	-5.045	5.487	0.07919	1.414251	0.137	0.035	0.424	0.071
INFLus12m	4805	-2.10	5.60	2.1734	1.20828	-0.224	0.035	0.608	0.071
INFLusVol	4805	0.108	2.746	0.63516	0.446558	2.238	0.035	5.782	0.071
Valid N (listwise)	4805								

Source: Own research

Table 133

Descriptive statistics: Hypothesis 2i final input data

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
FgoldLRP1d	4827	-4.374	4.488	0.02538	1.007719	-0.199	0.035	1.383	0.070
EPUusLRP20d	4827	-335.254	329.932	-0.03628	74.977339	0.064	0.035	0.989	0.070
DefaultPremLRP20d	4827	-35.364	46.550	-0.11360	9.130149	0.220	0.035	1.492	0.070
ECMusFutLRP1d	4827	-5.11	5.18	0.0027	1.08697	-0.230	0.035	2.468	0.070
GoldBeta200d	4827	-1.653	1.629	0.02027	0.549733	-0.377	0.035	1.530	0.070
IDXusdLRP20d	4827	-5.045	5.487	0.08288	1.425020	0.140	0.035	0.463	0.070
INFLus12m	4827	-2.10	5.60	2.1776	1.21797	-0.219	0.035	0.597	0.070
INFLusVol	4827	0.108	2.752	0.63865	0.454191	2.277	0.035	5.953	0.070
EPUeuLRP1m	4827	-80.817	107.083	0.26258	24.192325	0.285	0.035	1.460	0.070
INFLworld	4827	1.36	6.93	4.0368	1.07519	0.748	0.035	0.206	0.070
INFLworldVol	4827	0.104	1.979	0.44153	0.329488	1.842	0.035	4.253	0.070
Valid N (listwise)	4827								

Source: Own research

Table 134

Descriptive statistics: Hypothesis 3d final input data

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
FgoldLRP1d	4799	-4.374	4.488	0.02717	1.004362	-0.224	0.035	1.391	0.071
EPUusVol20d	4799	11.170	143.911	43.03425	19.941394	1.281	0.035	1.691	0.071
EPUusLRP20d	4799	-335.254	329.932	-0.46483	74.327144	0.052	0.035	0.952	0.071
EPUusVol200d*	4799	27.196	104.797	53.57025	18.695963	0.819	0.035	0.028	0.071
EPUusVol60d*	4799	22.040	154.131	47.50127	19.305978	1.727	0.035	4.732	0.071
DefaultPremLRP20d	4799	-35.364	46.135	-0.17122	9.071155	0.204	0.035	1.376	0.071
ECMusFutLRP1d	4799	-5.11	5.09	0.0065	1.07758	-0.209	0.035	2.413	0.071
GoldBeta200d	4799	-1.653	1.629	0.02131	0.550508	-0.379	0.035	1.522	0.071
IDXusdLRP20d	4799	-4.300	5.487	0.07612	1.410942	0.158	0.035	0.367	0.071
INFLus12m	4799	-2.10	5.60	2.1699	1.22225	-0.243	0.035	0.651	0.071
INFLusVol	4799	0.108	2.752	0.63963	0.455672	2.265	0.035	5.881	0.071
Valid N (listwise)	4799								

Source: Own research

Table 135

Descriptive statistics: Hypothesis 3i final input data

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
FgoldLRP1d	4814	-4.374	4.488	0.02553	1.007586	-0.219	0.035	1.342	0.071
EPUusVol20d	4814	11.170	143.911	43.05651	19.952559	1.284	0.035	1.731	0.071
EPUusLRP20d	4814	-383.922	329.932	-0.49359	74.563437	0.038	0.035	1.070	0.071
EPUusVol200d*	4814	27.196	104.797	53.64620	18.766476	0.817	0.035	0.011	0.071
EPUusVol60d*	4814	22.040	154.131	47.52124	19.334787	1.749	0.035	4.877	0.071
DefaultPremLRP20d	4814	-35.364	46.135	-0.22667	9.144782	0.173	0.035	1.407	0.071
ECMusFutLRP1d	4814	-5.11	5.18	0.0043	1.08569	-0.204	0.035	2.585	0.071
GoldBeta200d	4814	-1.653	1.629	0.02072	0.549999	-0.378	0.035	1.525	0.071
IDXusdLRP20d	4814	-4.838	5.547	0.07878	1.422844	0.151	0.035	0.442	0.071
INFLus12m	4814	-2.10	5.60	2.1666	1.23242	-0.259	0.035	0.639	0.071
INFLusVol	4814	0.108	2.752	0.64465	0.464755	2.281	0.035	5.885	0.071
EPUeuLRP1m	4814	-80.817	107.083	0.01493	23.793178	0.181	0.035	1.153	0.071
INFLworld	4814	1.36	6.93	4.0269	1.08105	0.720	0.035	0.223	0.071
INFLworldVol	4814	0.104	1.979	0.44589	0.337564	1.877	0.035	4.346	0.071
Valid N (listwise)	4814								

Source: Own research

Table 136

Descriptive statistics: Hypothesis 4c final input data

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
PgoldCnyLRP1m	202	-18.38	13.25	0.6469	4.96890	-0.268	0.171	0.774	0.341
EPUcnLRP6m	202	-156.26	263.22	4.7652	63.75142	0.345	0.171	0.729	0.341
DefaultPremLRP6m	202	-99.62	90.33	-0.2373	29.63369	0.017	0.171	1.055	0.341
ECMcnLRP1m	202	-4.51	2.87	0.1184	1.20571	-0.285	0.171	0.594	0.341
GoldBetaUS36m	202	-.7243	1.6622	.152415	0.6071058	0.715	0.171	-0.152	0.341
IDXcnyLRP6m	202	-17.95	11.63	-1.1008	5.21720	-0.643	0.171	1.099	0.341
INFLcn12	202	-1.7382	8.8009	2.254513	2.1278905	0.763	0.171	0.513	0.341
INFLcnVol	202	0.3132	3.5459	0.974705	0.6182789	1.697	0.171	3.816	0.341
Valid N (listwise)	202								

Source: Own research

Table 137

Descriptive statistics: Hypothesis 4e final input data

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
PgoldEurGbpLRP1m	202	-15.86	12.56	0.7421	4.79687	0.015	0.171	0.528	0.341
EPUeuLRP6m	202	-116.34	121.20	3.4654	37.13385	0.020	0.171	0.654	0.341
DefaultPremLRP6m	202	-99.62	90.33	0.3223	29.31331	0.020	0.171	0.985	0.341
ECMeuLRP1m	202	-2.19	1.76	0.1211	0.73284	-0.083	0.171	-0.115	0.341
GoldBetaUS36m	202	-0.7243	1.6622	0.159380	0.6128261	0.700	0.171	-0.212	0.341
IDXeurgbpLRP6m	202	-9.67	7.74	-0.1337	3.01600	-0.435	0.171	0.036	0.341
INFLeuuk12	202	-0.4240	4.1324	1.795686	0.9261315	-0.349	0.171	0.012	0.341
INFLeuukVol	202	0.0972	1.4516	0.353302	0.2450666	2.319	0.171	6.124	0.341
Valid N (listwise)	202								

Source: Own research

Table 138

Descriptive statistics: Hypothesis 4j final input data

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
PgoldJpyLRP1m	236	-17.31	13.70	0.6449	4.64213	-0.286	0.158	0.995	0.316
EPUjpLRP6m	236	-68.75	97.96	1.0499	30.65735	0.465	0.158	0.458	0.316
DefaultPremLRP6m	236	-77.85	90.33	0.8797	27.29762	0.345	0.158	0.552	0.316
ECMjpLRP1m	236	-2.42	2.37	0.0979	0.71915	-0.226	0.158	0.843	0.316
GoldBetaUS36m	236	-.7243	1.6622	0.115371	0.5771900	0.924	0.158	0.291	0.316
IDXjpyLRP6m	236	-23.05	26.57	-0.8535	7.57502	0.438	0.158	1.791	0.316
INFLjpn12	236	-2.2185	3.7386	0.128650	1.0806810	1.173	0.158	1.486	0.316
INFLjpnVol	236	0.1495	1.4834	0.513440	0.2961354	1.075	0.158	0.198	0.316
Valid N (listwise)	236								

Source: Own research

9.9 Regression model estimation details for hypothesis 1, 2, 3 and 4, and benchmarks

9.9.1 Benchmarking

9.9.1.1 Benchmark domestic study: Including ECM

Table 139

Model Summary: Benchmarking domestic study, including ECM

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.890[a]	.791	.785	2.18309	2.223

a. Predictors: (Constant), ECMusSpotLRP1m, INFLus12m, DefaultPremLRP6m, EPUusLRP6m, INFLusVol, GoldBetaUS36m, IDXusdLRP6m

b. Dependent Variable: PgoldLRP1m

Source: Own research

Table 140

Coefficients for benchmarking domestic study including ECM

	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
(Constant)	-0.539	0.472		-1.142	.255		
EPUusLRP6m	0.003	0.002	0.056	1.795	.074	.936	1.069
IDXusdLRP6m	-0.049	0.044	-0.043	-1.122	.263	.620	1.614
GoldBetaUS36m	-0.502	0.295	-0.061	-1.700	.090	.714	1.401
DefaultPremLRP6m	-0.004	0.006	-0.026	-0.727	.468	.705	1.418
INFLus12m	0.206	0.148	0.052	1.388	.167	.660	1.515
INFLusVol	0.768	0.361	0.070	2.125	.035	.853	1.172
ECMusSpotLRP1m	**0.837**	**0.030**	**0.871**	**27.869**	**.000**	**.946**	**1.057**

Source: Own research

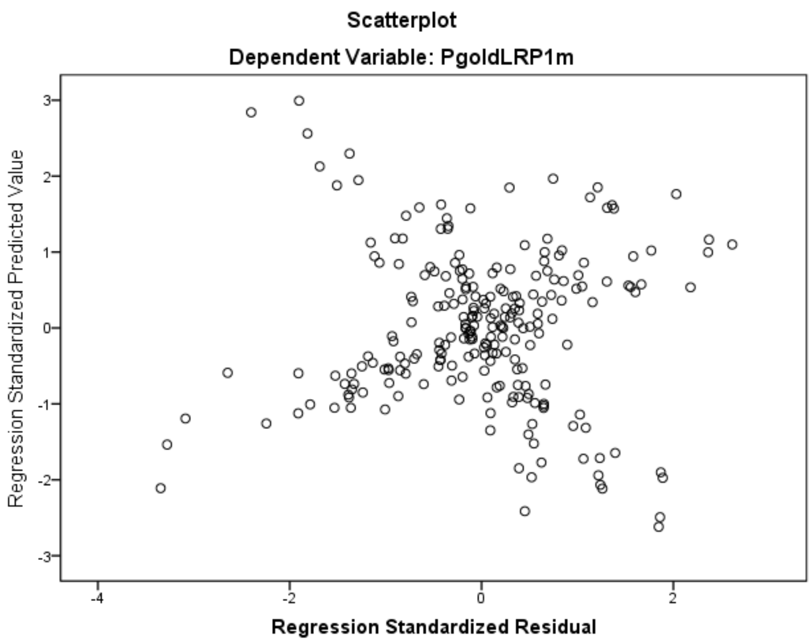


Figure 76 *Benchmark domestic study including ECMusSpotLRP1m: Scatterplot*

Source: Own research

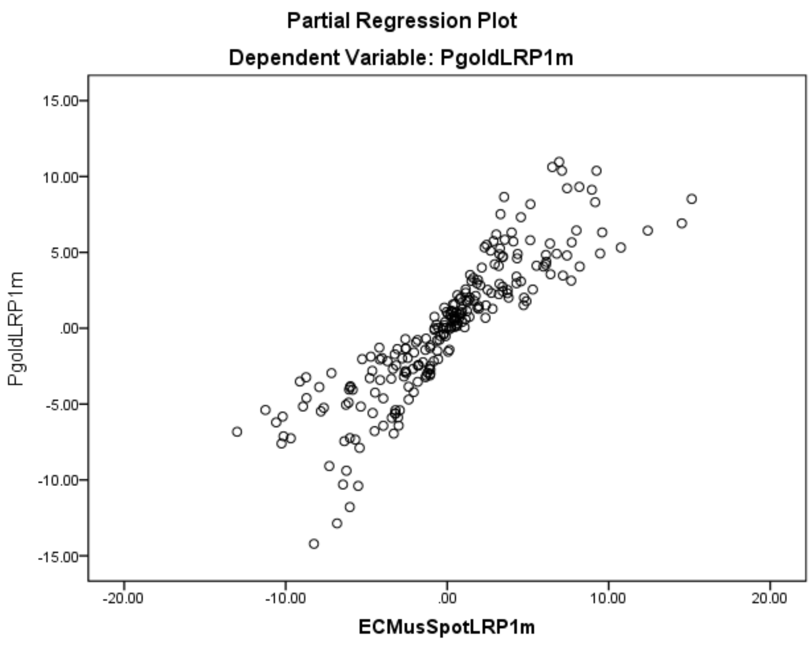


Figure 77 *Benchmark domestic study including ECMusSpotLRP1m: Partial regression plot showing strong spurious correlation.*

Source: Own research

9.9.1.2 *Benchmark domestic study: Jones and Sackley (2016) timeframe*

Table 141

Model Summary: Benchmark domestic study - Jones and Sackley (2016) timeframe

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.266[a]	.071	.039	4.48765	2.199

a. Predictors: (Constant), INFLusVol, EPUusLRP6m, GoldBetaUS36m, DefaultPremLRP6m, INFLus12m, IDXusdLRP6m

b. Dependent Variable: PgoldLRP1m

Source: Own research

Table 142

ANOVA: Benchmark domestic study - Jones and Sackley (2016) timeframe

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	267.386	6	44.564	2.213	.044[b]
	Residual	3504.179	174	20.139		
	Total	3771.564	180			

a. Dependent Variable: PgoldLRP1m

b. Predictors: (Constant), INFLusVol, EPUusLRP6m, GoldBetaUS36m, DefaultPremLRP6m, INFLus12m, IDXusdLRP6m

Source: Own research

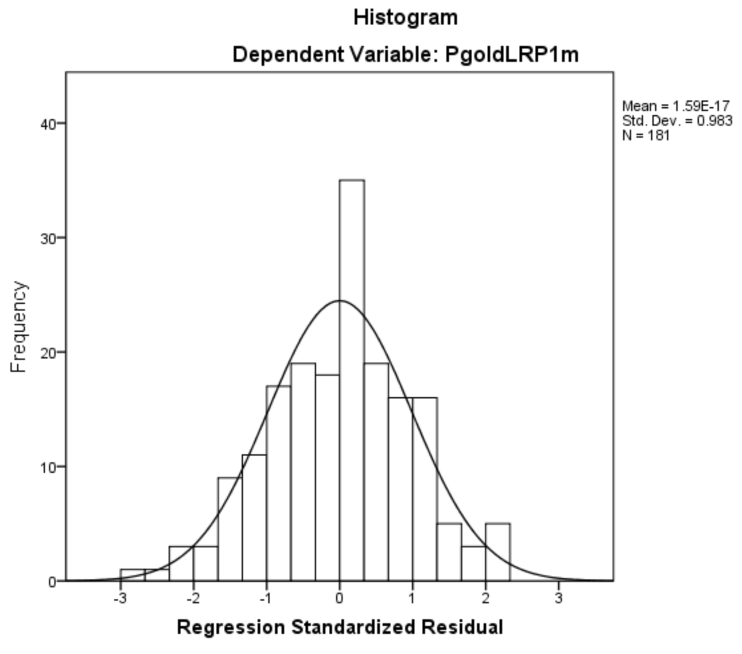


Figure 78 *Residuals histogram: Benchmark domestic study - Jones and Sackley (2016) timeframe*

Source: Own research

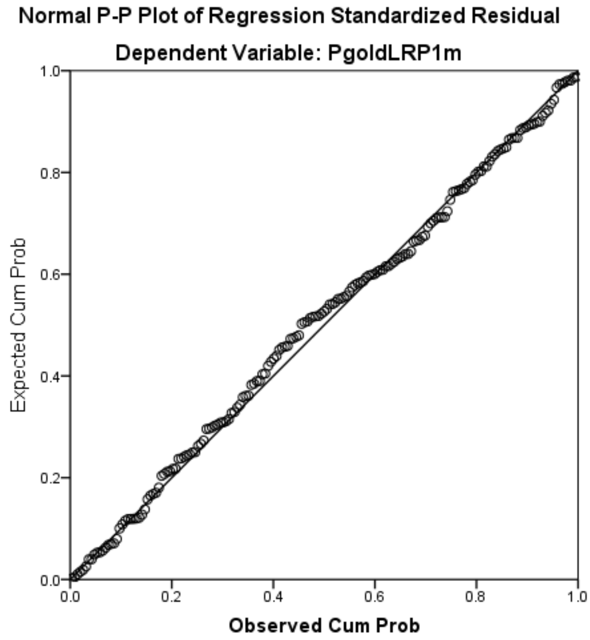


Figure 79 *P-P Plot: Benchmark domestic study - Jones and Sackley (2016) timeframe*

Source: Own research

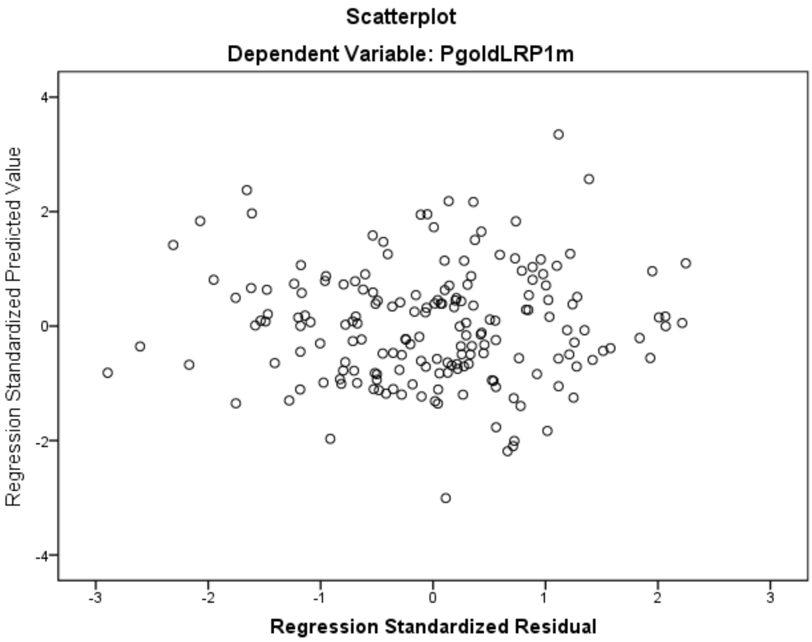


Figure 80 *Residual Scatterplot: Benchmark domestic study - Jones and Sackley (2016) timeframe*

Source: Own research

9.9.1.3 Benchmark domestic study: Complete timeframe

Table 143

Model Summary: Benchmark domestic study - Complete timeframe

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.273[a]	.075	.050	4.58820	2.195

a. Predictors: (Constant), INFLusVol, IDXusdLRP6m, EPUusLRP6m, GoldBetaUS36m, DefaultPremLRP6m, INFLus12m

b. Dependent Variable: PgoldLRP1m

Source: Own research

Table 144

ANOVA: Benchmark domestic study - Complete timeframe

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	384.681	6	64.114	3.046	.007[b]
	Residual	4778.706	227	21.052		
	Total	5163.387	233			

a. Dependent Variable: PgoldLRP1m

b. Predictors: (Constant), INFLusVol, IDXusdLRP6m, EPUusLRP6m, GoldBetaUS36m, DefaultPremLRP6m, INFLus12m

Source: Own research

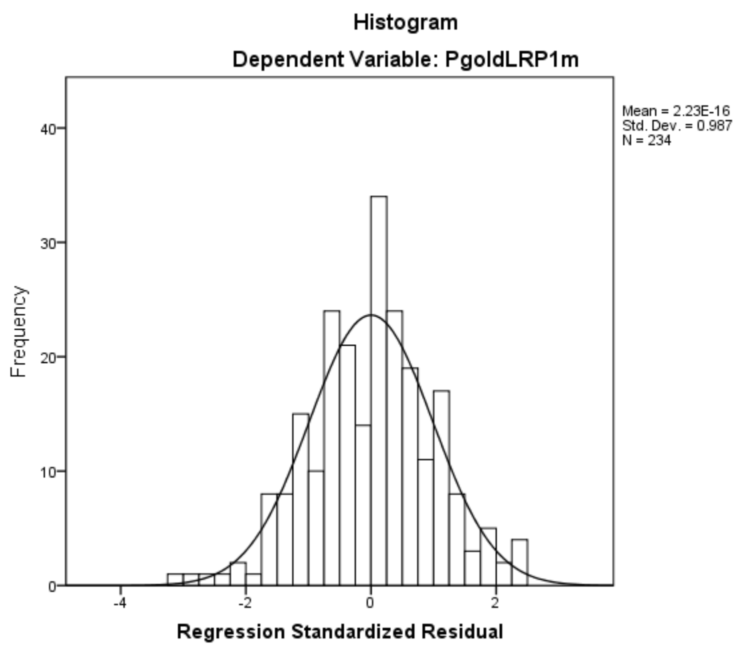


Figure 81 *Residuals histogram: Benchmark domestic study - Complete timeframe*

Source: Own research

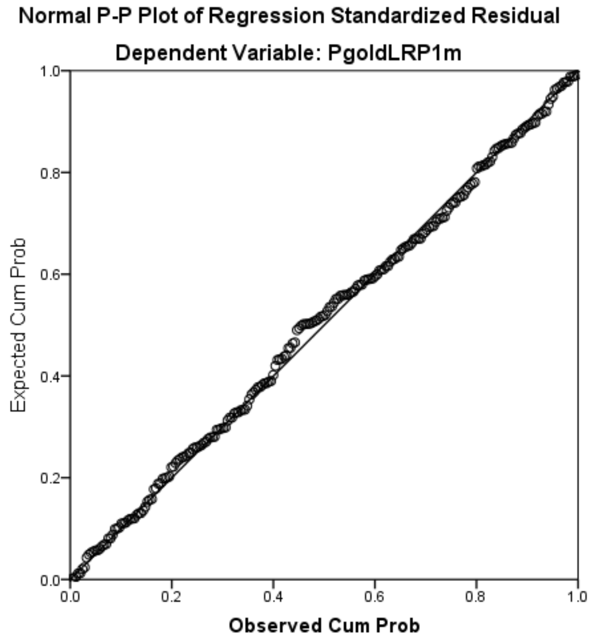


Figure 82 *P-P plot: Benchmark domestic study - Complete timeframe*

Source: Own research

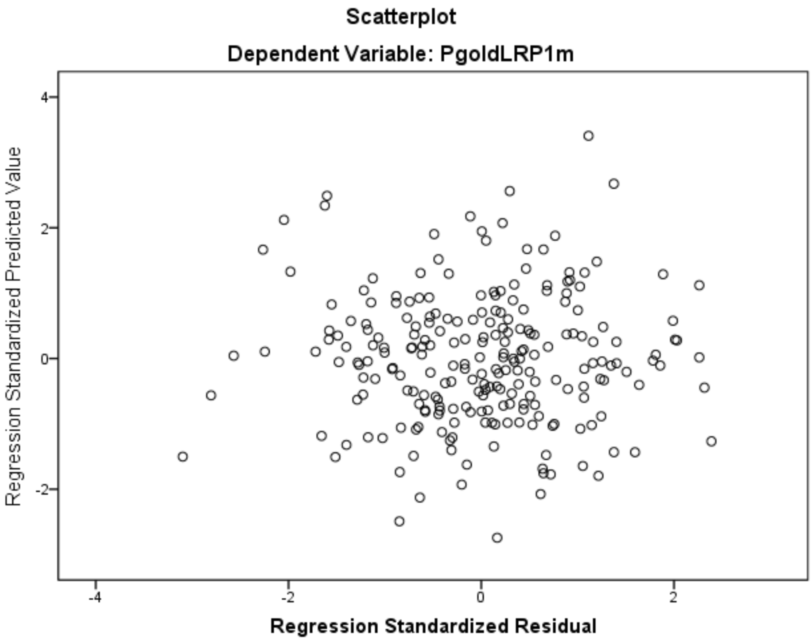


Figure 83 *Residual scatterplot: Benchmark domestic study - Complete timeframe*

Source: Own research

9.9.1.4 <u>Benchmark domestic study: Complete timeframe, with AR1 term</u>

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.307a	.094	.066	4.54884	2.005

a. Predictors: (Constant), INFLusVol, IDXusdLRP6m, EPUusLRP6m, PgoldLRP1m_L1, GoldBetaUS36m, DefaultPremLRP6m, INFLus12m

b. Dependent Variable: PgoldLRP1m

Source: Own research

Table 145

Model summary: Benchmark domestic study - Complete timeframe, with AR1

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.307[a]	.094	.066	4.54884	2.005

a. Predictors: (Constant), INFLusVol, IDXusdLRP6m, EPUusLRP6m, PgoldLRP1m_L1, GoldBetaUS36m, DefaultPremLRP6m, INFLus12m

b. Dependent Variable: PgoldLRP1m

Source: Own research

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	487.013	7	69.573	3.362	.002b
	Residual	4676.373	226	20.692		
	Total	5163.387	233			

a. Dependent Variable: PgoldLRP1m

b. Predictors: (Constant), INFLusVol, IDXusdLRP6m, EPUusLRP6m, PgoldLRP1m_L1, GoldBetaUS36m, DefaultPremLRP6m, INFLus12m

Source: Own research

Table 146

ANOVA: Benchmark domestic study - Complete timeframe, with AR1

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	487.013	7	69.573	3.362	.002[b]
	Residual	4676.373	226	20.692		
	Total	5163.387	233			

a. Dependent Variable: PgoldLRP1m

b. Predictors: (Constant), INFLusVol, IDXusdLRP6m, EPUusLRP6m, PgoldLRP1m_L1, GoldBetaUS36m, DefaultPremLRP6m, INFLus12m

Source: Own research

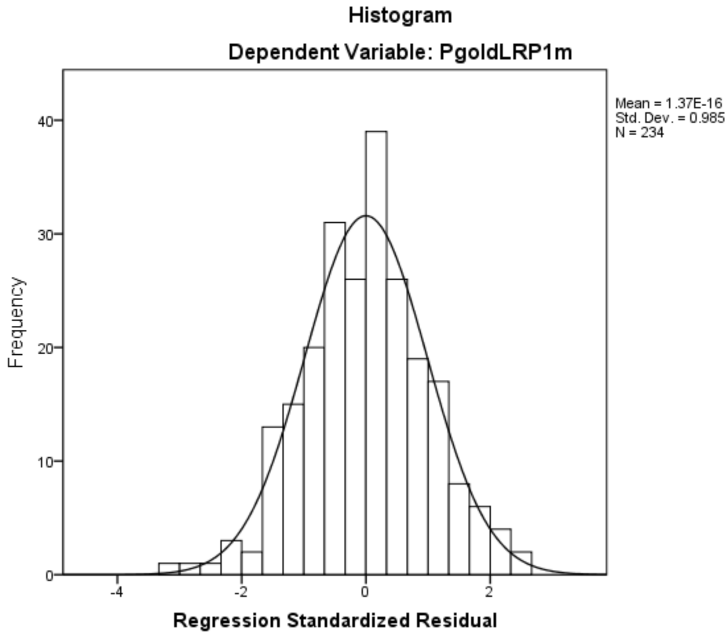


Figure 84 *Residual histogram: Benchmark domestic study - Complete timeframe, with AR1 term*

Source: Own research

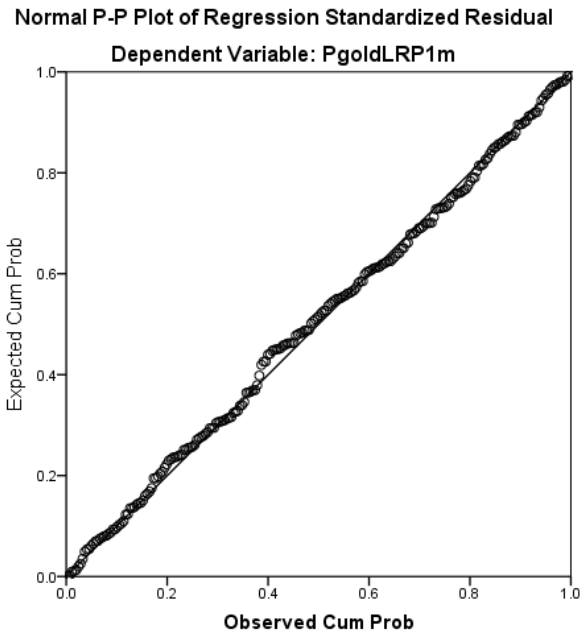


Figure 85 *P-P plot: Benchmark domestic study - Complete timeframe, with AR1 term*

Source: Own research

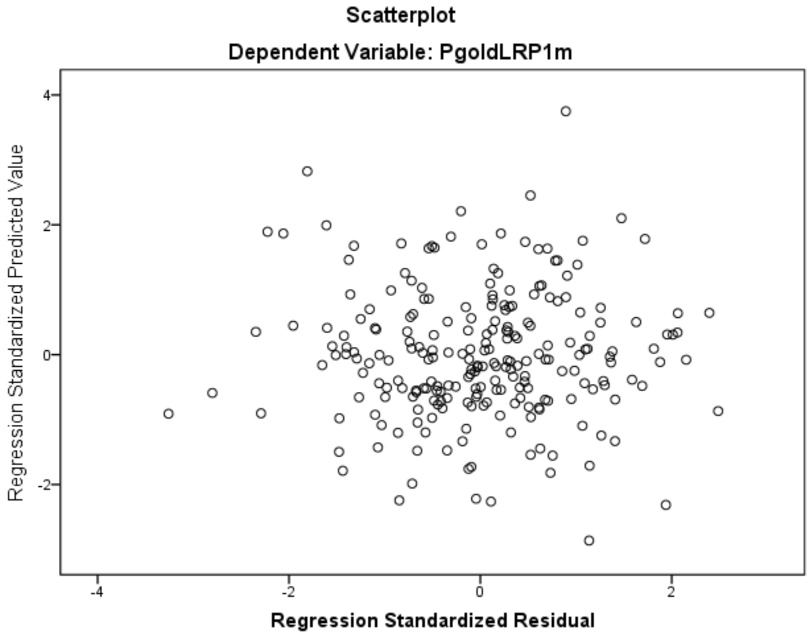


Figure 86 *Residual scatterplot: Benchmark domestic study - Complete timeframe, with AR1 term*

Source: Own research

9.9.1.5 Benchmark international study: Jones and Sackley (2016) timeframe

Table 147

Model summary: Benchmark international study - Jones and Sackley (2016) timeframe

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.275[a]	.076	.028	4.59152	2.295

a. Predictors: (Constant), INFLworldVol, INFLworld, EPUeuLRP6m, GoldBetaUS36m, IDXusdLRP6m, EPUusLRP6m, DefaultPremLRP6m, INFLus12m, INFLusVol

b. Dependent Variable: PgoldLRP1m

Source: Own research

Table 148

ANOVA: Benchmark international study - Jones and Sackley (2016) timeframe

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	298.903	9	33.211	1.575	.126[b]
	Residual	3647.201	173	21.082		
	Total	3946.104	182			

a. Dependent Variable: PgoldLRP1m

b. Predictors: (Constant), INFLworldVol, INFLworld, EPUeuLRP6m, GoldBetaUS36m, IDXusdLRP6m, EPUusLRP6m, DefaultPremLRP6m, INFLus12m, INFLusVol

Source: Own research

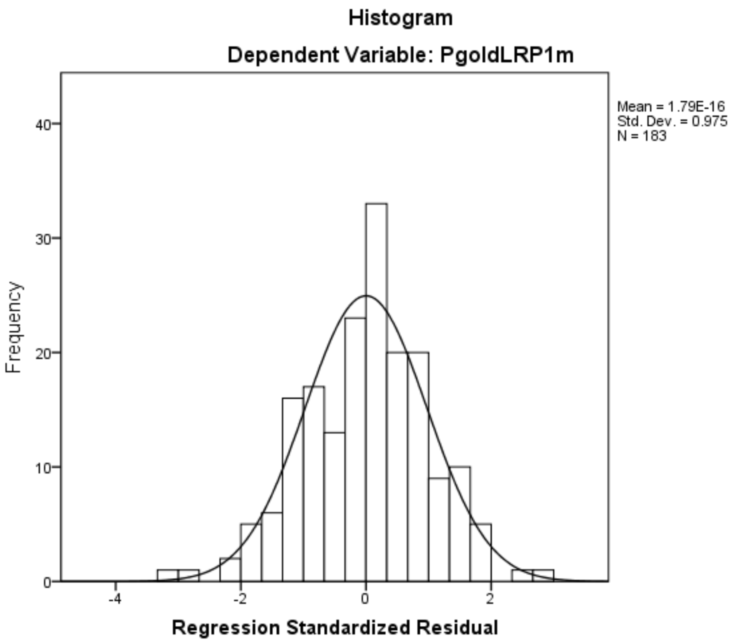


Figure 87 *Residual histogram: Benchmark international study - Jones and Sackley (2016) timeframe*

Source: Own research

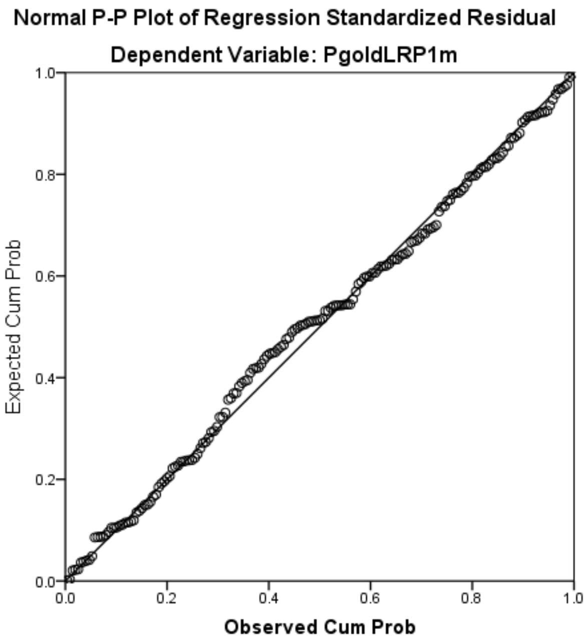


Figure 88 *P-P plot: Benchmark international study - Jones and Sackley (2016) timeframe*

Source: Own research

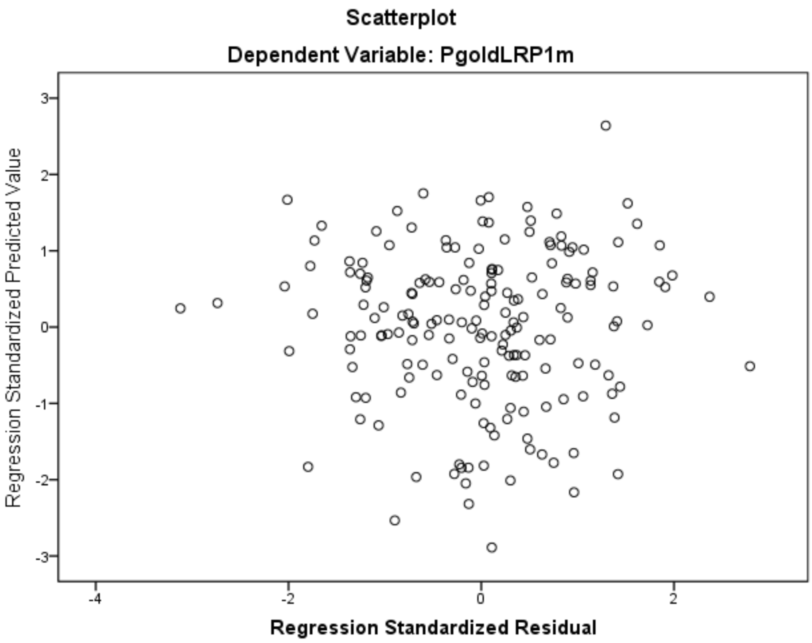


Figure 89 *Residual scatterplot: Benchmark international study - Jones and Sackley (2016) timeframe*

Source: Own research

9.9.1.6 Benchmark international study: Complete timeframe for this study

Table 149

Model summary: Benchmark international study – Complete timeframe

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.283[a]	.080	.043	4.66379	2.249

a. Predictors: (Constant), INFLworldVol, DefaultPremLRP6m, GoldBetaUS36m, EPUeuLRP6m, INFLworld, EPUusLRP6m, IDXusdLRP6m, INFLus12m, INFLusVol

b. Dependent Variable: PgoldLRP1m

Source: Own research

Table 150

ANOVA: Benchmark international study – Complete timeframe

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	428.073	9	47.564	2.187	.024[b]
	Residual	4915.708	226	21.751		
	Total	5343.781	235			

a. Dependent Variable: PgoldLRP1m

b. Predictors: (Constant), INFLworldVol, DefaultPremLRP6m, GoldBetaUS36m, EPUeuLRP6m, INFLworld, EPUusLRP6m, IDXusdLRP6m, INFLus12m, INFLusVol

Source: Own research

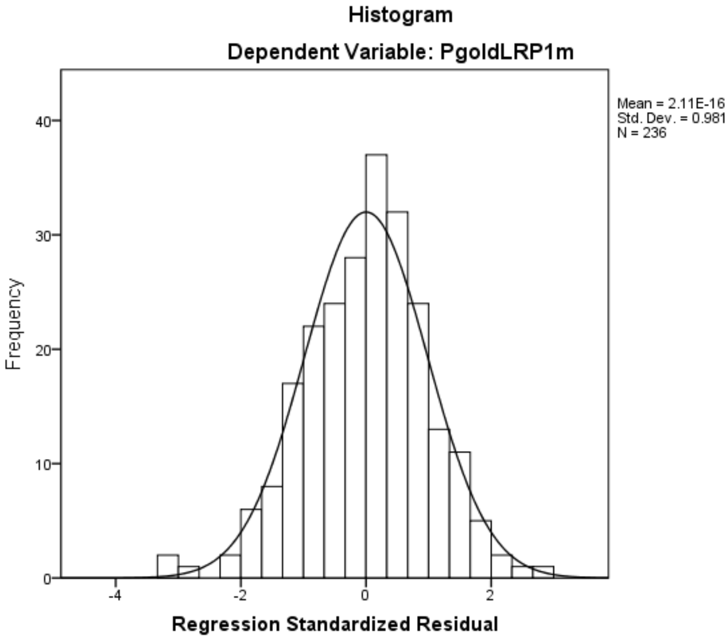


Figure 90 *Residual histogram: Benchmark international study – Complete timeframe*

Source: Own research

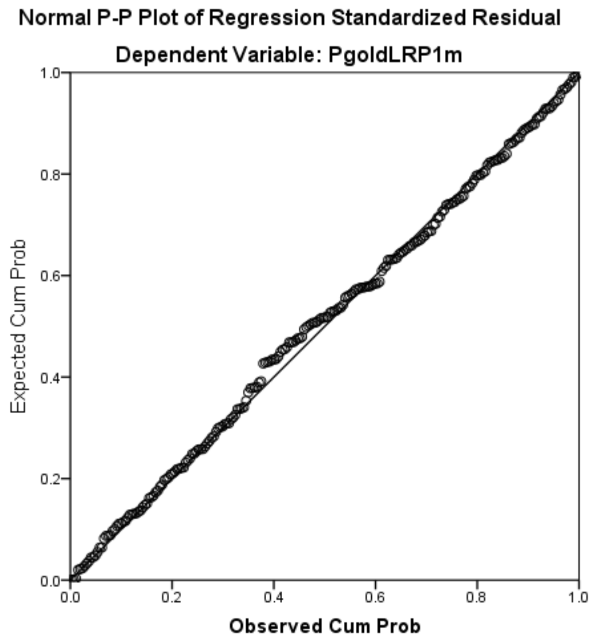


Figure 91 *P-P plot: Benchmark international study – Complete timeframe*

Source: Own research

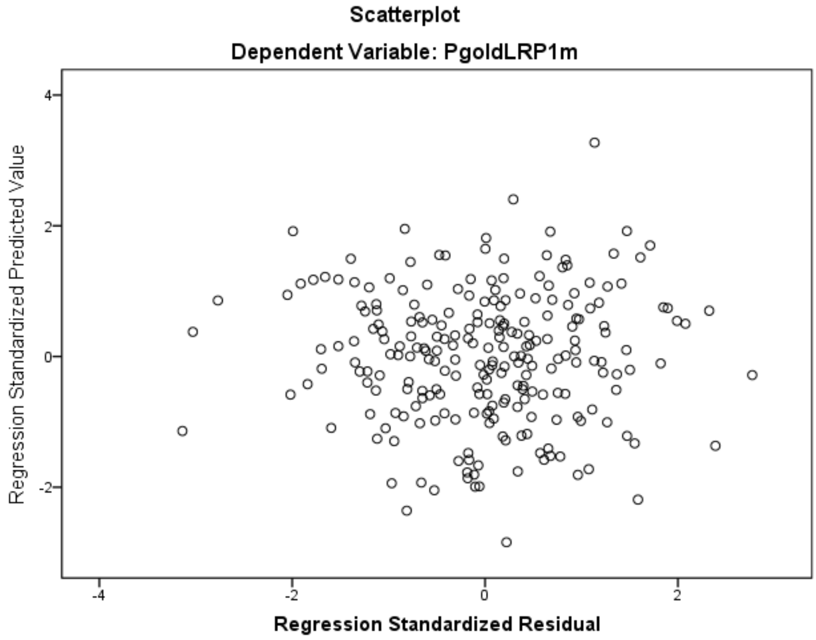


Figure 92 *Residual scatterplot: Benchmark international study – Complete timeframe*

Source: Own research

9.9.1.7 *Benchmark international study: Complete timeframe for this study, with AR1 term*

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.341a	.116	.077	4.58078	1.957

a. Predictors: (Constant), INFLworldVol, DefaultPremLRP6m, PgoldLRP1m_L1, GoldBetaUS36m, EPUeuLRP6m, INFLworld, EPUusLRP6m, IDXusdLRP6m, INFLus12m, INFLusVol

b. Dependent Variable: PgoldLRP1m

Source: own research

Table 151

Model summary: Benchmark international study – Complete timeframe, with AR1

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.341[a]	.116	.077	4.58078	1.957

a. Predictors: (Constant), INFLworldVol, DefaultPremLRP6m, PgoldLRP1m_L1, GoldBetaUS36m, EPUeuLRP6m, INFLworld, EPUusLRP6m, IDXusdLRP6m, INFLus12m, INFLusVol

b. Dependent Variable: PgoldLRP1m

Source: own research

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	622.473	10	62.247	2.966	.002b
	Residual	4721.308	225	20.984		
	Total	5343.781	235			

a. Dependent Variable: PgoldLRP1m

b. Predictors: (Constant), INFLworldVol, DefaultPremLRP6m, PgoldLRP1m_L1, GoldBetaUS36m, EPUeuLRP6m, INFLworld, EPUusLRP6m, IDXusdLRP6m, INFLus12m, INFLusVol

Source: own research

Table 152

ANOVA: Benchmark international study – Complete timeframe, with AR1

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	622.473	10	62.247	2.966	.002[b]
	Residual	4721.308	225	20.984		
	Total	5343.781	235			

a. Dependent Variable: PgoldLRP1m

b. Predictors: (Constant), INFLworldVol, DefaultPremLRP6m, PgoldLRP1m_L1, GoldBetaUS36m, EPUeuLRP6m, INFLworld, EPUusLRP6m, IDXusdLRP6m, INFLus12m, INFLusVol

Source: own research

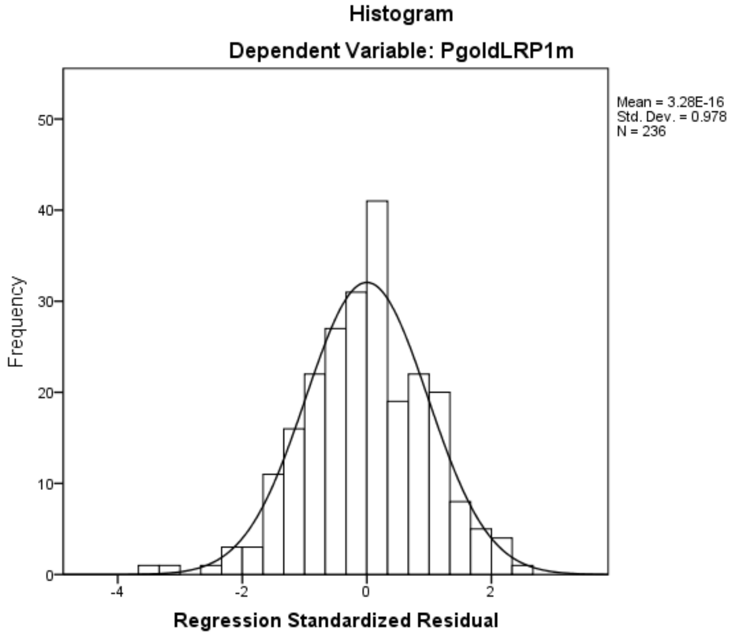


Figure 93 *Residual histogram: Benchmark international study – Complete timeframe, with AR1*

Source: Own research

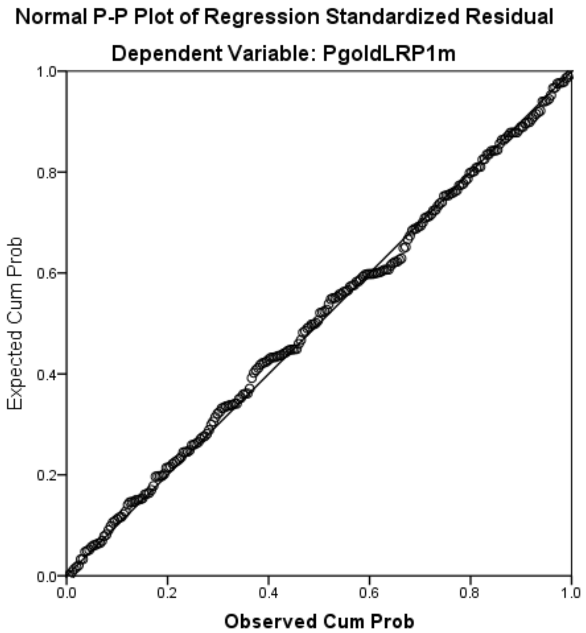


Figure 94 *P-P plot: Benchmark international study – Complete timeframe, with AR1*

Source: Own research

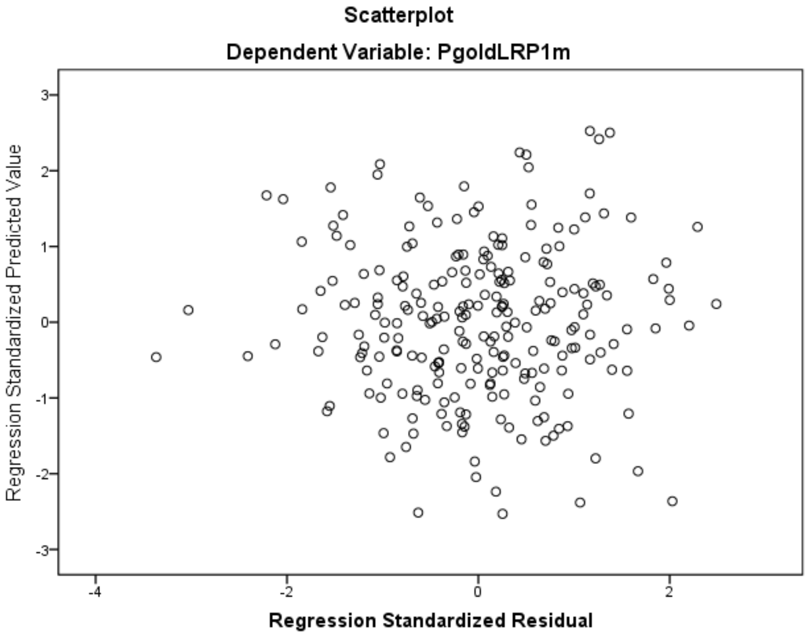


Figure 95 *Residual scatterplot: Benchmark international study – Complete timeframe, with AR1*

Source: Own research

9.9.2 Hypothesis 1

9.9.2.1 Hypothesis 1d, US domestic study, with 1-month EPU volatility

Table 153

Model summary: Hypothesis 1d, US domestic study, with 1-month EPU volatility

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.273[a]	.074	.046	4.70705	2.205

a. Predictors: (Constant), INFLusVol, IDXusdLRP6m, EPUusVol1m, GoldBetaUS36m, EPUusLRP6m, DefaultPremLRP6m, INFLus12m

b. Dependent Variable: PgoldLRP1m

Source: Own research

Table 154

ANOVA: Hypothesis 1d, US domestic study, with 1-month EPU volatility

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	402.927	7	57.561	2.598	.013[b]
	Residual	5007.332	226	22.156		
	Total	5410.259	233			

a. Dependent Variable: PgoldLRP1m

b. Predictors: (Constant), INFLusVol, IDXusdLRP6m, EPUusVol1m, GoldBetaUS36m, EPUusLRP6m, DefaultPremLRP6m, INFLus12m

Source: Own research

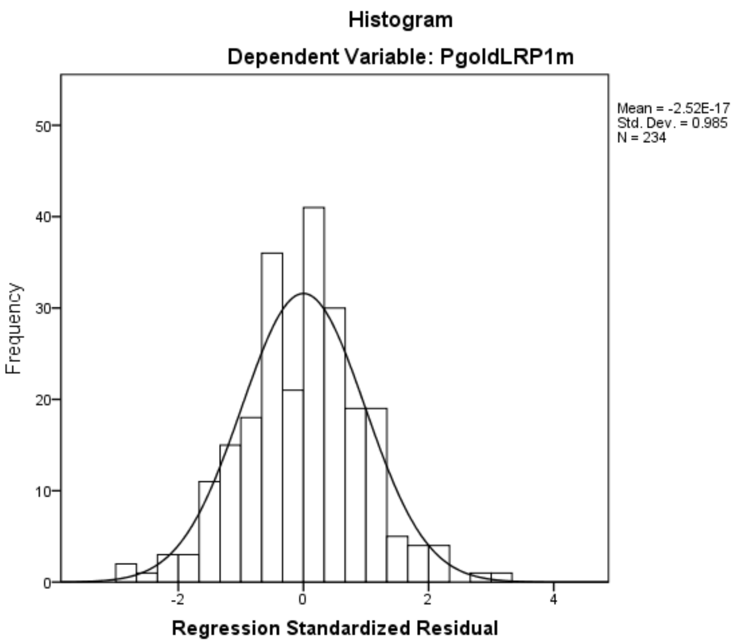


Figure 96 *Residual histogram: Hypothesis 1d, US domestic study, with 1-month EPU volatility*

Source: Own research

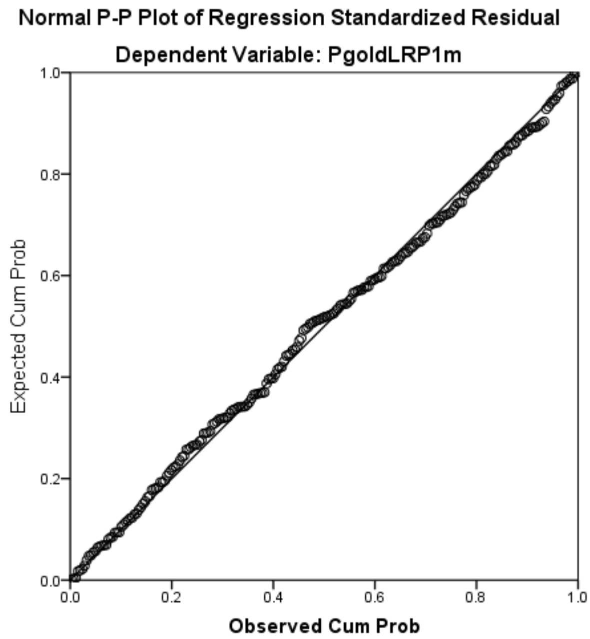


Figure 97 *P-P plot: Hypothesis 1d, US domestic study, with 1-month EPU volatility*

Source: Own research

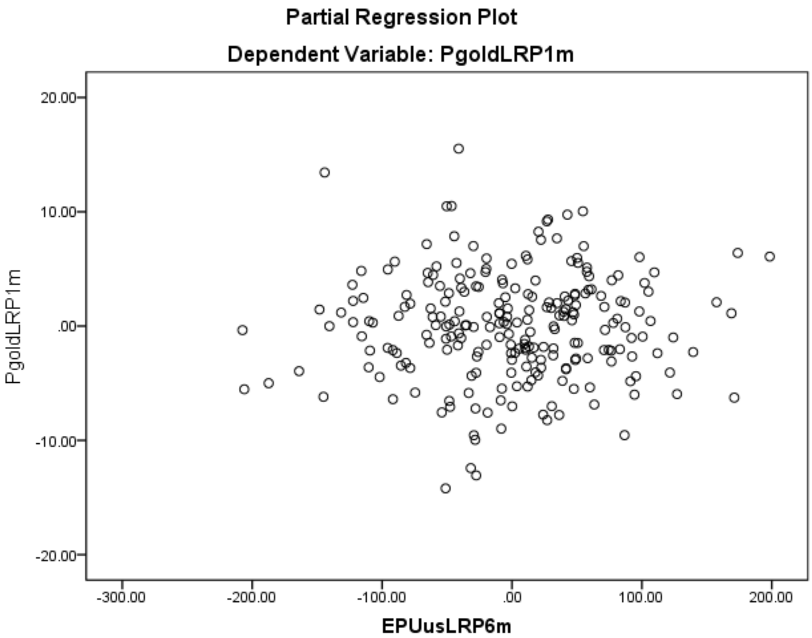


Figure 98 *Residual scatterplot: Hypothesis 1d, US domestic study, with 1-month EPU volatility*

Source: Own research

9.9.2.2 Hypothesis 1i, US international study, with 1-month EPU volatility

Table 155

Model summary: Hypothesis 1d, US international study, with 1-month EPU volatility

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.293[a]	.086	.045	4.74209	2.220

a. Predictors: (Constant), INFLworldVol, IDXusdLRP6m, EPUusVol1m, INFLworld, GoldBetaUS36m, EPUusLRP6m, EPUeuLRP6m, DefaultPremLRP6m, INFLus12m, INFLusVol

b. Dependent Variable: PgoldLRP1m

Source: Own research

Table 156

ANOVA: Hypothesis 1d, US international study, with 1-month EPU volatility

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	472.951	10	47.295	2.103	.025[b]
	Residual	5037.180	224	22.487		
	Total	5510.131	234			

a. Dependent Variable: PgoldLRP1m

b. Predictors: (Constant), INFLworldVol, IDXusdLRP6m, EPUusVol1m, INFLworld, GoldBetaUS36m, EPUusLRP6m, EPUeuLRP6m, DefaultPremLRP6m, INFLus12m, INFLusVol

Source: Own research

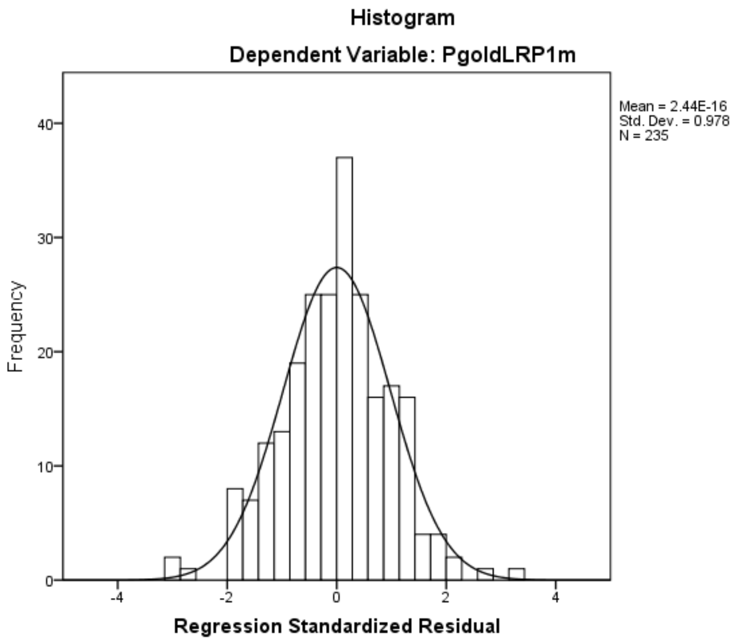


Figure 99 *Residual histogram: Hypothesis 1d, US international study, with 1-month EPU volatility*

Source: Own research

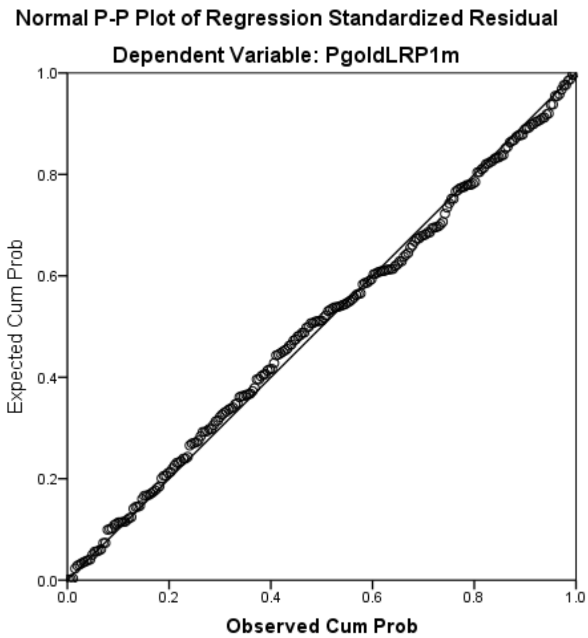


Figure 100 *P-P plot: Hypothesis 1d, US international study, with 1-month EPU volatility*

Source: Own research

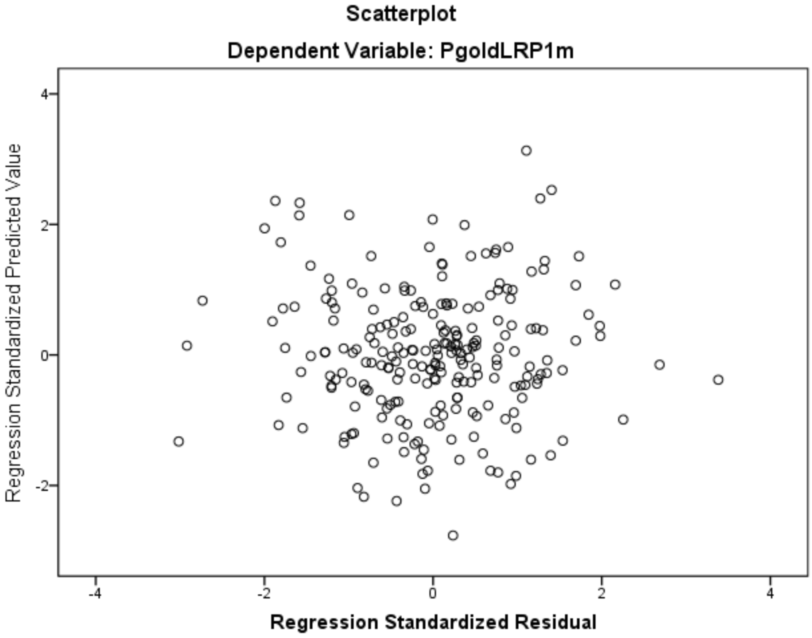


Figure 101 *Residual scatterplot: Hypothesis 1d, US international study, with 1-month EPU volatility*

Source: Own research

9.9.2.3 Hypothesis 1d, US domestic study, with 1-month EPU volatility and AR1

Table 157

Model summary: Hypothesis 1d, US domestic study, with 1-month EPU volatility and AR1

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.304[a]	.092	.060	4.67182	1.986

a. Predictors: (Constant), INFLusVol, IDXusdLRP6m, EPUusVol1m, PgoldLRP1m_L1, GoldBetaUS36m, EPUusLRP6m, DefaultPremLRP6m, INFLus12m

b. Dependent Variable: PgoldLRP1m

Source: Own research

Table 158

ANOVA: Hypothesis 1d, US domestic study, with 1-month EPU volatility and AR1

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	499.425	8	62.428	2.860	.005[b]
	Residual	4910.834	225	21.826		
	Total	5410.259	233			

a. Dependent Variable: PgoldLRP1m

b. Predictors: (Constant), INFLusVol, IDXusdLRP6m, EPUusVol1m, PgoldLRP1m_L1, GoldBetaUS36m, EPUusLRP6m, DefaultPremLRP6m, INFLus12m

Source: Own research

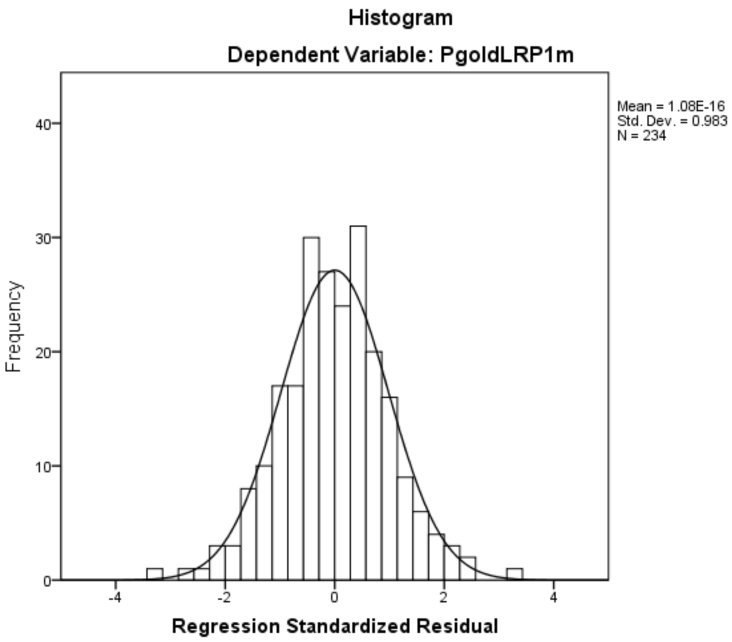


Figure 102 *Residual histogram: Hypothesis 1d, US domestic study, with 1-month EPU volatility and AR1*

Source: Own research

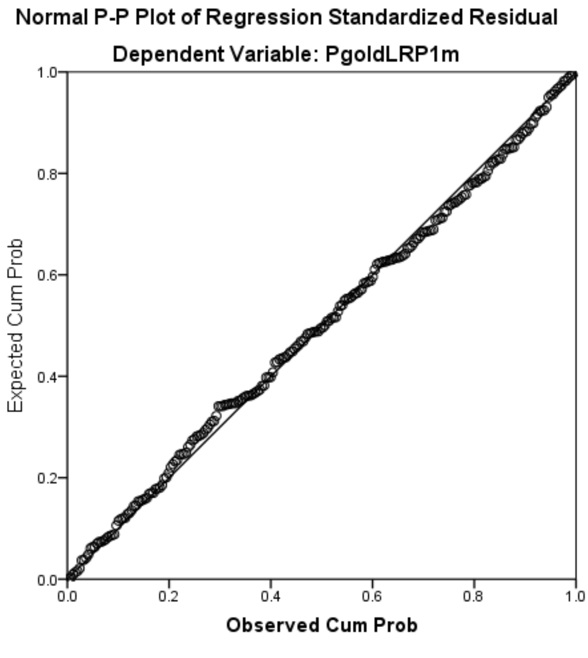


Figure 103 *P-P plot: Hypothesis 1d, US domestic study, with 1-month EPU volatility and AR1*

Source: Own research

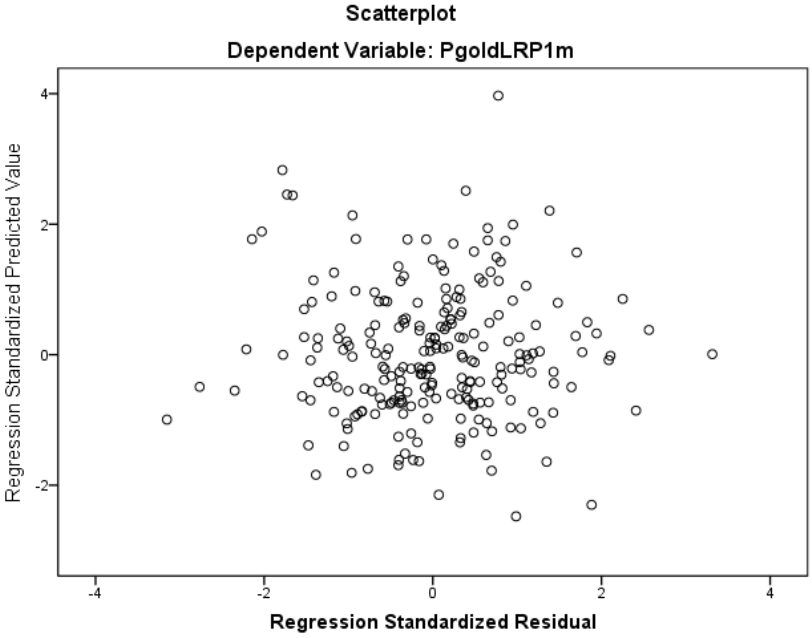


Figure 104 *Residual scatterplot: Hypothesis 1d, US domestic study, with 1-month EPU volatility and AR1*

Source: Own research

9.9.2.4 <u>*Hypothesis 1i, US international study, with 1-month EPU volatility and AR1*</u>

Table 159

Model summary: Hypothesis 1d, US international study, with 1-month EPU volatility and AR1

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.339[a]	.115	.071	4.67646	1.941

a. Predictors: (Constant), INFLworldVol, IDXusdLRP6m, EPUusVol1m, PgoldLRP1m_L1, INFLworld, GoldBetaUS36m, EPUusLRP6m, EPUeuLRP6m, DefaultPremLRP6m, INFLus12m, INFLusVol

b. Dependent Variable: PgoldLRP1m

Source: Own research

Table 160

ANOVA: Hypothesis 1d, US international study, with 1-month EPU volatility and AR1

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	633.274	11	57.570	2.632	.004[b]
	Residual	4876.857	223	21.869		
	Total	5510.131	234			

a. Dependent Variable: PgoldLRP1m

b. Predictors: (Constant), INFLworldVol, IDXusdLRP6m, EPUusVol1m, PgoldLRP1m_L1, INFLworld, GoldBetaUS36m, EPUusLRP6m, EPUeuLRP6m, DefaultPremLRP6m, INFLus12m, INFLusVol

Source: Own research

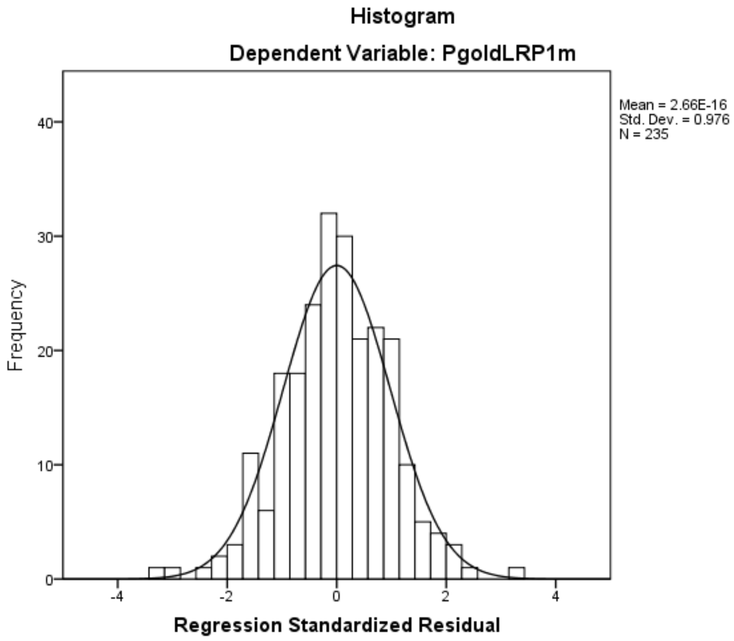


Figure 105 *Residual histogram: Hypothesis 1d, US international study, with 1-month EPU volatility and AR1*

Source: Own research

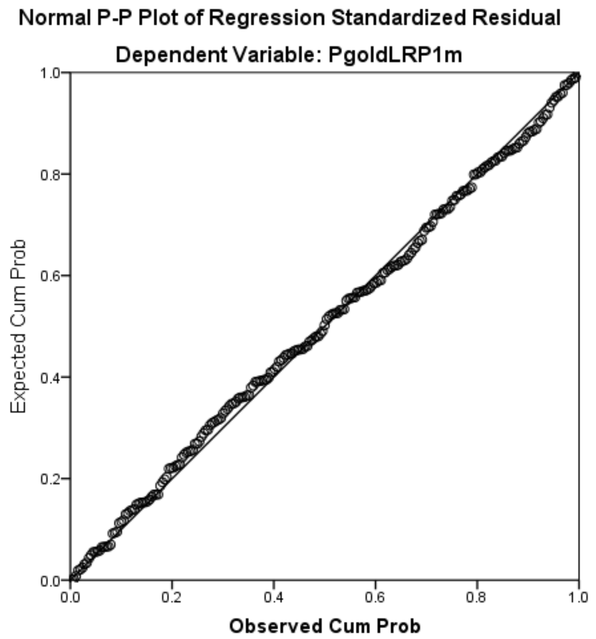


Figure 106 *P-P plot: Hypothesis 1d, US international study, with 1-month EPU volatility and AR1*

Source: Own research

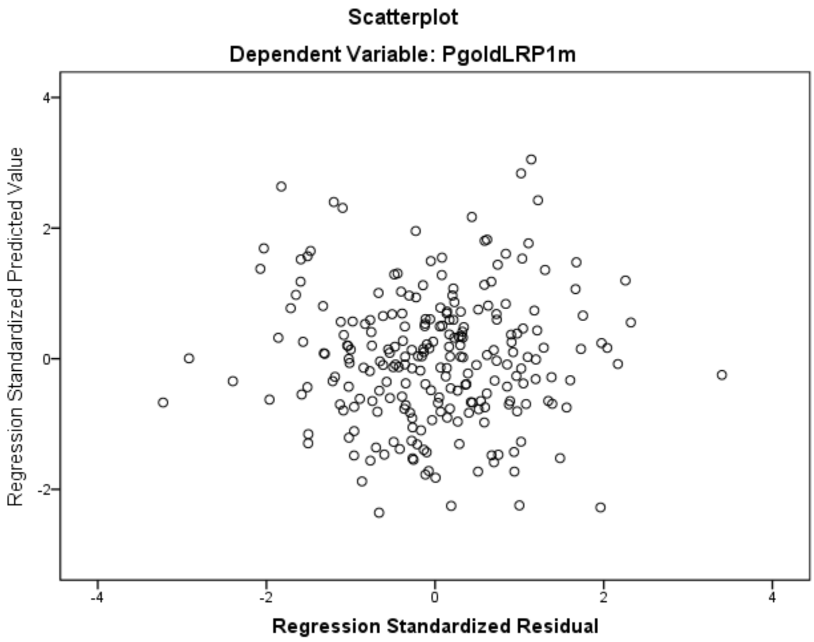


Figure 107 *Residual scatterplot: Hypothesis 1d, US international study, with 1-month EPU volatility and AR1*

Source: Own research

9.9.2.5 *Granger causality tests for selected variables in hypothesis 1*

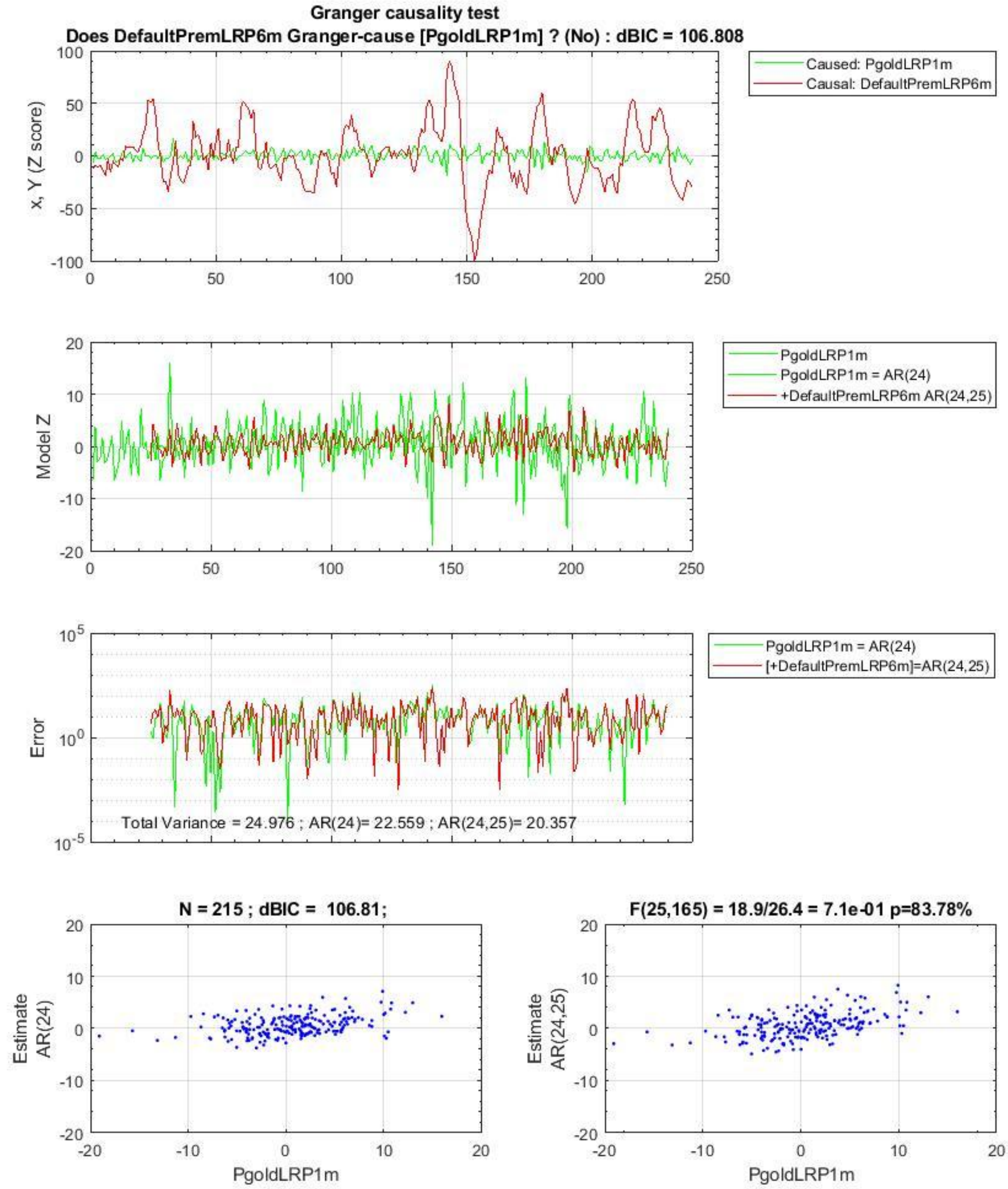


Figure 108 *Results of the test to determine whether DefaultPremiumLRP6m Granger-causes PgoldLRP1m*

Source: Own research

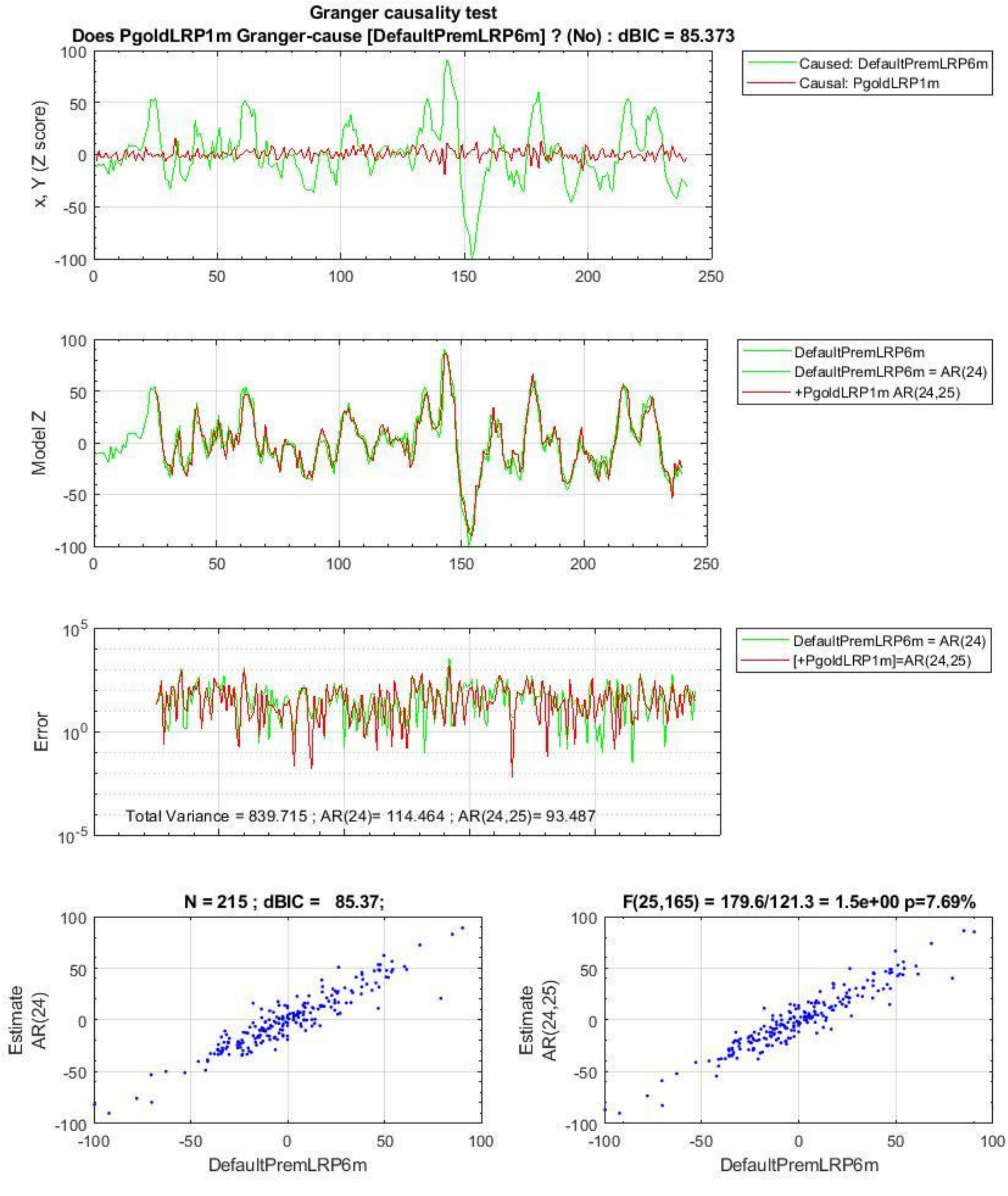


Figure 109 *Results of the test to determine whether PgoldLRP1m Granger-causes DefaultPremiumLRP6m*

Source: Own research

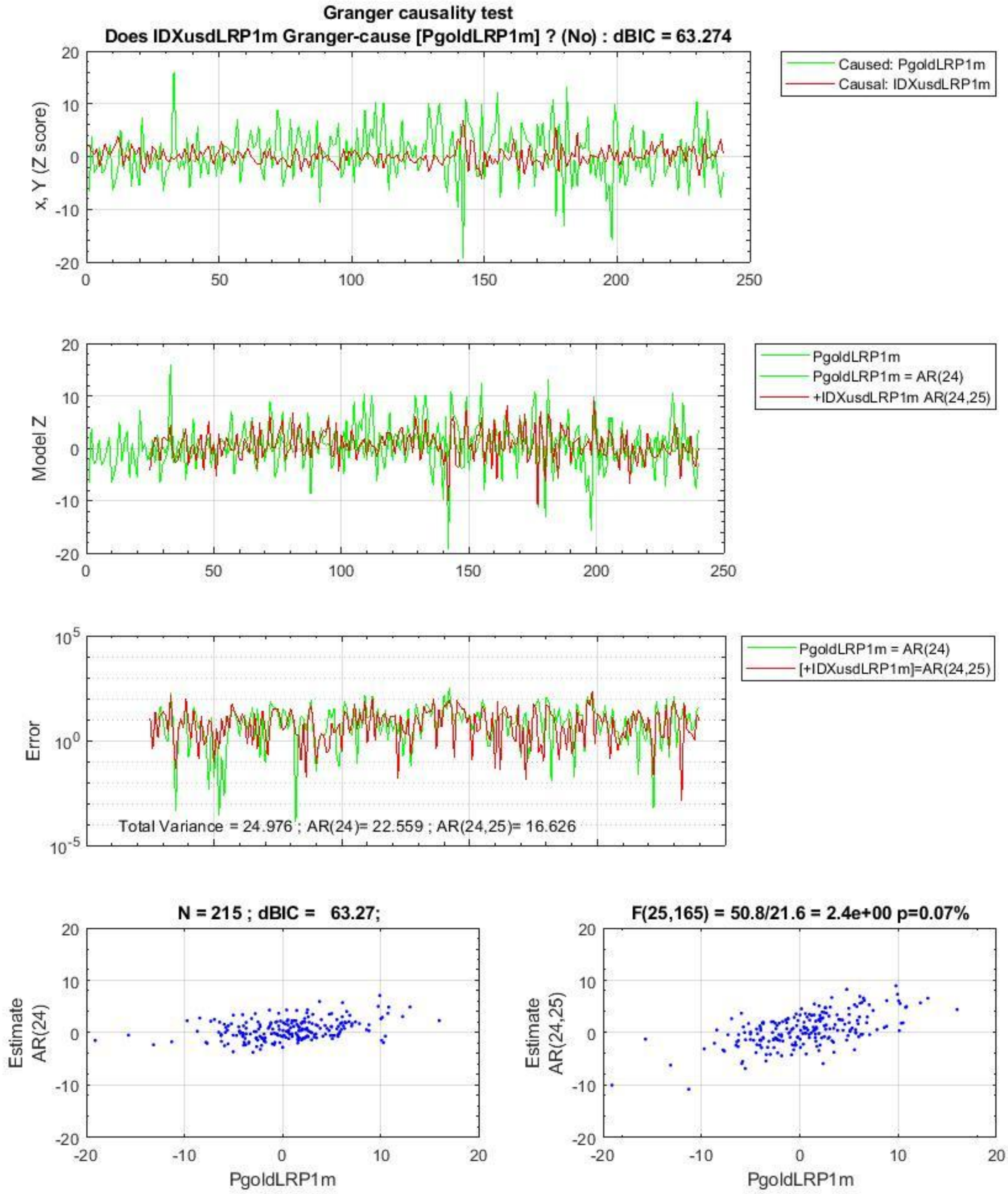


Figure 110 *Results of the test to determine whether IDXusdLRP1m Granger-causes DefaultPremiumLRP6m*

Source: Own research

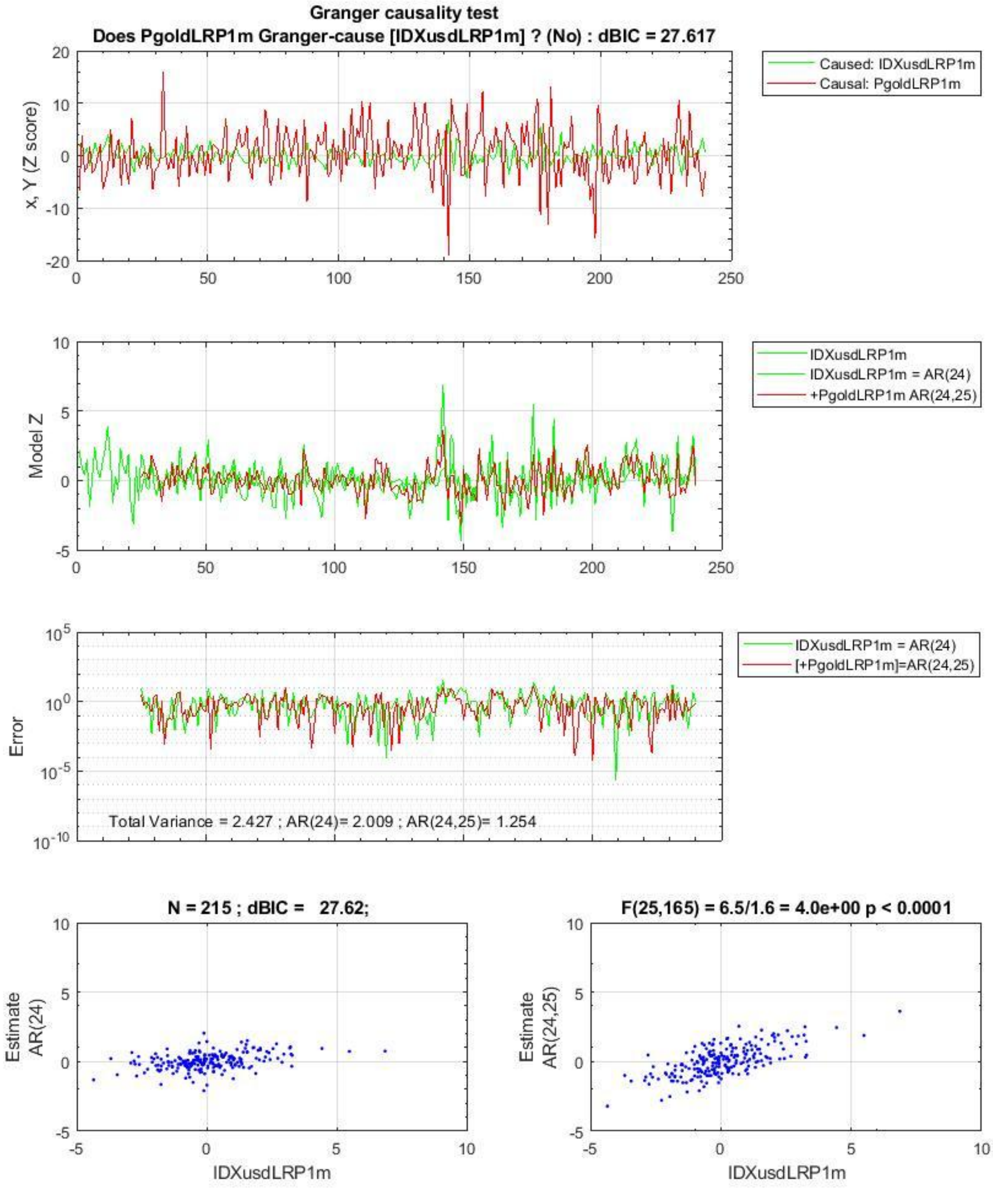


Figure 111 *Results of the test to determine whether DefaultPremiumLRP6m Granger-causes IDXusdLRP1m*

Source: Own research

9.9.3 Hypothesis 2

9.9.3.1 Hypothesis 2d, US domestic study, with gold futures as the dependent variable

Table 161

Model summary: Hypothesis 2d, US domestic study, with gold futures as the dependent variable

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.100[a]	.010	.009	.987385	2.035

a. Predictors: (Constant), INFLusVol, EPUusLRP20d, DefaultPremLRP20d, GoldBeta200d, IDXusdLRP20d, INFLus12m

b. Dependent Variable: FgoldLRP1d

Source: Own research

Table 162

ANOVA: Hypothesis 2d, US domestic study, with gold futures as the dependent variable

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	47.443	6	7.907	8.110	.000[b]
	Residual	4677.706	4798	.975		
	Total	4725.149	4804			

a. Dependent Variable: FgoldLRP1d

b. Predictors: (Constant), INFLusVol, EPUusLRP20d, DefaultPremLRP20d, GoldBeta200d, IDXusdLRP20d, INFLus12m

Source: Own research

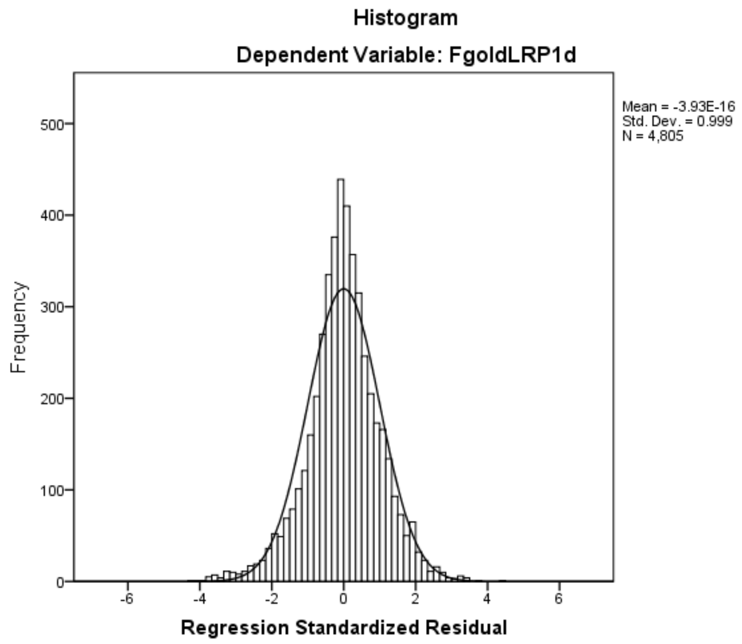


Figure 112 *Residual histogram: Hypothesis 2d, US domestic study, with gold futures as the dependent variable*

Source: Own research

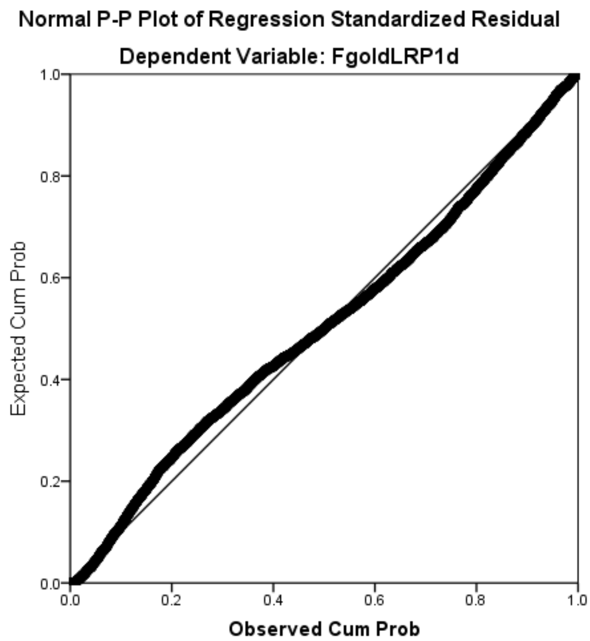


Figure 113 *P-P plot: Hypothesis 2d, US domestic study, with gold futures as the dependent variable*

Source: Own research

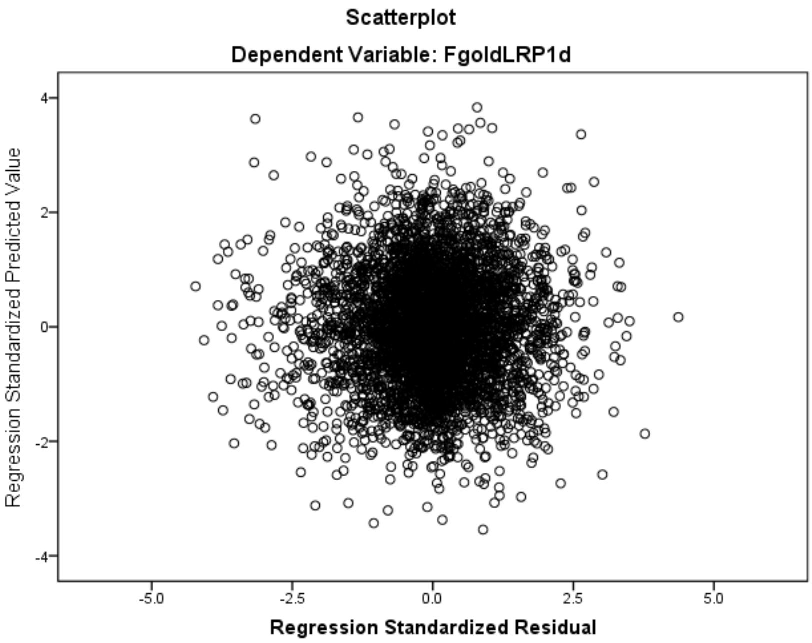


Figure 114 *Residual scatterplot: Hypothesis 2d, US domestic study, with gold futures as the dependent variable*

Source: Own research

9.9.3.2 *Hypothesis 2i, US international study, with gold futures as the dependent variable*

Table 163

Model summary: Hypothesis 2d, US international study, with gold futures as the dependent variable

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.104[a]	.011	.009	1.003194	2.035

a. Predictors: (Constant), INFLworldVol, EPUeuLRP1m, DefaultPremLRP20d, GoldBeta200d, EPUusLRP20d, INFLus12m, IDXusdLRP20d, INFLworld, INFLusVol

b. Dependent Variable: FgoldLRP1d

Source: Own research

Table 164

ANOVA: Hypothesis 2d, US international study, with gold futures as the dependent variable

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	52.969	9	5.885	5.848	.000[b]
	Residual	4847.819	4817	1.006		
	Total	4900.788	4826			

a. Dependent Variable: FgoldLRP1d

b. Predictors: (Constant), INFLworldVol, EPUeuLRP1m, DefaultPremLRP20d, GoldBeta200d, EPUusLRP20d, INFLus12m, IDXusdLRP20d, INFLworld, INFLusVol

Source: Own research

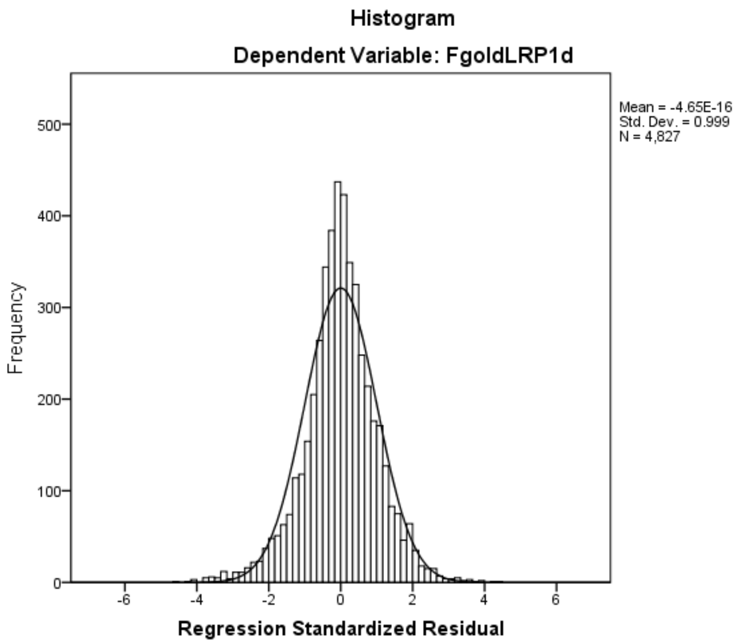


Figure 115 *Residual histogram: Hypothesis 2d, US international study, with gold futures as the dependent variable*

Source: Own research

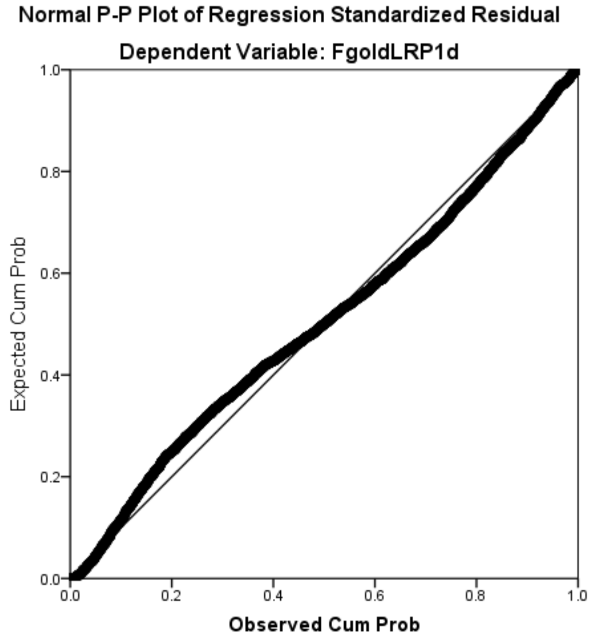


Figure 116 *P-P plot: Hypothesis 2d, US international study, with gold futures as the dependent variable*

Source: Own research

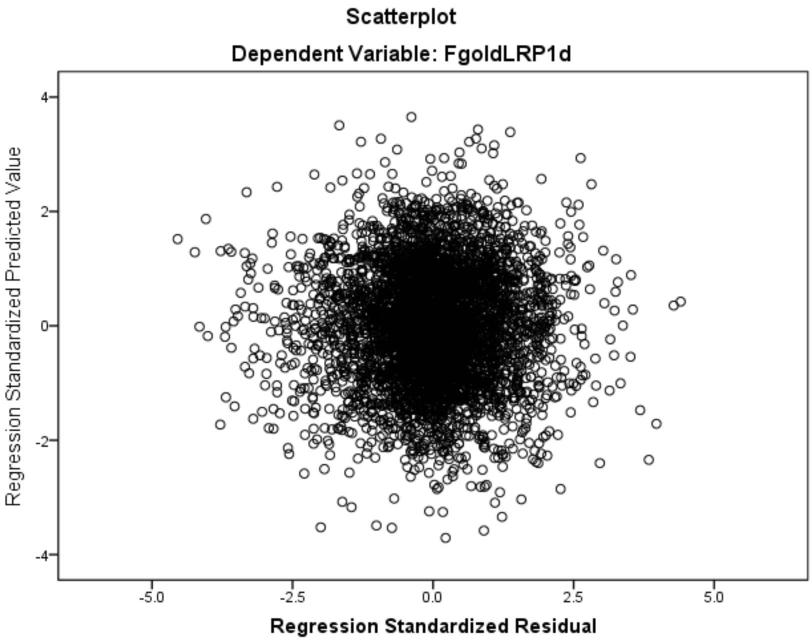


Figure 117 *Residual scatterplot: Hypothesis 2d, US international study, with gold futures as the dependent variable*

Source: Own research

9.9.3.3 *Hypothesis 2d, US domestic study, with gold futures as the dependent variable and AR1*

Table 165

Model summary: Hypothesis 2d, US domestic study, with gold futures as the dependent variable, and AR1

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.106[a]	.011	.010	.986862	1.974

a. Predictors: (Constant), INFLusVol, EPUusLRP20d, FgoldLRP1d_L1, DefaultPremLRP20d, GoldBeta200d, IDXusdLRP20d, INFLus12m

b. Dependent Variable: FgoldLRP1d

Source: Own research

Table 166

ANOVA: Hypothesis 2d, US domestic study, with gold futures as the dependent variable, and AR1

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	53.366	7	7.624	7.828	.000[b]
	Residual	4671.783	4797	.974		
	Total	4725.149	4804			

a. Dependent Variable: FgoldLRP1d

b. Predictors: (Constant), INFLusVol, EPUusLRP20d, FgoldLRP1d_L1, DefaultPremLRP20d, GoldBeta200d, IDXusdLRP20d, INFLus12m

Source: Own research

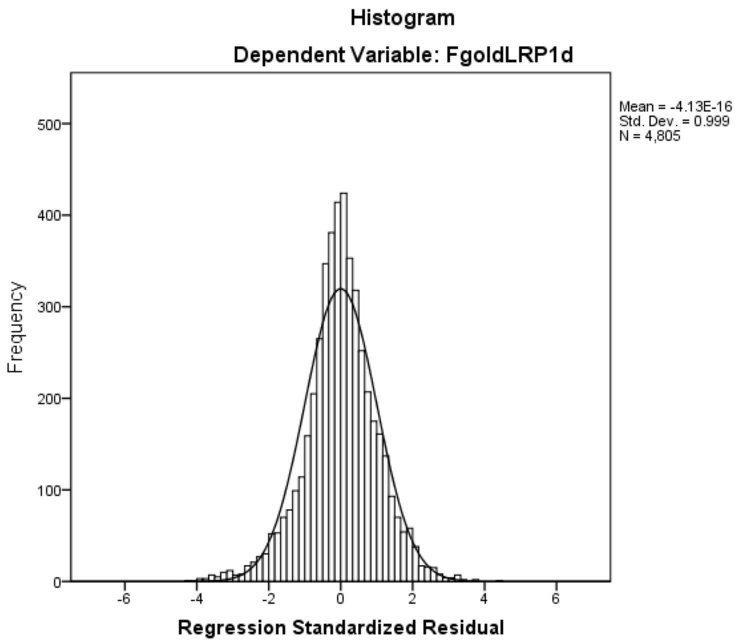


Figure 118 *Residual histogram: Hypothesis 2d, US domestic study, with gold futures as the dependent variable, and AR1*

Source: Own research

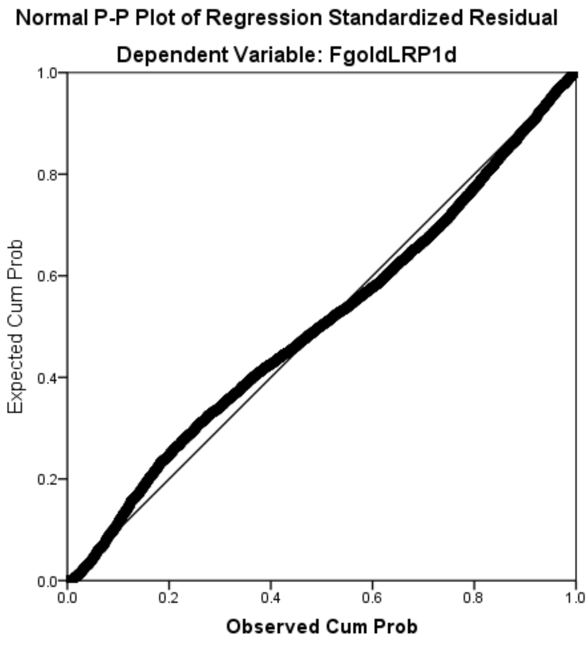


Figure 119 *P-P plot: Hypothesis 2d, US domestic study, with gold futures as the dependent variable, and AR1*

Source: Own research

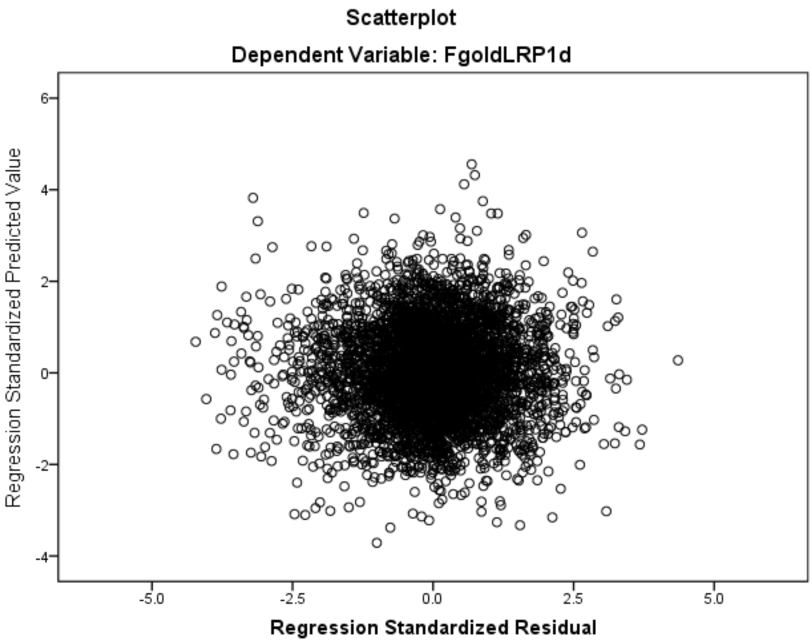


Figure 120 *Residual scatterplot: Hypothesis 2d, US domestic study, with gold futures as the dependent variable, and AR1*

Source: Own research

9.9.3.4 Hypothesis 2i, US international study, with gold futures as the dependent variable and AR1

Table 167

Model summary: Hypothesis 2d, US international study, with gold futures as the dependent variable, and AR1

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.109[a]	.012	.010	1.002718	1.975

a. Predictors: (Constant), INFLworldVol, EPUeuLRP1m, FgoldLRP1d_L1, DefaultPremLRP20d, GoldBeta200d, EPUusLRP20d, INFLus12m, IDXusdLRP20d, INFLworld, INFLusVol

b. Dependent Variable: FgoldLRP1d

Source: Own research

Table 168

ANOVA: Hypothesis 2d, US international study, with gold futures as the dependent variable, and AR1

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	58.576	10	5.858	5.826	.000[b]
	Residual	4842.212	4816	1.005		
	Total	4900.788	4826			

a. Dependent Variable: FgoldLRP1d

b. Predictors: (Constant), INFLworldVol, EPUeuLRP1m, FgoldLRP1d_L1, DefaultPremLRP20d, GoldBeta200d, EPUusLRP20d, INFLus12m, IDXusdLRP20d, INFLworld, INFLusVol

Source: Own research

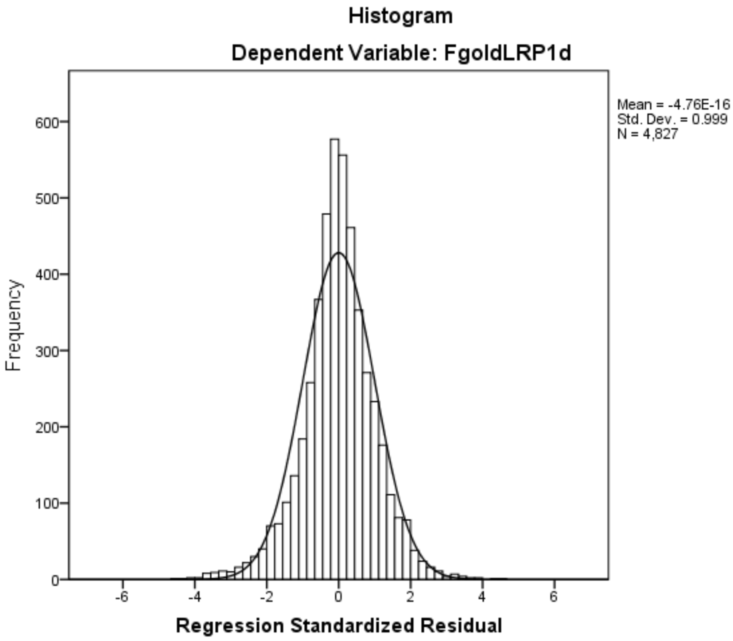


Figure 121 *Residual histogram: Hypothesis 2d, US international study, with gold futures as the dependent variable, and AR1*

Source: Own research

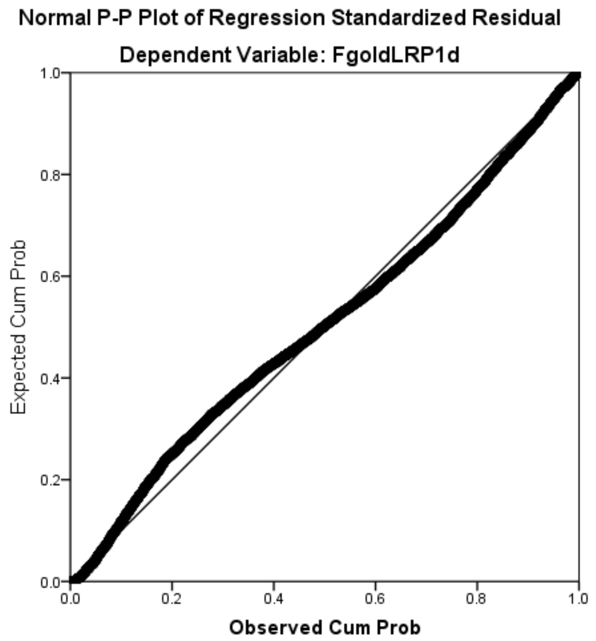


Figure 122 *P-P plot: Hypothesis 2d, US international study, with gold futures as the dependent variable, and AR1*

Source: Own research

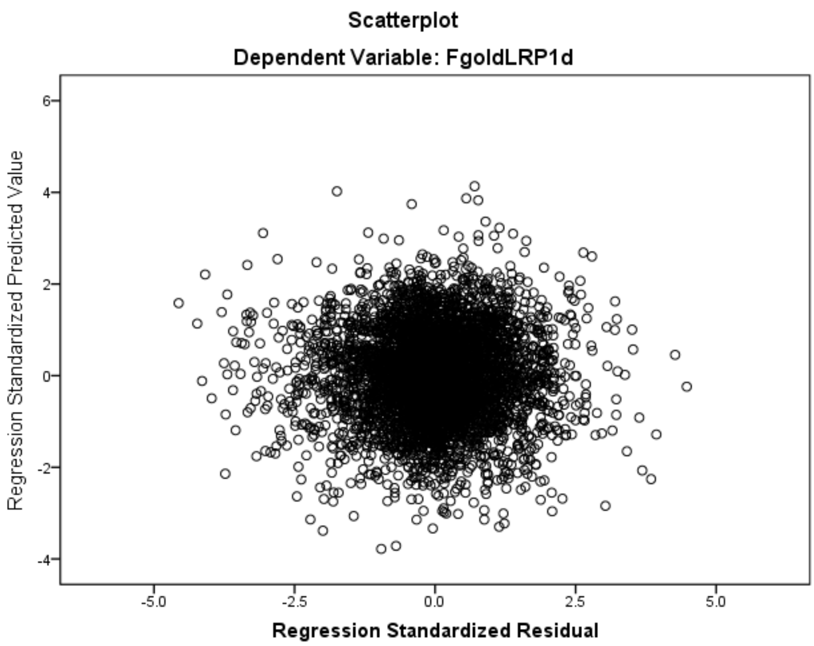


Figure 123 *Residual scatterplot: Hypothesis 2d, US international study, with gold futures as the dependent variable, and AR1*

Source: Own research

9.9.4 Hypothesis 3

9.9.4.1 Hypothesis 3d, US domestic study, with gold futures as the dependent variable and EPU volatility added as an independent variable

Table 169

Model summary: Hypothesis 3d, US domestic study, with gold futures as the dependent variable and EPU volatility added as an independent variable

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.093[a]	.009	.007	1.000723	2.024

a. Predictors: (Constant), INFLusVol, EPUusLRP20d, DefaultPremLRP20d, EPUusVol20d, GoldBeta200d, IDXusdLRP20d, INFLus12m

b. Dependent Variable: FgoldLRP1d

Source: Own research

Table 170

ANOVA: Hypothesis 3d, US domestic study, with gold futures as the dependent variable and EPU volatility added as an independent variable

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	42.028	7	6.004	5.995	.000[b]
	Residual	4797.926	4791	1.001		
	Total	4839.954	4798			

a. Dependent Variable: FgoldLRP1d

b. Predictors: (Constant), INFLusVol, EPUusLRP20d, DefaultPremLRP20d, EPUusVol20d, GoldBeta200d, IDXusdLRP20d, INFLus12m

Source: Own research

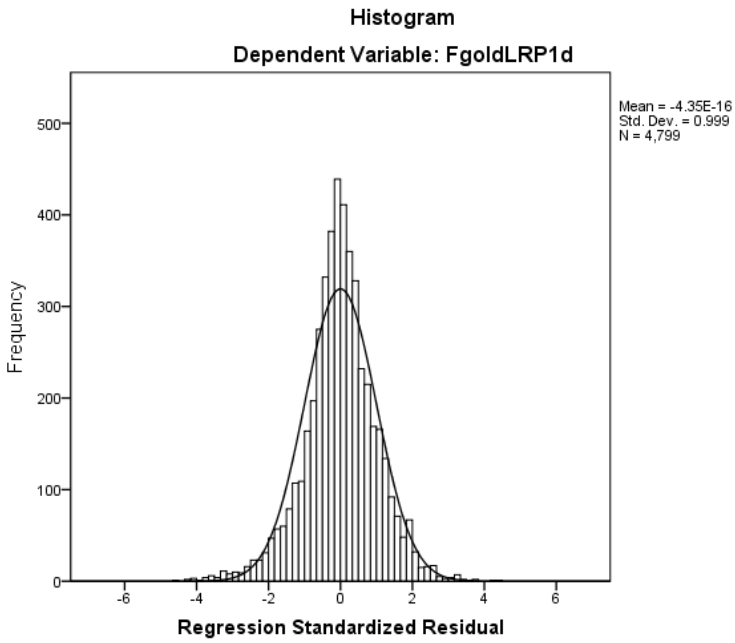


Figure 124 *Residual histogram: Hypothesis 3d, US domestic study, with gold futures as the dependent variable and EPU volatility added as an independent variable*

Source: Own research

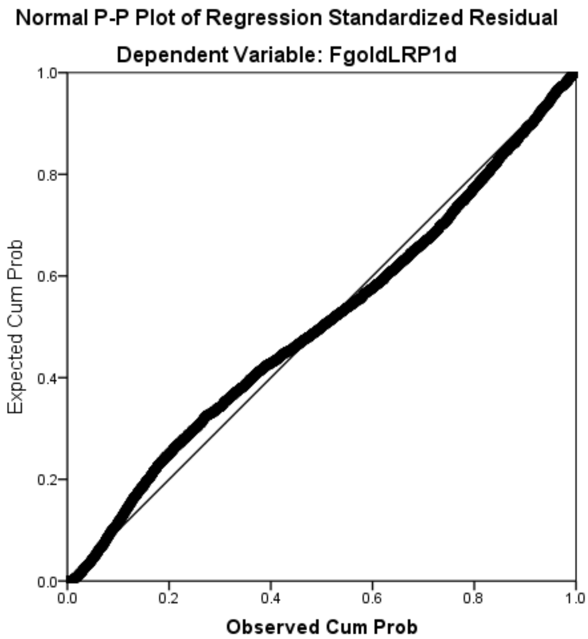


Figure 125 *P-P plot: Hypothesis 3d, US domestic study, with gold futures as the dependent variable and EPU volatility added as an independent variable*

Source: Own research

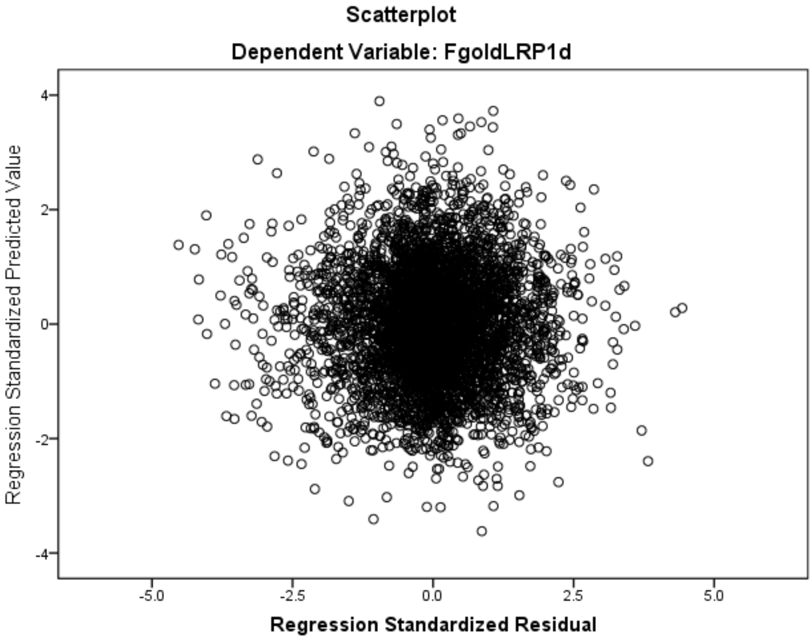


Figure 126 *Residual scatterplot: Hypothesis 3d, US domestic study, with gold futures as the dependent variable and EPU volatility added as an independent variable*

Source: Own research

9.9.4.2 Hypothesis 3i, US international study, with gold futures as the dependent variable and EPU volatility added as an independent variable

Table 171

Model summary: Hypothesis 3d, US international study, with gold futures as the dependent variable and EPU volatility added as an independent variable

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.098[a]	.010	.007	1.003809	2.036

a. Predictors: (Constant), INFLworldVol, EPUeuLRP1m, GoldBeta200d, DefaultPremLRP20d, EPUusVol20d, EPUusLRP20d, IDXusdLRP20d, INFLus12m, INFLworld, INFLusVol

b. Dependent Variable: FgoldLRP1d

Source: Own research

Table 172

ANOVA: Hypothesis 3d, US international study, with gold futures as the dependent variable and EPU volatility added as an independent variable

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	46.638	10	4.664	4.628	.000[b]
	Residual	4839.658	4803	1.008		
	Total	4886.297	4813			

a. Dependent Variable: FgoldLRP1d

b. Predictors: (Constant), INFLworldVol, EPUeuLRP1m, GoldBeta200d, DefaultPremLRP20d, EPUusVol20d, EPUusLRP20d, IDXusdLRP20d, INFLus12m, INFLworld, INFLusVol

Source: Own research

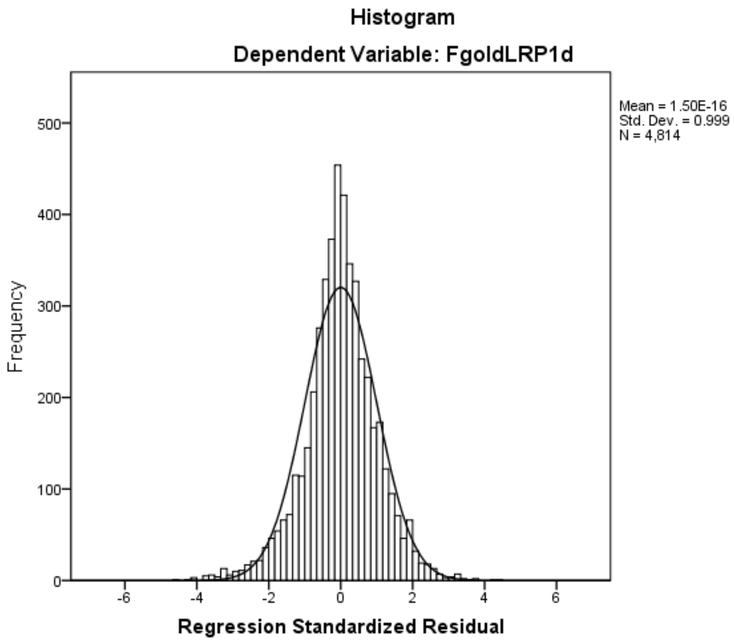


Figure 127 *Residual histogram: Hypothesis 3d, US international study, with gold futures as the dependent variable and EPU volatility added as an independent variable*

Source: Own research

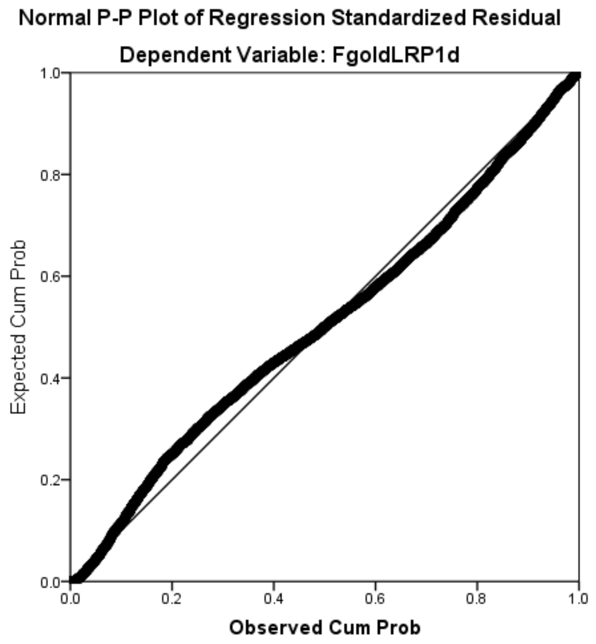


Figure 128 *P-P plot: Hypothesis 3d, US international study, with gold futures as the dependent variable and EPU volatility added as an independent variable*

Source: Own research

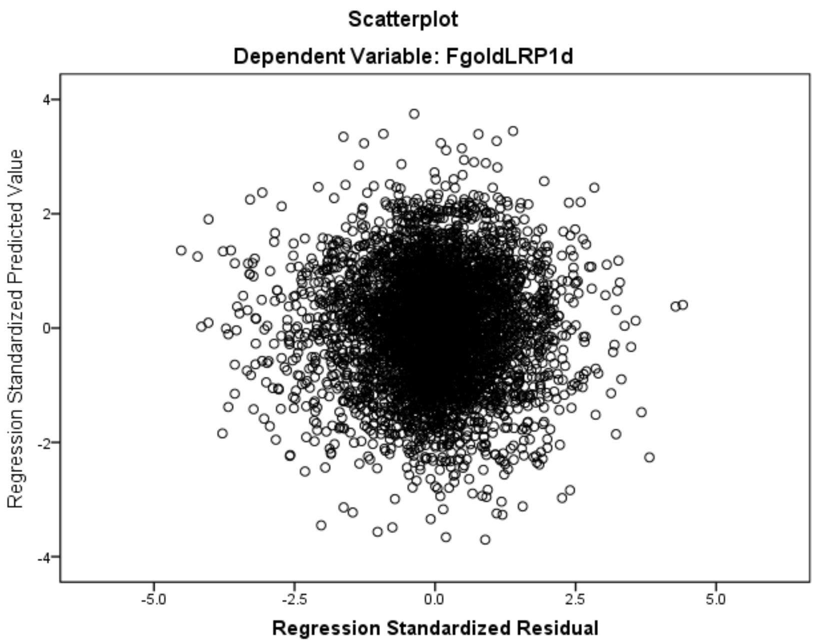


Figure 129 *Residual scatterplot: Hypothesis 3d, US international study, with gold futures as the dependent variable and EPU volatility added as an independent variable*

Source: Own research

9.9.4.3 Hypothesis 3d, US domestic study, with gold futures as the dependent variable and EPU volatility added as an independent variable and AR1

Table 173

Model summary: Hypothesis 3d, US domestic study, with gold futures as the dependent variable and EPU volatility added as an independent variable, and AR1 term

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.097[a]	.009	.008	1.000431	1.974

a. Predictors: (Constant), INFLusVol, EPUusLRP20d, FgoldLRP1d_L1, DefaultPremLRP20d, EPUusVol20d, GoldBeta200d, IDXusdLRP20d, INFLus12m

b. Dependent Variable: FgoldLRP1d

Source: Own research

Table 174

ANOVA: Hypothesis 3d, US domestic study, with gold futures as the dependent variable and EPU volatility added as an independent variable, and AR1 term

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	45.820	8	5.728	5.723	.000[b]
	Residual	4794.134	4790	1.001		
	Total	4839.954	4798			

a. Dependent Variable: FgoldLRP1d

b. Predictors: (Constant), INFLusVol, EPUusLRP20d, FgoldLRP1d_L1, DefaultPremLRP20d, EPUusVol20d, GoldBeta200d, IDXusdLRP20d, INFLus12m

Source: Own research

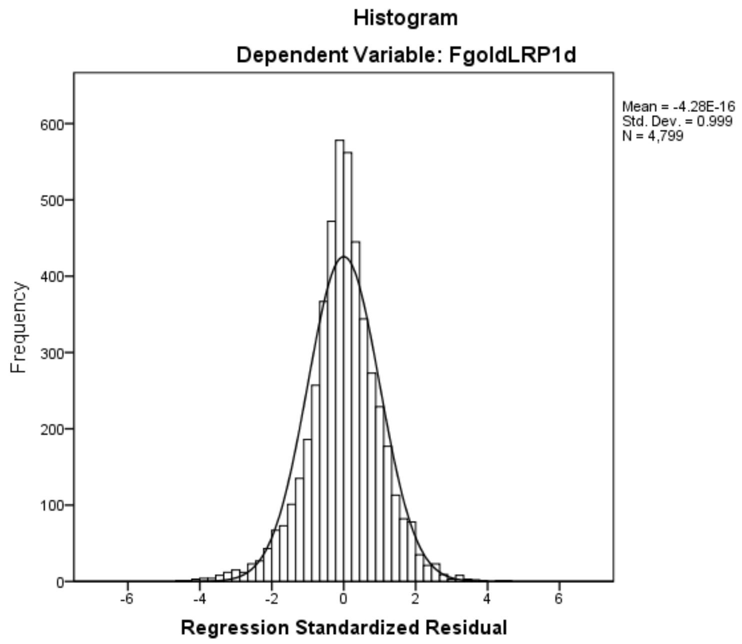


Figure 130 *Residual histogram: Hypothesis 3d, US domestic study, with gold futures as the dependent variable and EPU volatility added as an independent variable, and AR1 term*

Source: Own research

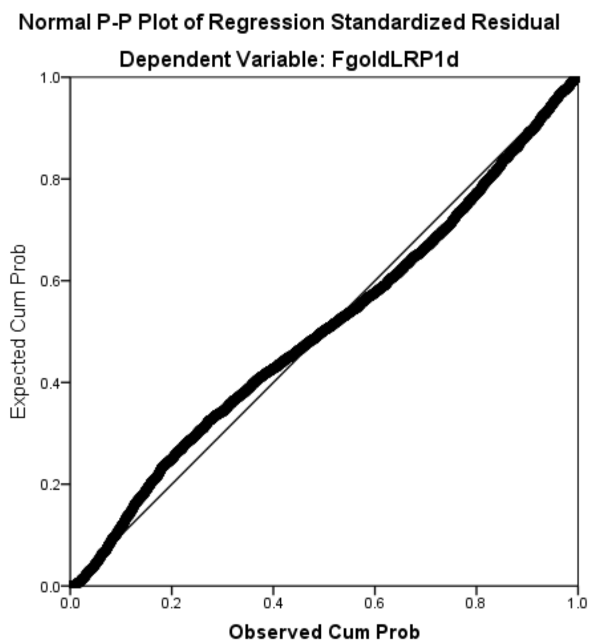


Figure 131 *P-P plot: Hypothesis 3d, US domestic study, with gold futures as the dependent variable and EPU volatility added as an independent variable, and AR1 term*

Source: Own research

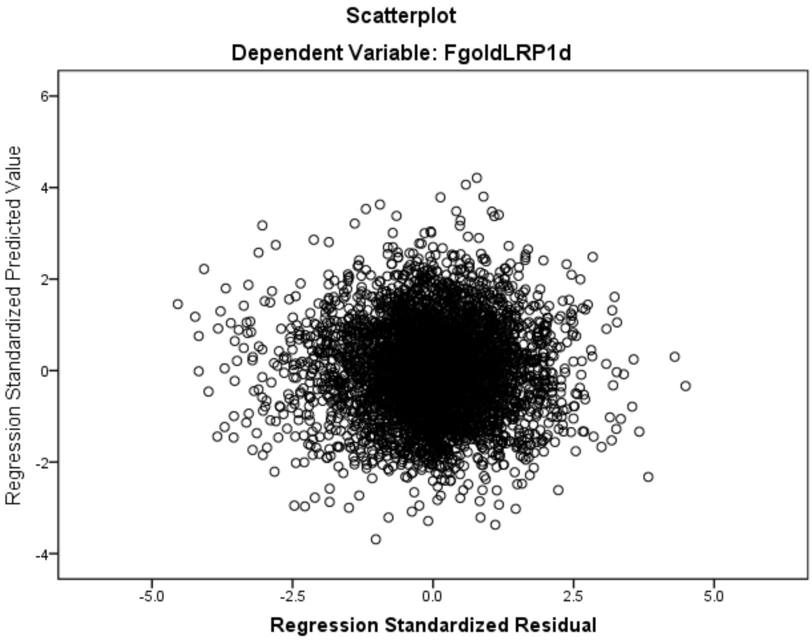


Figure 132 *Residual scatterplot: Hypothesis 3d, US domestic study, with gold futures as the dependent variable and EPU volatility added as an independent variable, and AR1 term*

Source: Own research

9.9.4.4 Hypothesis 3i, US international study, with gold futures as the dependent variable and EPU volatility added as an independent variable and AR1

Table 175

Model summary: Hypothesis 3d, US international study, with gold futures as the dependent variable and EPU volatility added as an independent variable, and AR1 term

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.102[a]	.010	.008	1.003457	1.983

a. Predictors: (Constant), INFLworldVol, EPUeuLRP1m, FgoldLRP1d_L1, GoldBeta200d, DefaultPremLRP20d, EPUusVol20d, EPUusLRP20d, INFLus12m, IDXusdLRP20d, INFLworld, INFLusVol

b. Dependent Variable: FgoldLRP1d

Source: Own research

Table 176

ANOVA: Hypothesis 3d, US international study, with gold futures as the dependent variable and EPU volatility added as an independent variable, and AR1 term

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	51.034	11	4.639	4.608	.000[b]
	Residual	4835.262	4802	1.007		
	Total	4886.297	4813			

a. Dependent Variable: FgoldLRP1d

b. Predictors: (Constant), INFLworldVol, EPUeuLRP1m, FgoldLRP1d_L1, GoldBeta200d, DefaultPremLRP20d, EPUusVol20d, EPUusLRP20d, INFLus12m, IDXusdLRP20d, INFLworld, INFLusVol

Source: Own research

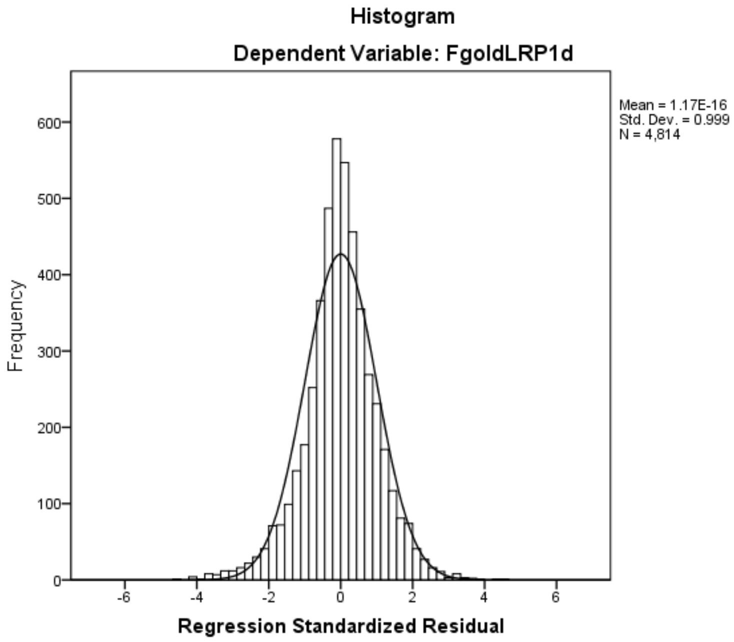


Figure 133 *Residual histogram: Hypothesis 3d, US international study, with gold futures as the dependent variable and EPU volatility added as an independent variable, and AR1 term*

Source: Own research

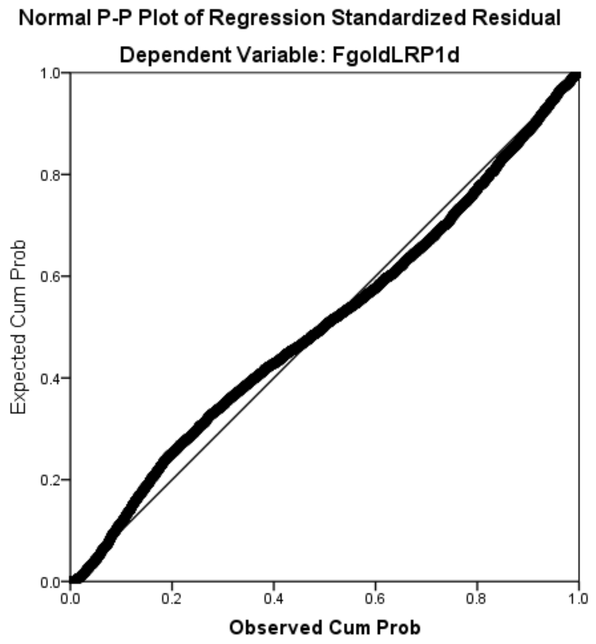


Figure 134 *P-P plot: Hypothesis 3d, US international study, with gold futures as the dependent variable and EPU volatility added as an independent variable, and AR1 term*

Source: Own research

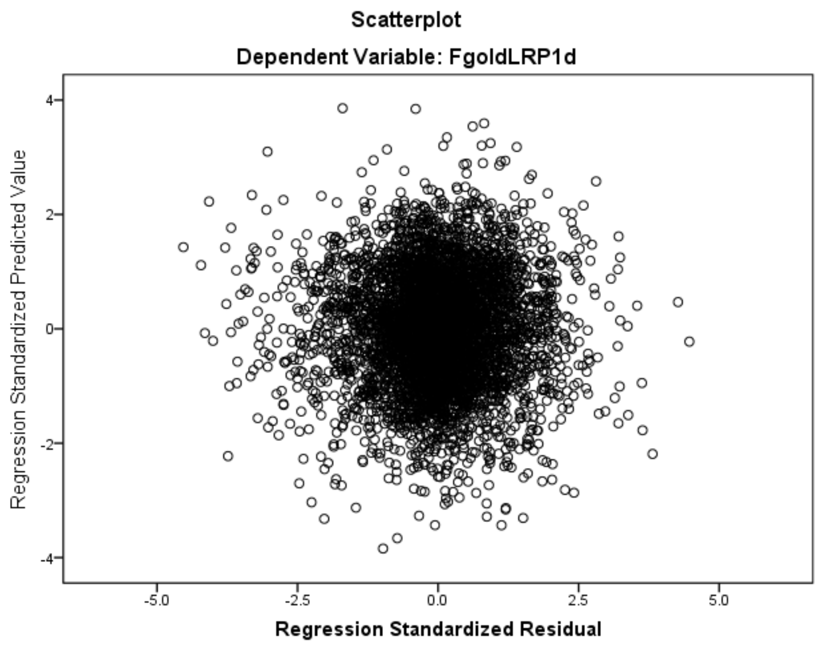


Figure 135 *Residual scatterplot: Hypothesis 3d, US international study, with gold futures as the dependent variable and EPU volatility added as an independent variable, and AR1 term*

Source: Own research

9.9.5 Hypothesis 4

9.9.5.1 Hypothesis 4c, China domestic study

Table 177

Model summary: Hypothesis 4c, China domestic study

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.213[a]	.046	.016	4.92858	2.312

a. Predictors: (Constant), INFLcnVol, DefaultPremLRP6m, INFLcn12, EPUcnLRP6m, GoldBetaUS36m, IDXcnyLRP6m

b. Dependent Variable: PgoldCnyLRP1m

Source: Own research

Table 178

ANOVA: Hypothesis 4c, China domestic study

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	225.959	6	37.660	1.550	.164[b]
	Residual	4736.730	195	24.291		
	Total	4962.689	201			

a. Dependent Variable: PgoldCnyLRP1m

b. Predictors: (Constant), INFLcnVol, DefaultPremLRP6m, INFLcn12, EPUcnLRP6m, GoldBetaUS36m, IDXcnyLRP6m

Source: Own research

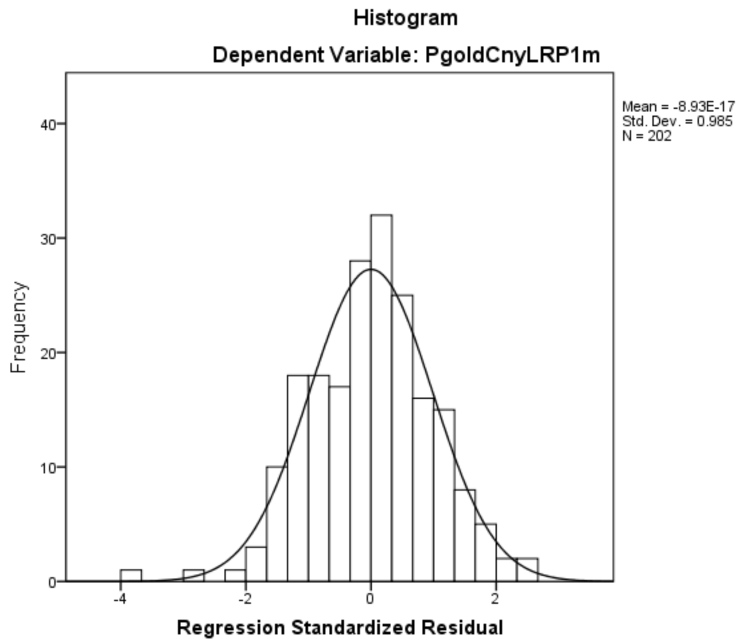


Figure 136 *Residual histogram: Hypothesis 4c, China domestic study*

Source: Own research

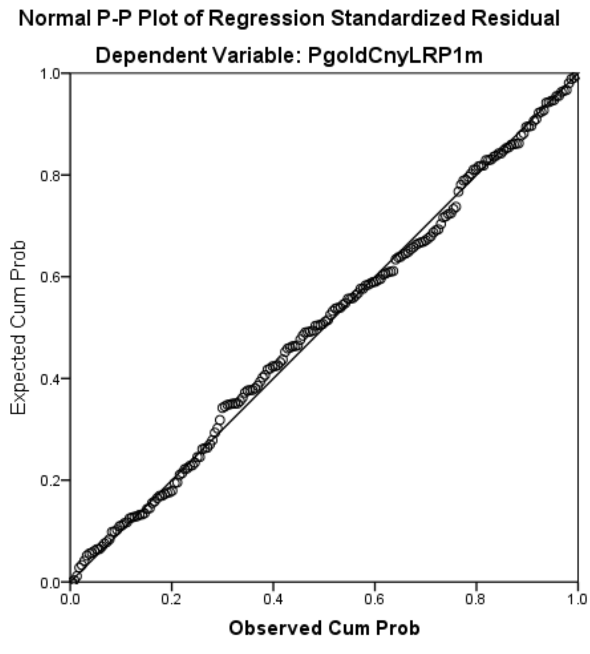


Figure 137 *P-P plot: Hypothesis 4c, China domestic study*

Source: Own research

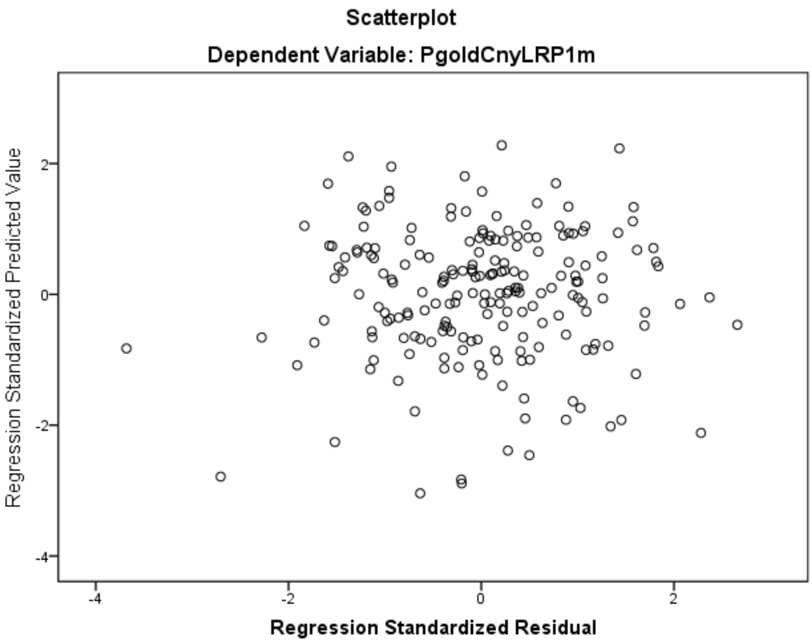


Figure 138 *Residual scatterplot: Hypothesis 4c, China domestic study*

Source: Own research

9.9.5.2 Hypothesis 4e, Europe domestic study

Table 179

Model summary: Hypothesis 4e, Europe domestic study

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.294[a]	.086	.058	4.65498	2.236

a. Predictors: (Constant), INFLeuukVol, EPUeuLRP6m, INFLeuuk12, IDXeurgbpLRP6m, DefaultPremLRP6m, GoldBetaUS36m

b. Dependent Variable: PgoldEurGbpLRP1m

Source: Own research

Table 180

ANOVA: Hypothesis 4e, Europe domestic study

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	399.580	6	66.597	3.073	.007[b]
	Residual	4225.421	195	21.669		
	Total	4625.001	201			

a. Dependent Variable: PgoldEurGbpLRP1m

b. Predictors: (Constant), INFLeuukVol, EPUeuLRP6m, INFLeuuk12, IDXeurgbpLRP6m, DefaultPremLRP6m, GoldBetaUS36m

Source: Own research

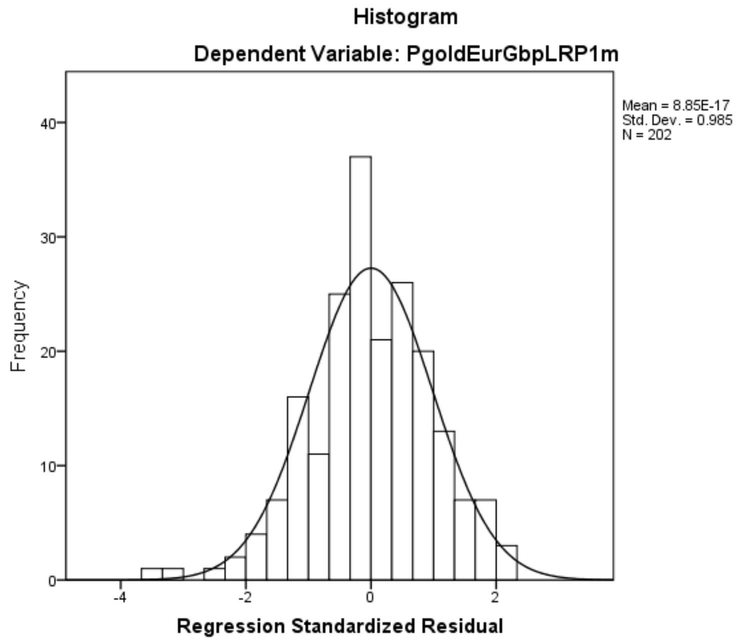


Figure 139 *Residual histogram: Hypothesis 4e, Europe domestic study*

Source: Own research

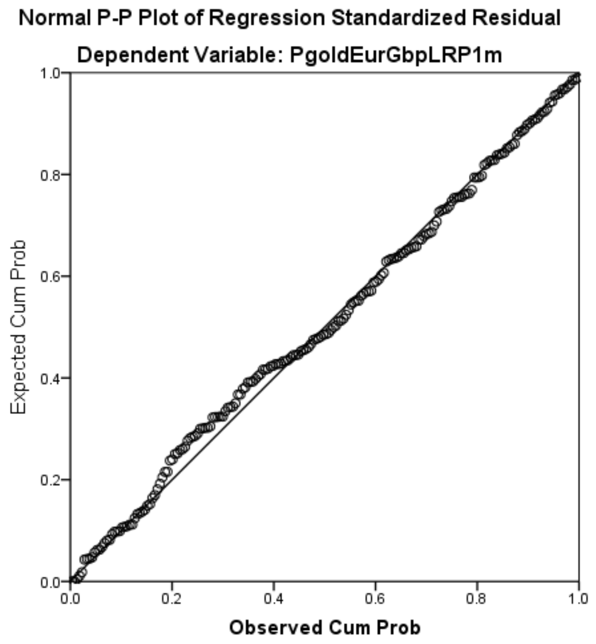


Figure 140 *P-P plot: Hypothesis 4e, Europe domestic study*

Source: Own research

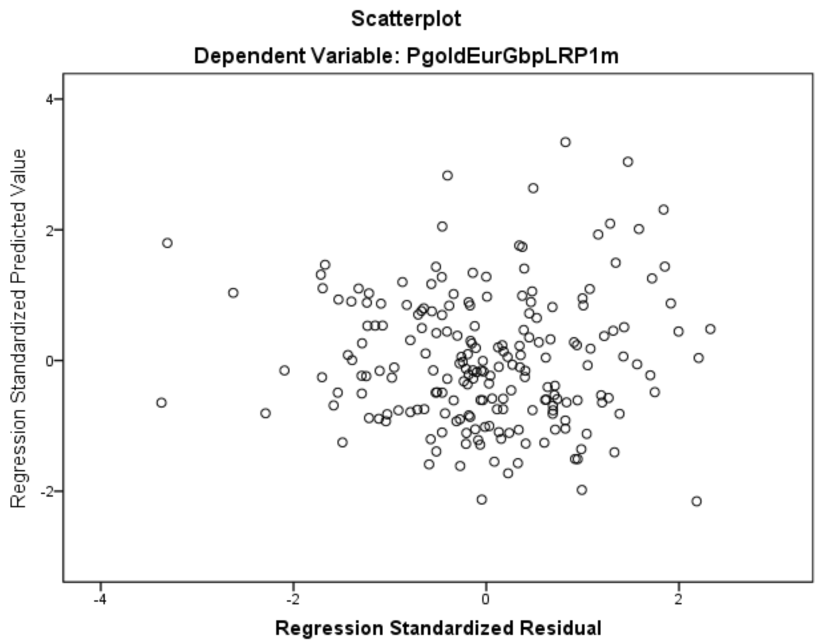


Figure 141 *Residual scatterplot: Hypothesis 4e, Europe domestic study*

Source: Own research

9.9.5.3 *Hypothesis 4j, Japan domestic study*

Table 181

Model summary: Hypothesis 4j, Japan domestic study

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.175[a]	.031	.005	4.62991	2.323

a. Predictors: (Constant), INFLjpnVol, EPUjpLRP6m, IDXjpyLRP6m, DefaultPremLRP6m, INFLjpn12, GoldBetaUS36m

b. Dependent Variable: PgoldJpyLRP1m

Source: Own research

Table 182

ANOVA: Hypothesis 4j, Japan domestic study

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	155.242	6	25.874	1.207	.303[b]
	Residual	4908.859	229	21.436		
	Total	5064.101	235			

a. Dependent Variable: PgoldJpyLRP1m

b. Predictors: (Constant), INFLjpnVol, EPUjpLRP6m, IDXjpyLRP6m, DefaultPremLRP6m, INFLjpn12, GoldBetaUS36m

Source: Own research

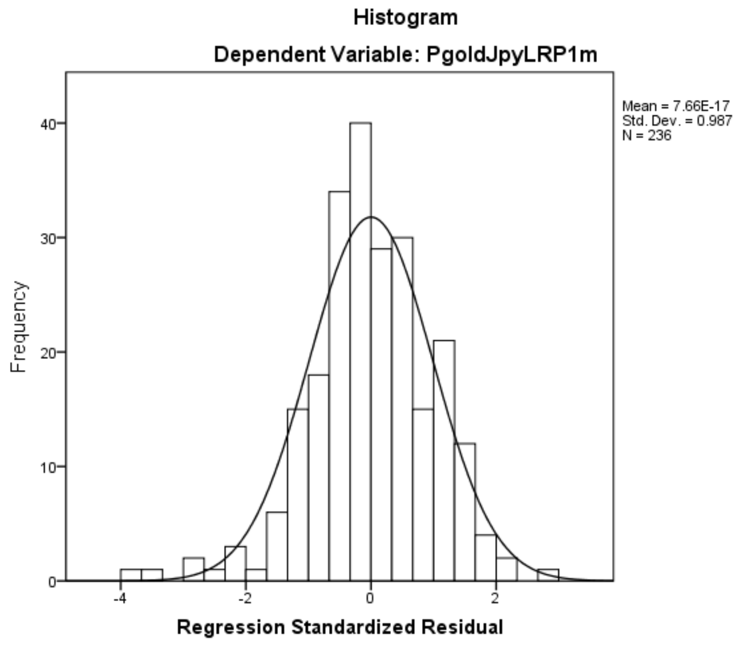


Figure 142 *Residual histogram: Hypothesis 4j, Japan domestic study*

Source: Own research

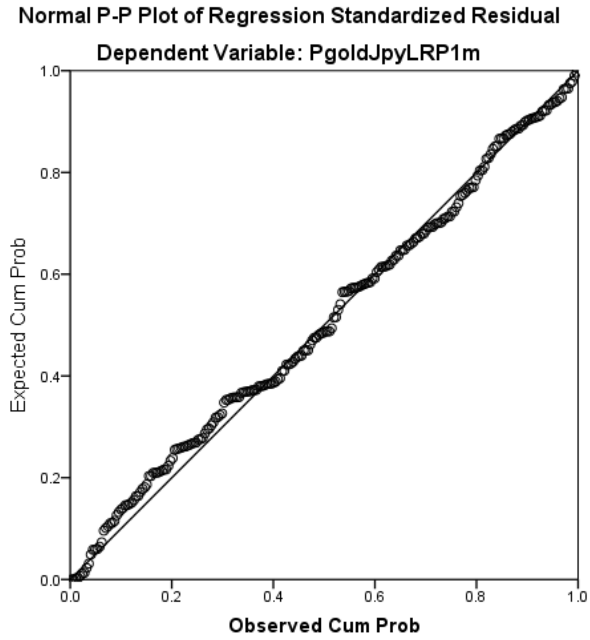


Figure 143 *P-P plot: Hypothesis 4j, Japan domestic study*

Source: Own research

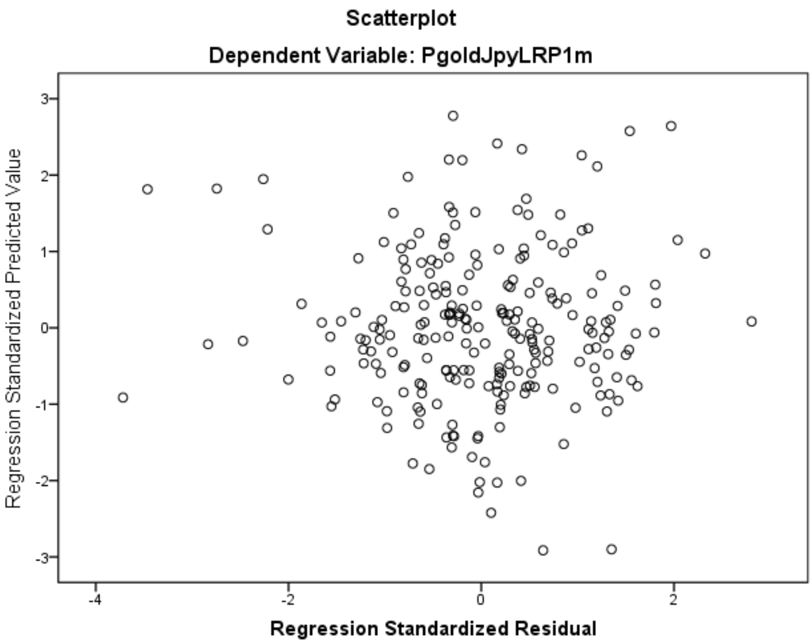


Figure 144 *Residual scatterplot: Hypothesis 4j, Japan domestic study*

Source: Own research

9.9.5.4 *Hypothesis 4c, China domestic study with AR1*

Table 183

Model summary: Hypothesis 4c, China domestic study with AR1 term

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.287[a]	.082	.049	4.84478	1.977

a. Predictors: (Constant), INFLcnVol, DefaultPremLRP6m, PgoldCnyLRP1m_L1, INFLcn12, EPUcnLRP6m, GoldBetaUS36m, IDXcnyLRP6m

b. Dependent Variable: PgoldCnyLRP1m

Source: Own research

Table 184

ANOVA: Hypothesis 4c, China domestic study with AR1 term

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	409.133	7	58.448	2.490	.018[b]
	Residual	4553.555	194	23.472		
	Total	4962.689	201			

a. Dependent Variable: PgoldCnyLRP1m

b. Predictors: (Constant), INFLcnVol, DefaultPremLRP6m, PgoldCnyLRP1m_L1, INFLcn12, EPUcnLRP6m, GoldBetaUS36m, IDXcnyLRP6m

Source: Own research

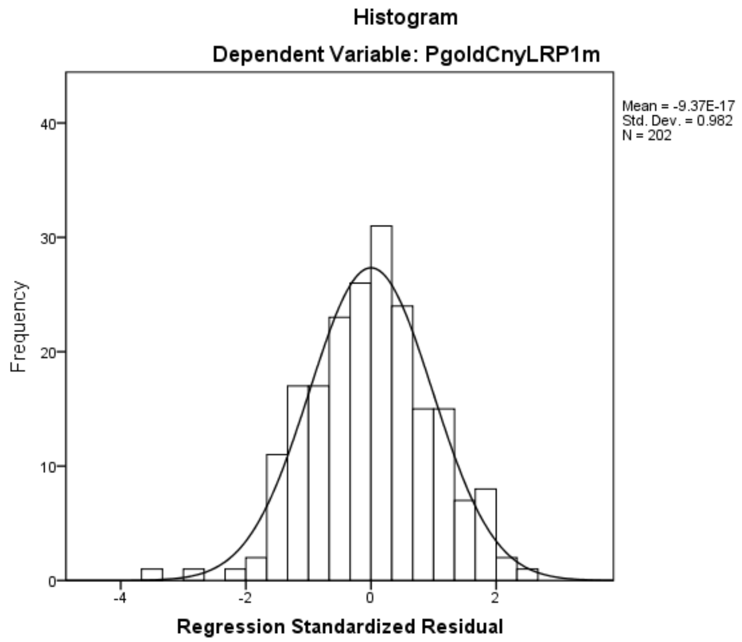


Figure 145 *Residual histogram: Hypothesis 4c, China domestic study with AR1 term*

Source: Own research

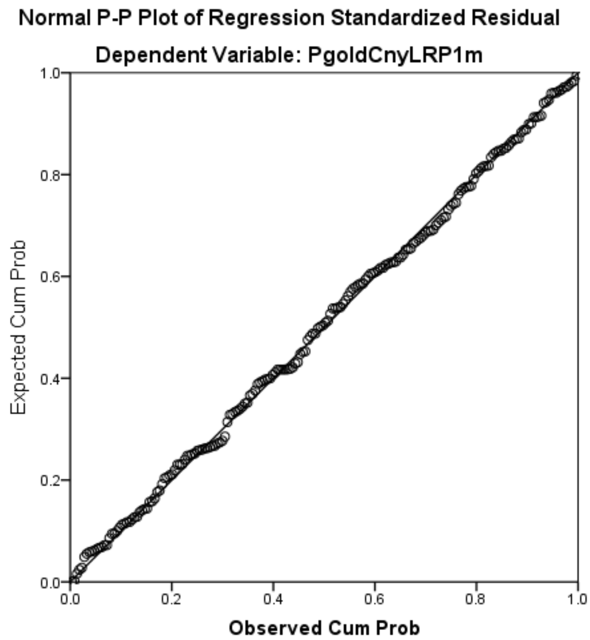


Figure 146 *P-P plot: Hypothesis 4c, China domestic study with AR1 term*

Source: Own research

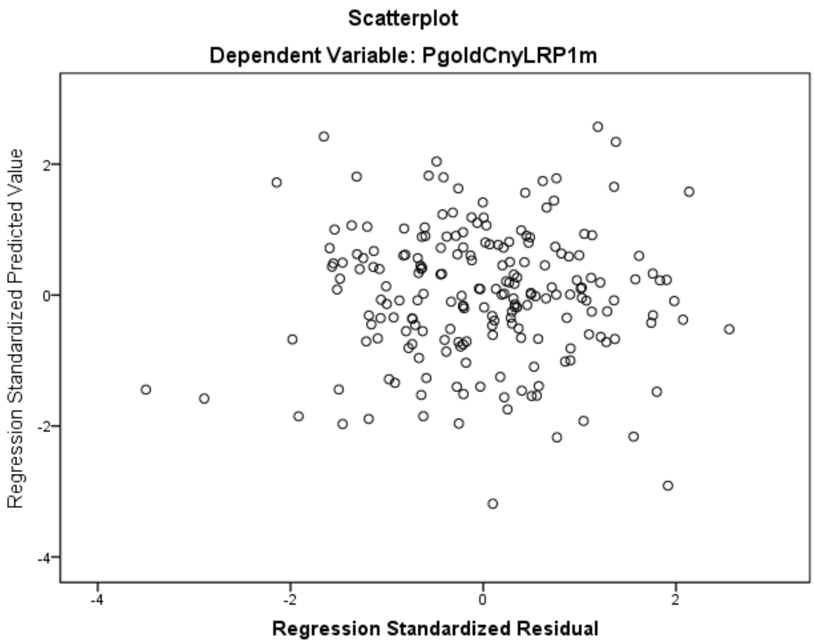


Figure 147 *Residual scatterplot: Hypothesis 4c, China domestic study with AR1 term*

Source: Own research

9.9.5.5 *Hypothesis 4e, Europe domestic study with AR1*

Table 185

Model summary: Hypothesis 4e, Europe domestic study with AR1 term

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.343[a]	.118	.086	4.58582	1.921

a. Predictors: (Constant), INFLeuukVol, EPUeuLRP6m, INFLeuuk12, PgoldEurGbpLRP1m_L1, IDXeurgbpLRP6m, DefaultPremLRP6m, GoldBetaUS36m

b. Dependent Variable: PgoldEurGbpLRP1m

Source: Own research

Table 186

ANOVA: Hypothesis 4e, Europe domestic study with AR1 term

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	545.222	7	77.889	3.704	.001[b]
	Residual	4079.779	194	21.030		
	Total	4625.001	201			

a. Dependent Variable: PgoldEurGbpLRP1m

b. Predictors: (Constant), INFLeuukVol, EPUeuLRP6m, INFLeuuk12, PgoldEurGbpLRP1m_L1, IDXeurgbpLRP6m, DefaultPremLRP6m, GoldBetaUS36m

Source: Own research

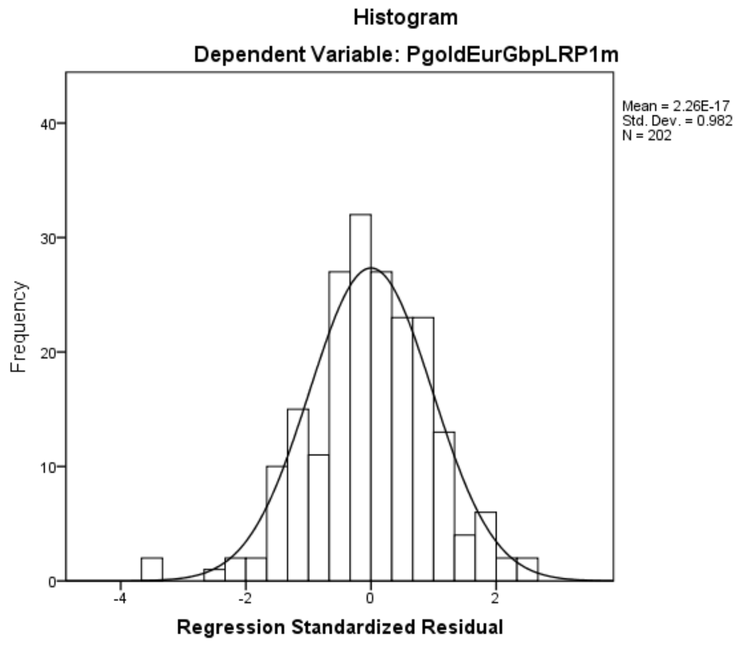


Figure 148 *Residual histogram: Hypothesis 4e, Europe domestic study with AR1 term*

Source: Own research

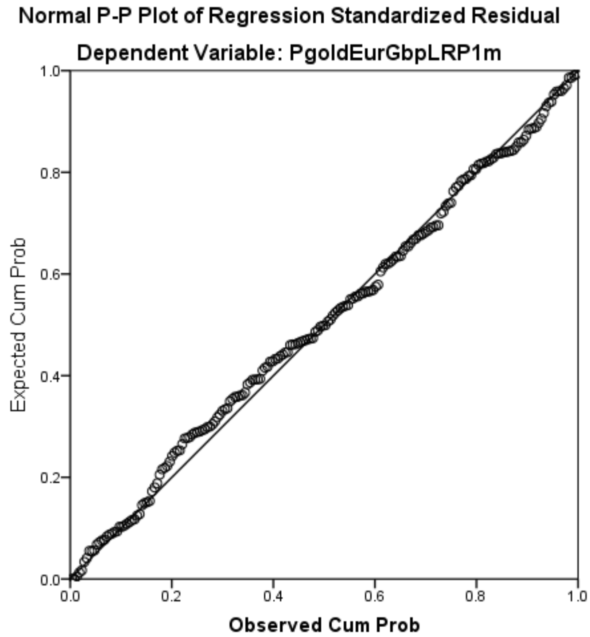


Figure 149 *P-P plot: Hypothesis 4e, Europe domestic study with AR1 term*

Source: Own research

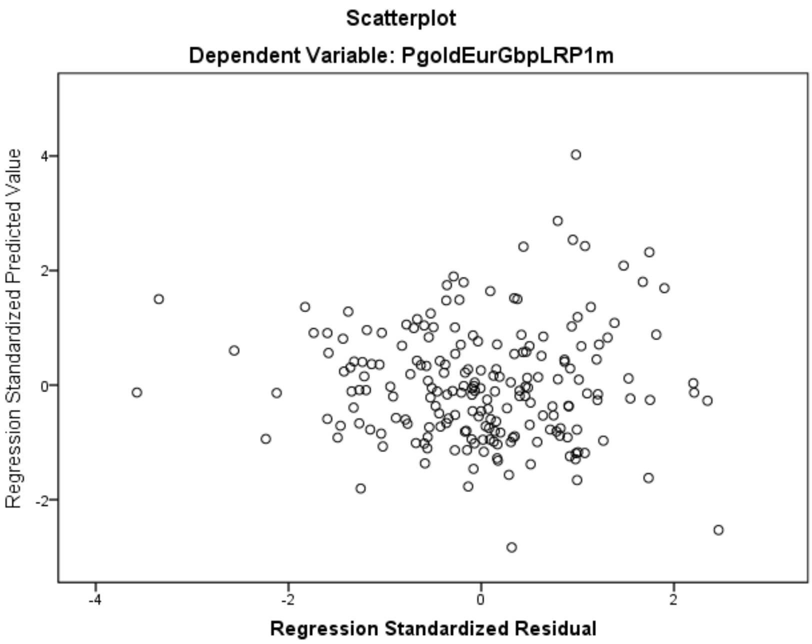


Figure 150 *Residual scatterplot: Hypothesis 4e, Europe domestic study with AR1 term*

Source: Own research

9.9.5.6 *Hypothesis 4j, Japan domestic study with AR1*

Table 187

Model summary: Hypothesis 4j, Japan domestic study with AR1 term

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.265[a]	.070	.041	4.54500	2.043

a. Predictors: (Constant), INFLjpnVol, EPUjpLRP6m, PgoldJpyLRP1m_L1, IDXjpyLRP6m, DefaultPremLRP6m, INFLjpn12, GoldBetaUS36m

b. Dependent Variable: PgoldJpyLRP1m

Source: Own research

Table 188

ANOVA: Hypothesis 4j, Japan domestic study with AR1 term

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	354.301	7	50.614	2.450	.019[b]
	Residual	4709.800	228	20.657		
	Total	5064.101	235			

a. Dependent Variable: PgoldJpyLRP1m

b. Predictors: (Constant), INFLjpnVol, EPUjpLRP6m, PgoldJpyLRP1m_L1, IDXjpyLRP6m, DefaultPremLRP6m, INFLjpn12, GoldBetaUS36m

Source: Own research

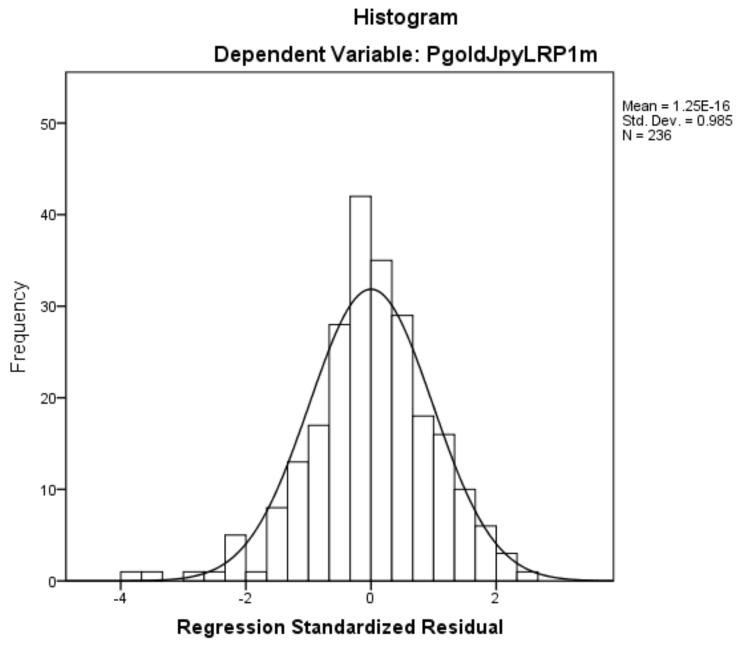


Figure 151 *Residual histogram: Hypothesis 4j, Japan domestic study with AR1 term*

Source: Own research

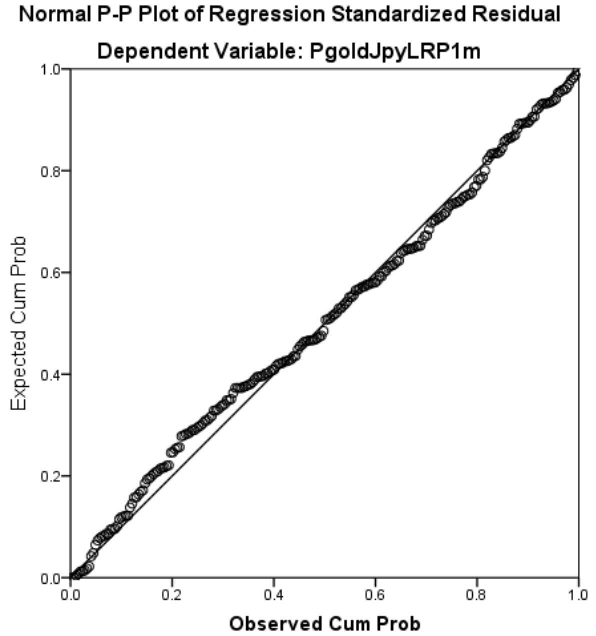


Figure 152 *P-P plot: Hypothesis 4j, Japan domestic study with AR1 term*

Source: Own research

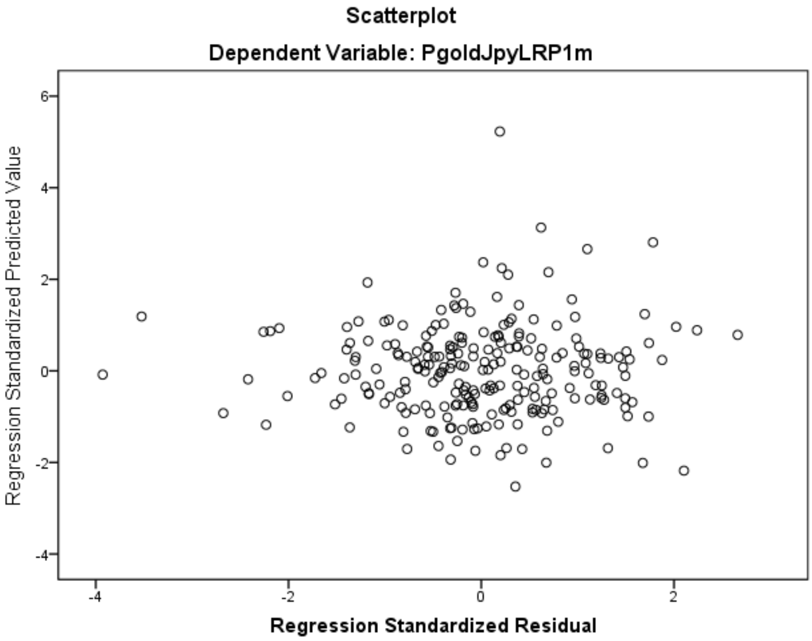


Figure 153 *Residual scatterplot: Hypothesis 4j, Japan domestic study with AR1 term*

Source: Own research

9.9.5.7 *Granger causality tests for selected variables in hypothesis 4*

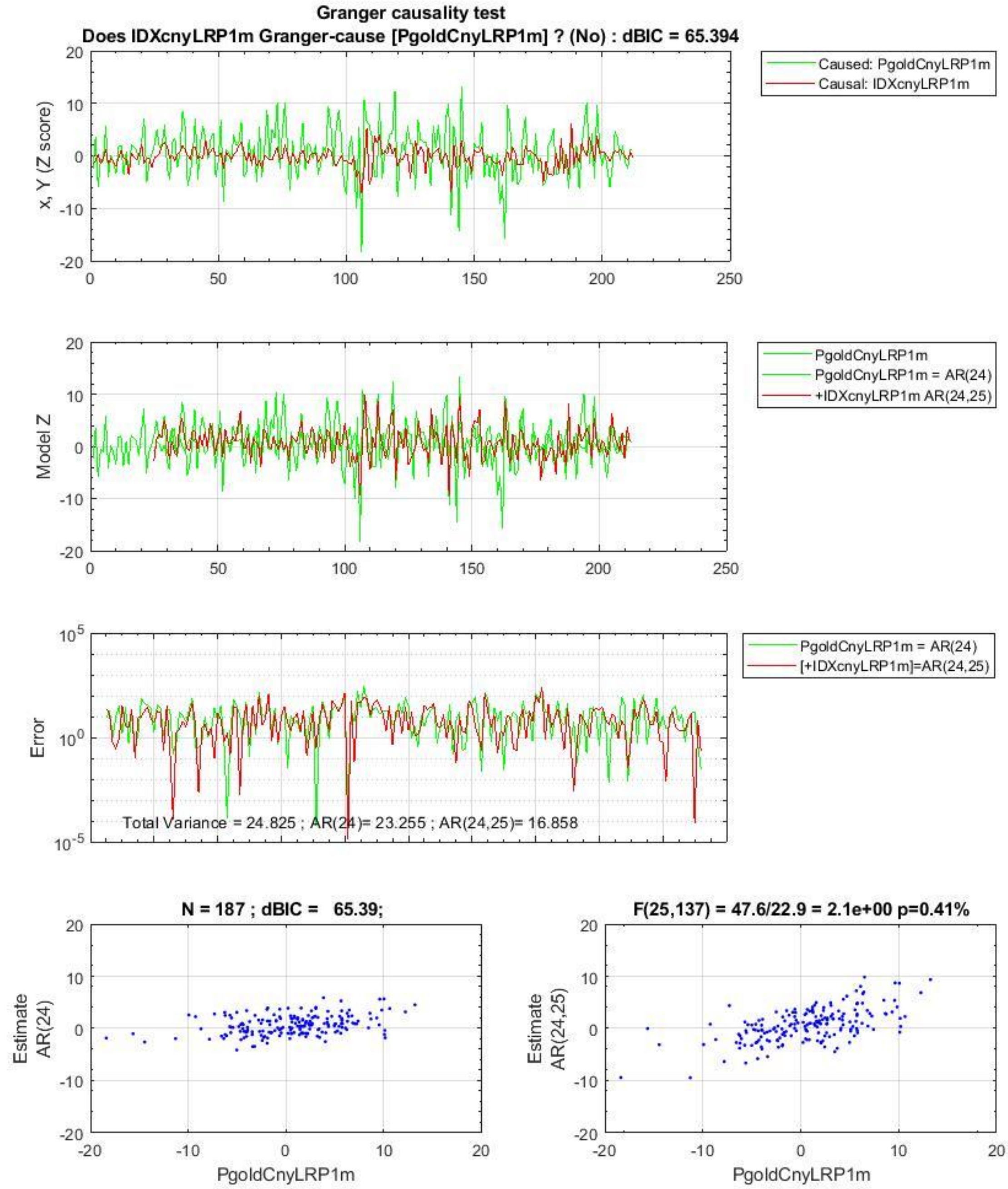


Figure 154 *Results of the test to determine whether IDXcnyLRP1m Granger-causes PgoldCNYLRP1m*

Source: Own research

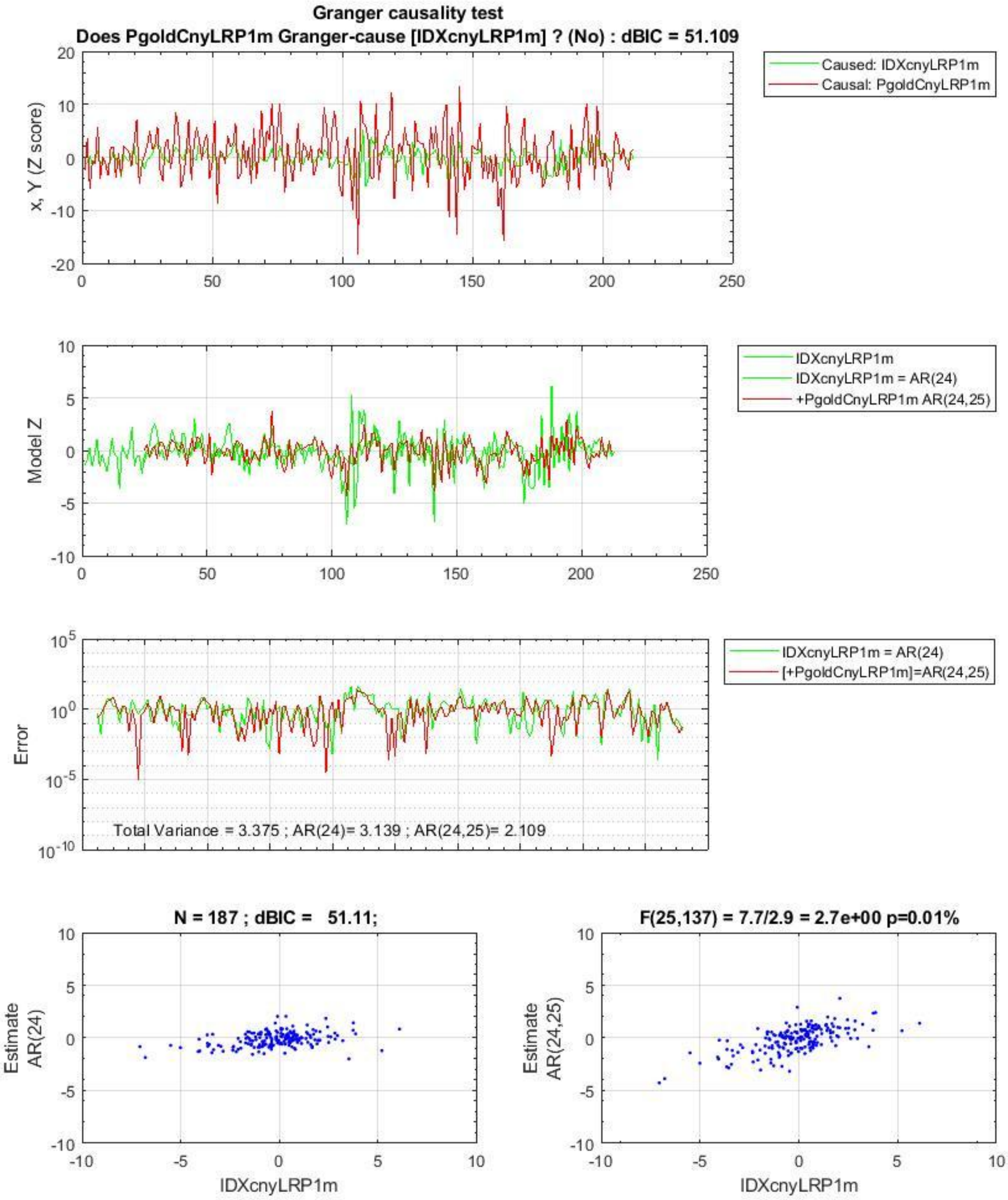


Figure 155 *Results of the test to determine whether PgoldCNYLRP1m Granger-causes IDXcnyLRP1m*

Source: Own research

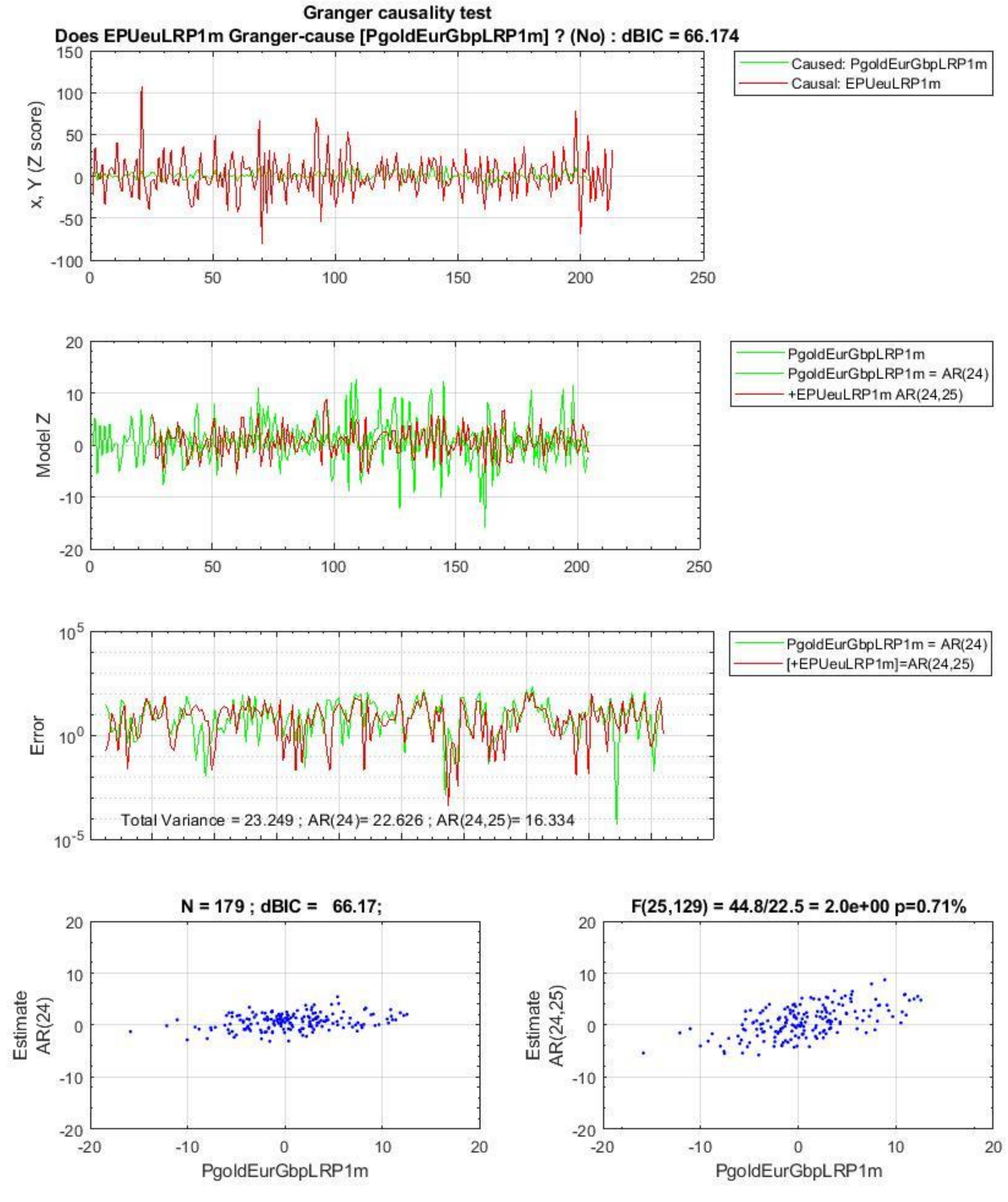


Figure 156 *Results of the test to determine whether EPUeuLRP1m Granger-causes PgoldEurGbpLRP1m*

Source: Own research

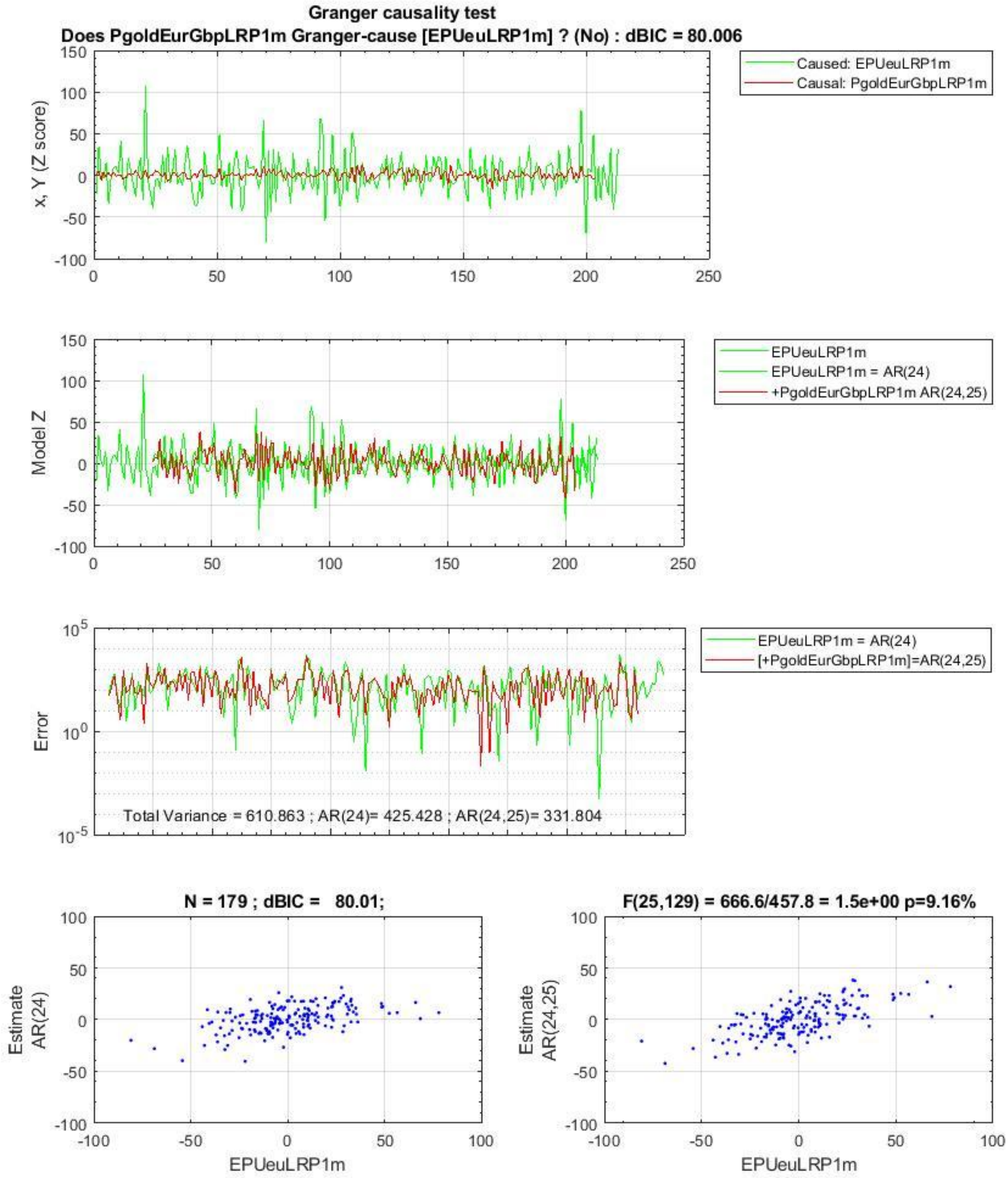


Figure 157 *Results of the test to determine whether PgoldEurGbpLRP1m Granger-causes EPUeuLRP1m*

Source: Own research

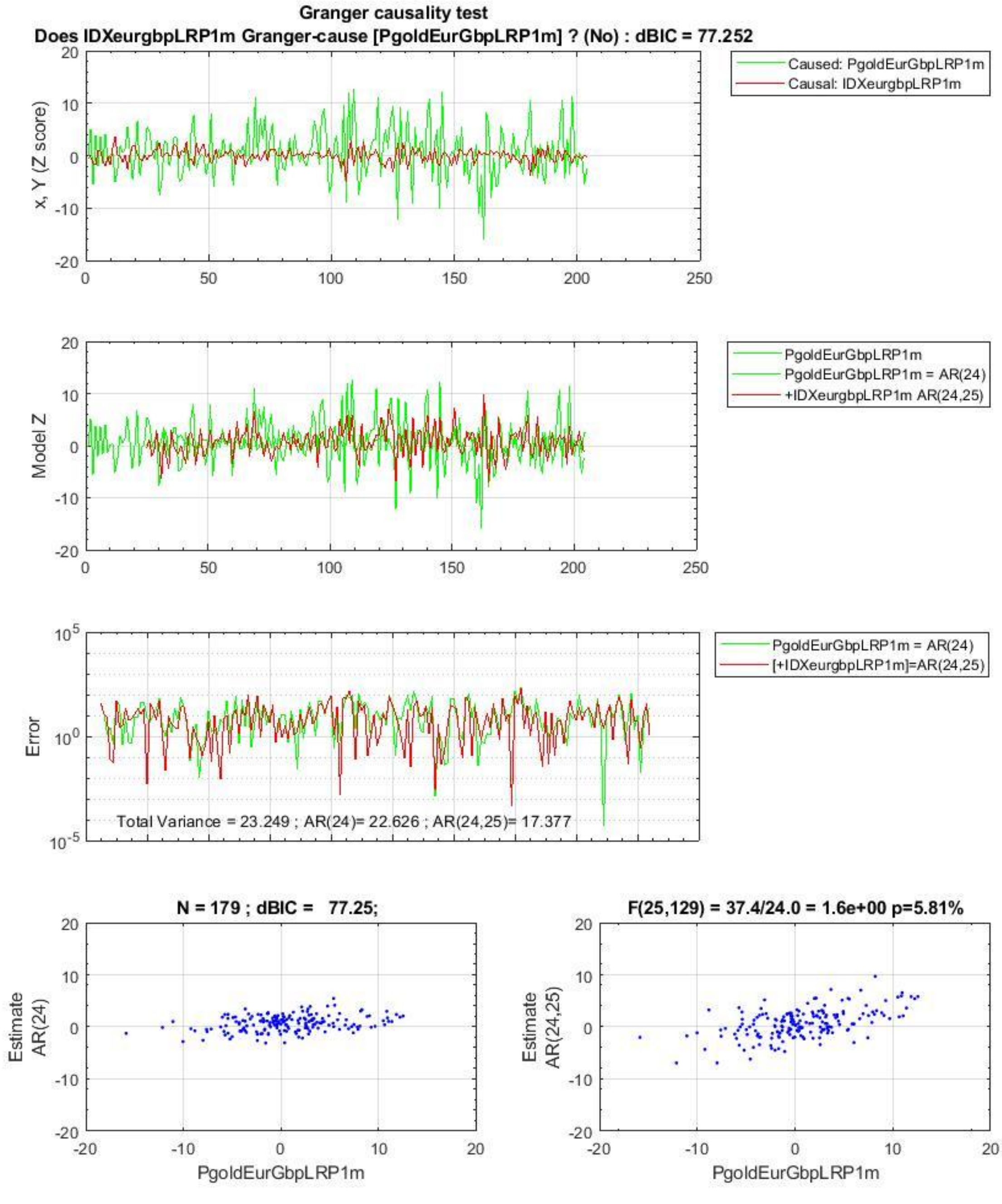


Figure 158 *Results of the test to determine whether IDXeurgbpLRP1m Granger-causes PgoldEurGbpLRP1m*

Source: Own research

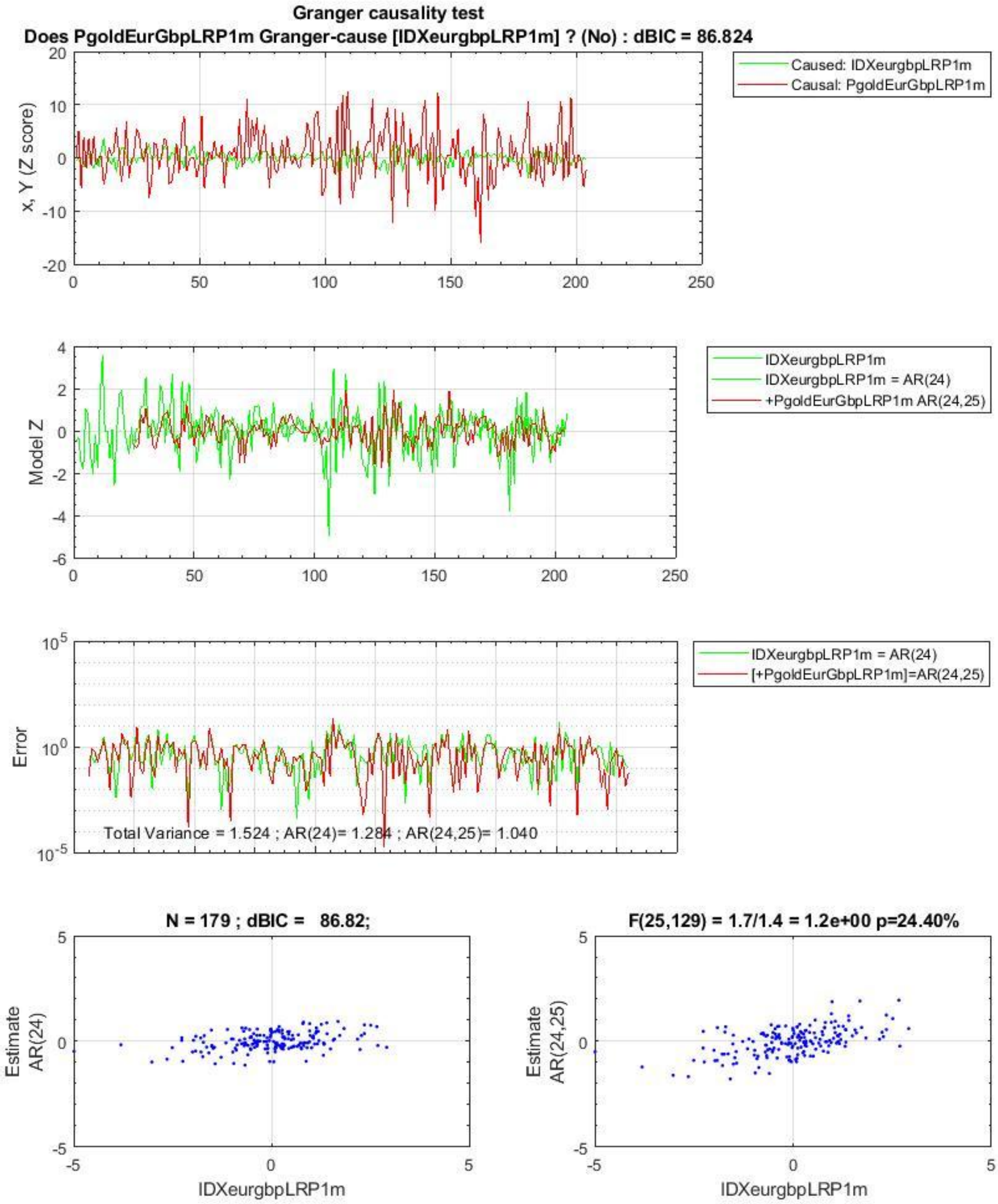


Figure 159 *Results of the test to determine whether PgoldEurGbpLRP1m Granger-causes IDXeurgbpLRP1m*

Source: Own research

9.9.6 Analysis of backwardation and contango in the gold market

Table 189

Comparative statistics of daily backwardation and contango in the 3-month gold futures market: Pre- and

Descriptive statistics		Before 2008	2008 to present
Mean		1.318%	0.312%
95% Confidence Interval for Mean	Lower Bound	1.285%	0.283%
	Upper Bound	1.352%	0.340%
Median		1.309%	0.251%
Std. Deviation		0.895%	0.688%
Minimum		-4.321%	-4.209%
Maximum		11.033%	5.080%
Range		15.354%	9.289%
Interquartile Range		1.040%	0.660%
Skewness		1.0439	0.4511
Kurtosis		12.7185	5.1626

Source: Own research

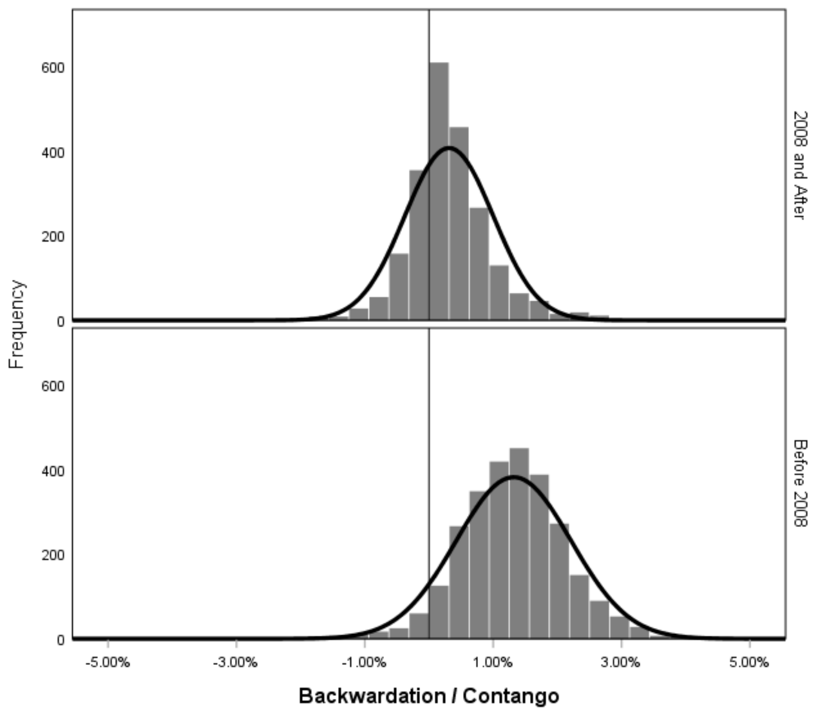


Figure 160 *Comparative plot of daily backwardation and contango in the 3-month gold futures market: Pre- and post-2008*

Source: Own research

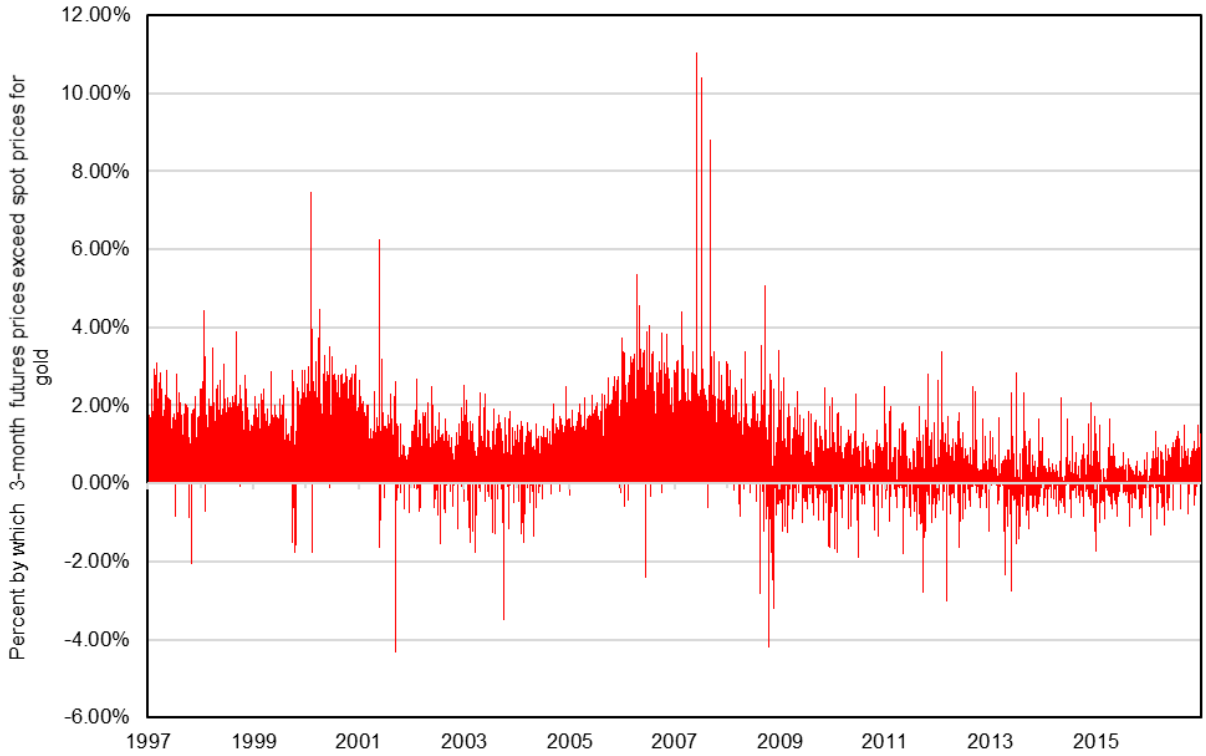


Figure 161 *Plot of daily differences between 3-month gold futures and spot prices indicating the extent of backwardation and contango*

Source: Own research

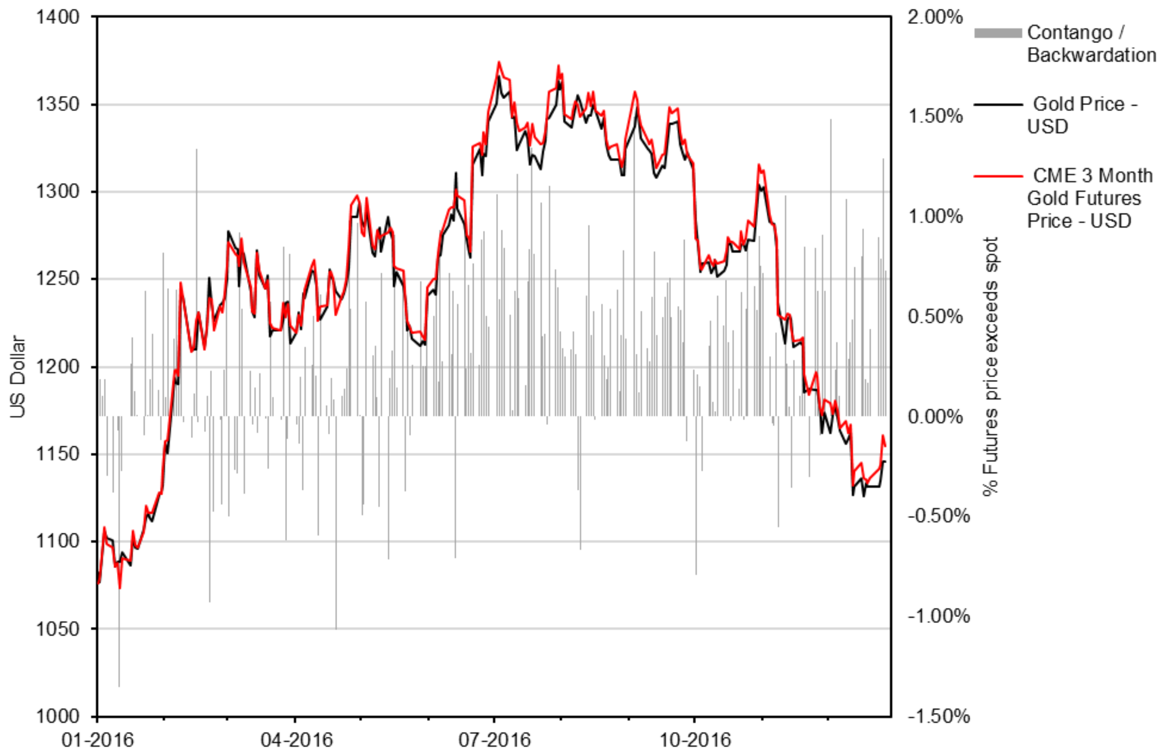


Figure 162 *Gold spot prices and 3-month futures prices for 2016*

Source: Own research

9.9.7 Additional ARIMAX model estimated for hypothesis 2 & 3 data

Table 190

Hypothesis 2 & 3, supplemental model estimation with SPSS expert modeller: Model statistics

Model		H2 & H3 Domestic	H2 & H3 International
Model Type		ARIMA (0,1,11)	ARIMA (0,1,11)
Number of Predictors		3	5
Model Fit statistics	Stationary R-squared	0.325	0.328
	R-squared	1.000	1.000
	RMSE	9.172	9.168
	MAPE	0.681	0.680
	MAE	5.626	5.624
	MaxAPE	4.182	4.181
	MaxAE	63.911	63.941
	Normalized BIC	4.511	4.516
Ljung-Box Q(18)	Statistics	20.434	19.966
	DF	17	17
	Sig.	.253	.276
n		4917	4917
Number of Outliers		32	32

Source: Own research

Table 191

Hypothesis 2 & 3 domestic context, supplemental model estimation with SPSS expert modeller: Model parameters

Panel A: Domestic variable set

Variable	Transformation			Estimate	SE	t	Sig.
Fgold	Natural Logarithm	Constant		0.0003	0.0001	2.1560	.0311
		Difference		1			
		MA	Lag 11	0.0681	0.0140	4.8509	.0000
IDXusd	Natural Logarithm	Numerator	Lag 0	-1.5620	0.0441	-35.4488	.0000
		Difference		1			
GoldBeta200d	No Transformation	Delay		2			
		Numerator	Lag 0	0.1098	0.0480	2.2859	.0223
		Difference		2			
INFLus12m	No Transformation	Delay		2			
		Numerator	Lag 0	0.0049	0.0014	3.5767	.0004
		Difference		1			

Source: Own research

Table 192

Hypothesis 2 & 3 international context, supplemental model estimation with SPSS expert modeller: Model parameters

Panel B: International variable set

Variable	Transformation			Estimate	SE	t	Sig.
Fgold	Natural Logarithm	Constant		0.0003	0.0001	2.1546	.0312
		Difference		1			
		MA	Lag 11	0.0696	0.0139	5.0196	.0000
IDXusd	Natural Logarithm	Numerator	Lag 0	-1.5678	0.0440	-35.6175	.0000
		Difference		1.0000			
GoldBeta200d	No Transformation	Delay		2			
		Numerator	Lag 0	0.1104	0.0479	2.3033	.0213
		Difference		2			
INFLus12m	No Transformation	Delay		2			
		Numerator	Lag 0	0.0047	0.0014	3.4337	.0006
		Difference		1			
INFLworld	Natural Logarithm	Delay		1			
		Numerator	Lag 0	0.0269	0.0089	3.0046	.0027
			Lag 6	0.0232	0.0090	2.5849	.0098
		Difference		1			
EPUeu	Natural Logarithm	Delay		2			
		Numerator	Lag 0	0.0053	0.0025	2.1510	.0315
		Difference		1			

Source: Own research

9.10 Results of post estimation tests to ensure model quality: Hypothesis 4e

9.10.1 Test for normal distribution of errors

In accordance with section 4.3.6, the residuals of the proposed model were tested for normality using the Shapiro-Wilk tests detailed in 4.3.1.

Table 193

Test for normal distribution, hypothesis 5 residuals

Shapiro-Wilk test (Residuals – H4):	
W	0.987
p-value (Two-tailed)	.059
alpha	.05

Source: Own research

- The criteria for acceptance or rejection of the null hypothesis are that:
    - Fail to reject the null hypothesis when p-value is greater than or equal to α = .050, and conclude that the data are normally distributed to a 95% confidence level (Shapiro & Wilk, 1965);
    - Reject the null hypothesis when p-value is less α = .050, and conclude that the data are not normally distributed beyond a 95% confidence level (Shapiro & Wilk, 1965).

In the case of the residuals of the estimation for hypothesis 4e, p=.059, which is greater than alpha, and the null hypotheses is accepted.

It was concluded that the residuals were normally distributed.

9.10.2 Inspection of residuals for linearity

In accordance with section 4.3.7, scatterplots were inspected for linearity of the relationship between the dependent and independent variables. The plots indicated no non-linear relationships that were of concern to the validity of the model.

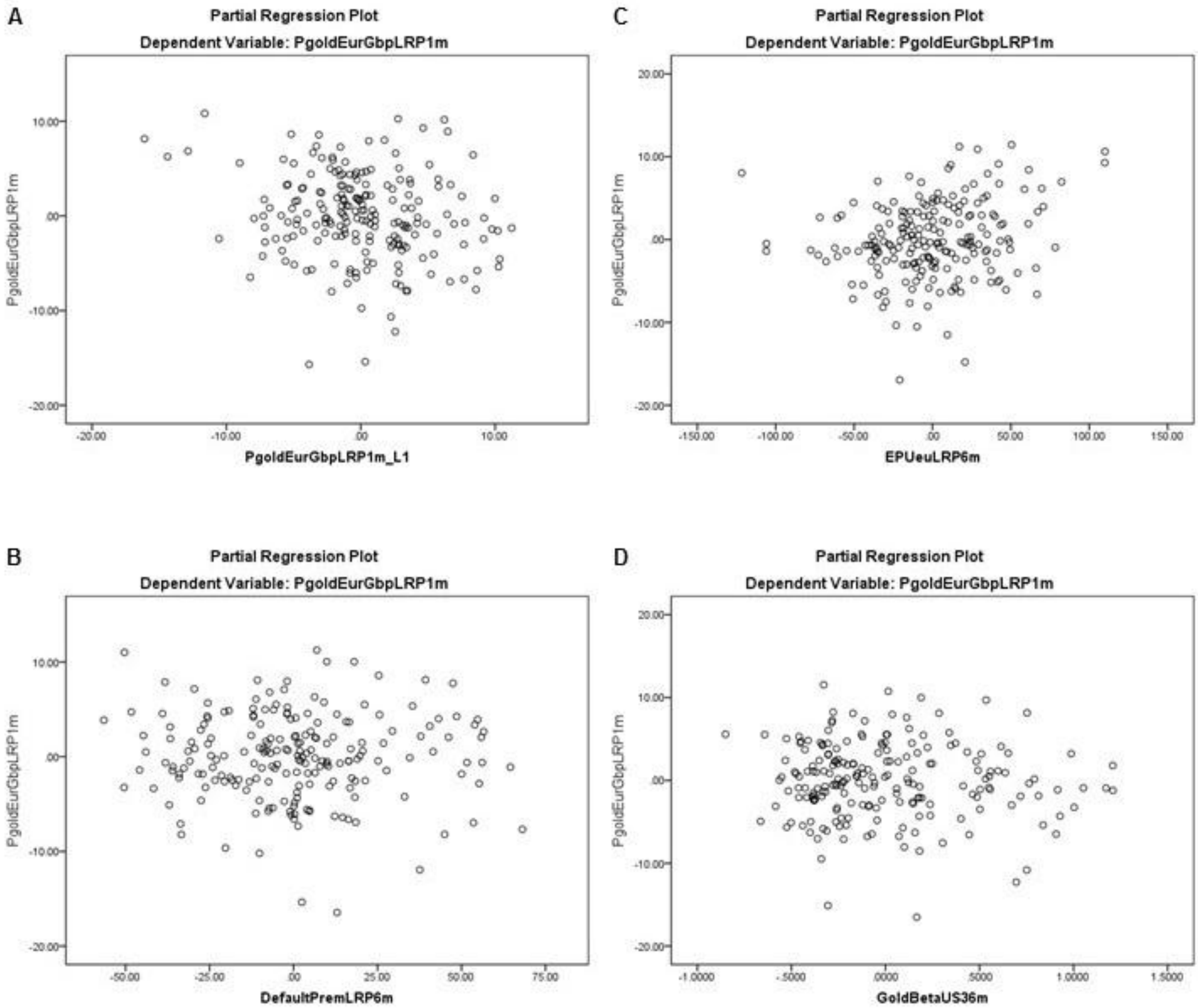


Figure 163 *Scatterplot of individual variables for hypothesis 4 model estimation (1 of 2)*

Source: Own research

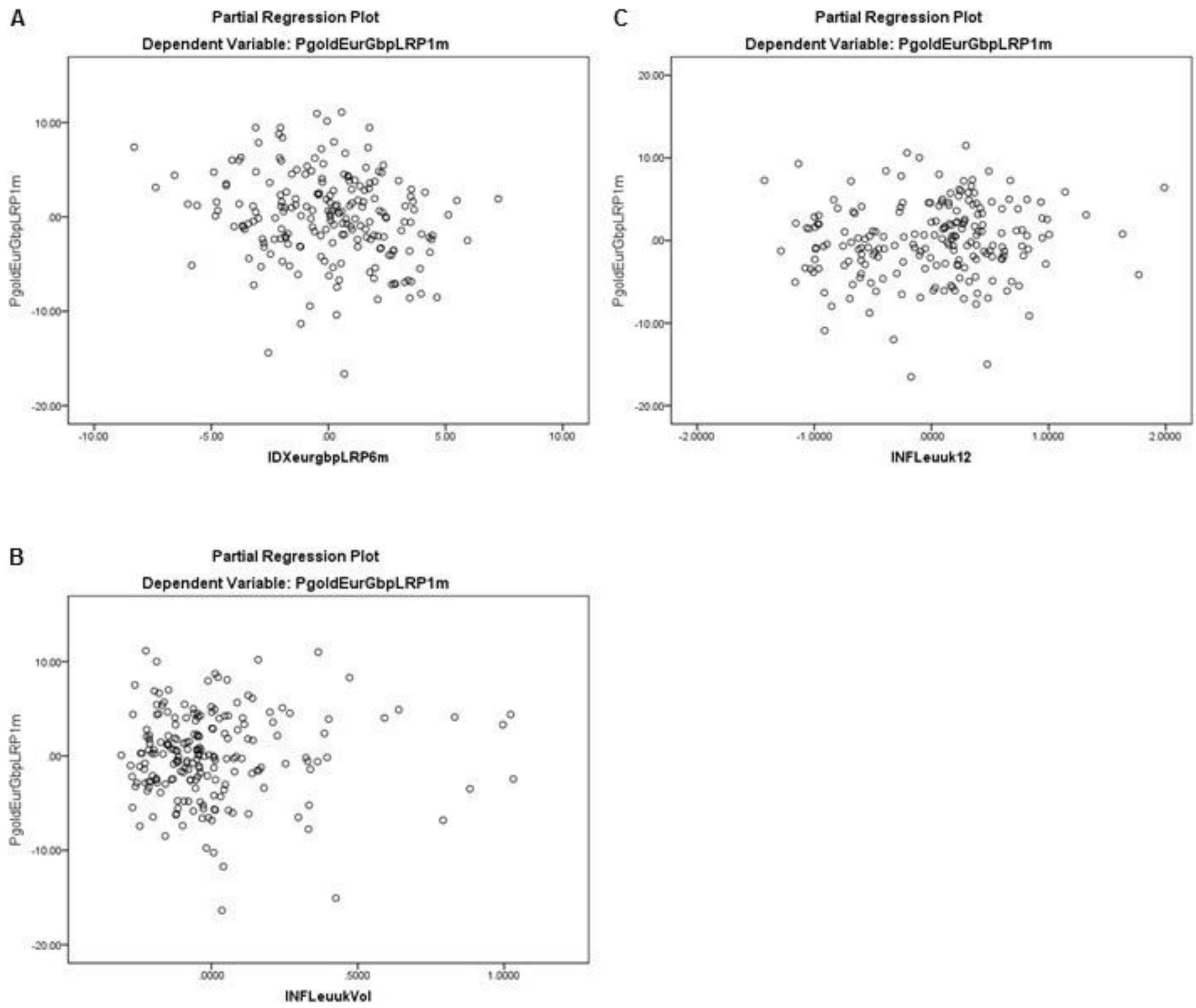


Figure 164 *Scatterplot of individual variables for hypothesis 4 model estimation (2 of 2)*

Source: Own research

9.10.3 Test for homoscedasticity

In terms of section 4.3.8, White's test was used to determine if heteroscedasticity was present in residuals. The test was performed using Oleg Komorov's (2009) script in MATLAB 2017b.

For White's test:

- The conclusion of homoscedastic residuals lies in the null hypothesis (White, 1980);
- The criteria for acceptance or rejection of the null hypothesis are as follows:
  - Accept the null hypothesis when the p-value is greater than or equal to α = .050, and conclude that the residuals are homoscedastic to a 95% confidence level (White, 1980);

- Reject the null hypothesis when the p-value is less than α = .050, and conclude that the residuals are heteroscedastic beyond a 95% confidence level (White, 1980).

The output of the test was as follows:

```
>> PVAL = TestHet (MyResiduals,MyPredictors,'-W')

PVAL =

    0.5845
```

Figure 165 *White's test output*

Source: Own research

The conclusion was that since *p*=.5845, which is greater than α = .050, the study failed to reject the null hypothesis, and it was concluded that the data were free from significant heteroscedasticity.

9.10.4 Test for autocorrelation

In terms of section 4.3.9, the Ljung-Box test was used to determine if autocorrelation was present in the residuals for the model estimated for hypothesis 4e.

For the Ljung-Box test:

- The conclusion of absence of autocorrelation of residuals lies in the null hypothesis (Ljung & Box, 1978);
- The criteria for acceptance or rejection of the null hypothesis are as follows:
  - Fail to reject the null hypothesis when the p-value is greater than or equal to α = .050, and conclude that the residuals are not autocorrelated to a 95% confidence level (Ljung & Box, 1978);
  - Reject the null hypothesis when the p-value is less than α = .050, and conclude that the residuals are autocorrelated beyond a 95% confidence level (Ljung & Box, 1978).

The output of the test was as follows:

```
>> [h,pValue,stat,cValue] = lbqtest(MyResiduals)

h =

  logical

   0


pValue =

    0.4223


stat =

   20.5779


cValue =

   31.4104
```

Figure 166 *Output of Ljung-Box test*

Source: Own research

The conclusion was that since *p*=.4223, which is greater than α = .050, the study failed to reject the null hypothesis, and it was concluded that the data were free from significant autocorrelation.

9.10.5 Test for cointegration

In terms of section 4.3.10, the Engle-Granger test was performed to test for co-integration in MATLAB R2017b (Mathworks, 2018a). The results of the test are sown in *Figure 167*.

```
h =

  logical

   1


pValue =

   1.0000e-03


stat =

  -13.5957


cValue =

   -5.3439
```

```
reg1 =

  struct with fields:

        num: 202
       size: 202
      names: {8×1 cell}
      coeff: [8×1 double]
         se: [8×1 double]
        Cov: [8×8 double]
     tStats: [1×1 struct]
      FStat: [1×1 struct]
        yMu: 0.7421
     ySigma: 4.7969
       yHat: [202×1 double]
        res: [202×1 double]
     DWStat: 1.9211
        SSR: 545.2216
        SSE: 4.0798e+03
        SST: 4.6250e+03
        MSE: 21.0298
       RMSE: 4.5858
        RSq: 0.1179
       aRSq: 0.0861
         LL: -590.2655
        AIC: 1.1965e+03
        BIC: 1.2230e+03
        HQC: 1.2072e+03
```

```
reg2 =

  struct with fields:

         num: 202
        size: 201
       names: {'a'}
       coeff: 0.0381
          se: 0.0708
         Cov: 0.0050
      tStats: [1×1 struct]
       FStat: [1×1 struct]
         yMu: 0.0041
      ySigma: 4.5161
        yHat: [201×1 double]
         res: [201×1 double]
     autoCov: 'PP tests only'
       NWEst: 'PP tests only'
      DWStat: 1.9869
         SSR: 5.9004
         SSE: 4.0732e+03
         SST: 4.0791e+03
         MSE: 20.3659
        RMSE: 4.5129
         RSq: 0.0014
        aRSq: 0.0014
          LL: -587.6000
         AIC: 1.1772e+03
         BIC: 1.1805e+03
         HQC: 1.1785e+03
```

Figure 167 *Engle-granger test result*

Source: Own research

9.10.6 Test for structural stability

In terms of section 4.3.12, the Cusum test was performed in MATLAB R2017b to determine structural stability of the coefficients.

For the Cusum test:

- The conclusion of absence of significant structural change lies in the null hypothesis (Mathworks United Kingdom, 2017a);
- MATLAB R2017b produces a plot of the test criticals and test statistics at progressive iterations (Mathworks United Kingdom, 2017a);
- The test is conducted to a 95% confidence level;
- The criteria for acceptance or rejection of the null hypothesis are as follows:
  - Fail to reject the null hypothesis as long as the test statistic remains within the bounds of the upper and lower test critical bounds, and conclude that no structural

change of the model is present to a 95% confidence level (Mathworks United Kingdom, 2017a);

- Reject the null hypothesis if the test statistic exceeds either the upper or lower test critical bounds, and conclude that structural change of the model is present beyond a 95% confidence level (Mathworks United Kingdom, 2017a);

The results of the test are detailed in *Figure 168* and *Figure 169*.

```
RESULTS SUMMARY

***************
Test 1

Test type: cusum
Test direction: forward
Intercept: yes
Number of iterations: 194

Decision: Fail to reject coefficient stability
Significance level: 0.0500
```

Figure 168 *Summary results from Cusum test*

Source: Own research

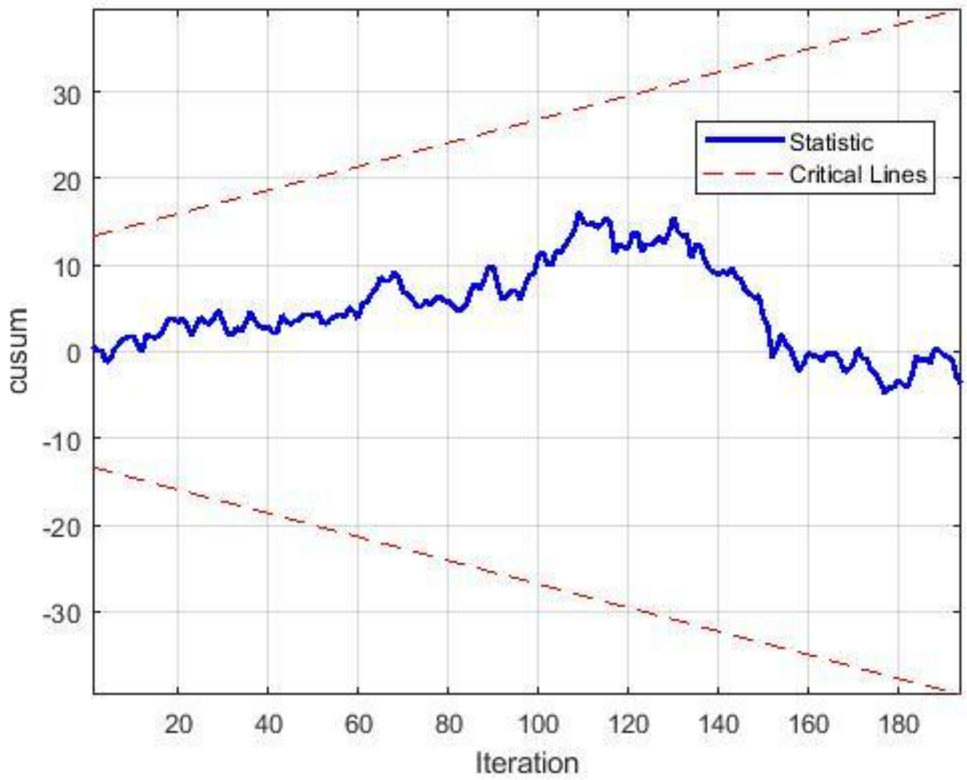


Figure 169 *Cusum test plot*

Source: Own research

The plot in *Figure 169* confirms the result from the output in *Figure 168*. The study failed to reject the null hypothesis, and it was concluded that no significant structural change exists in the model.

9.10.7 Further plots to assess impact of cointegration

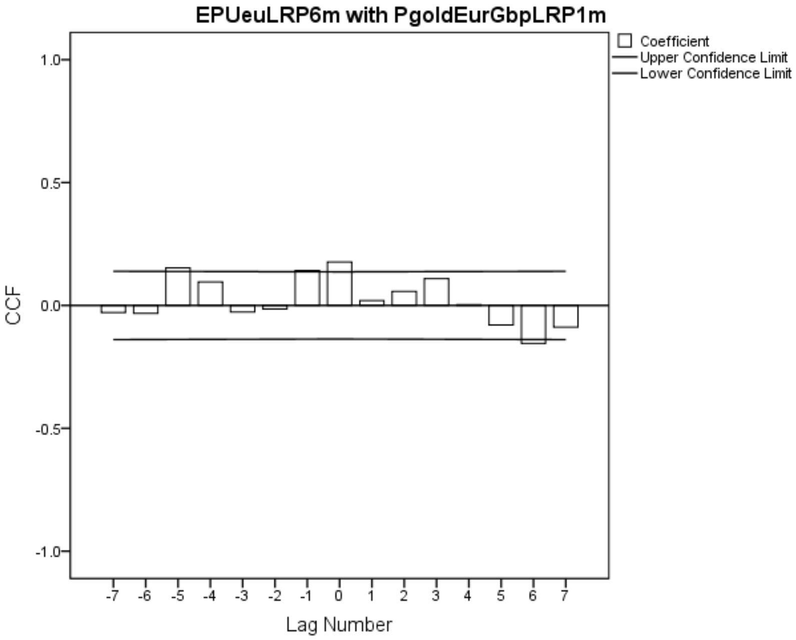


Figure 170 Cross-correlation function, EPU with Pgold

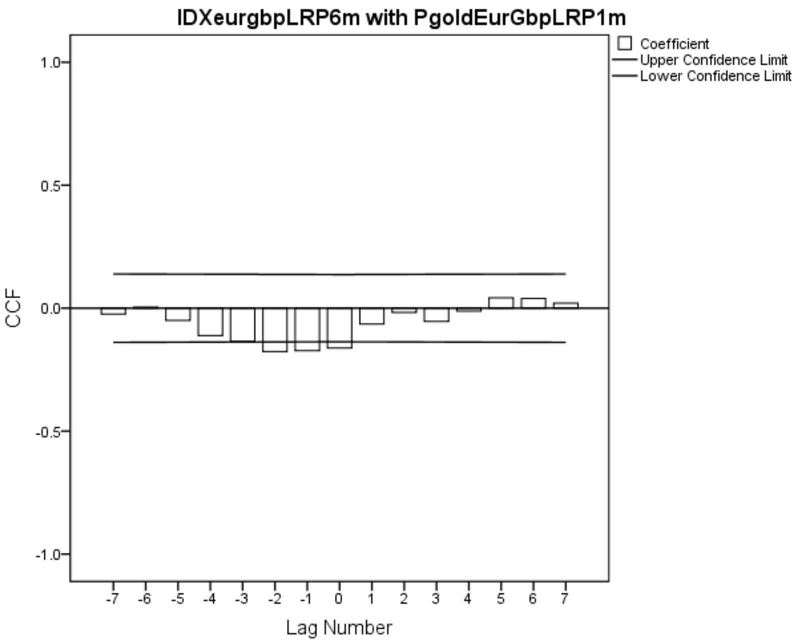


Figure 171 Cross-correlation function, IDXeur with gold

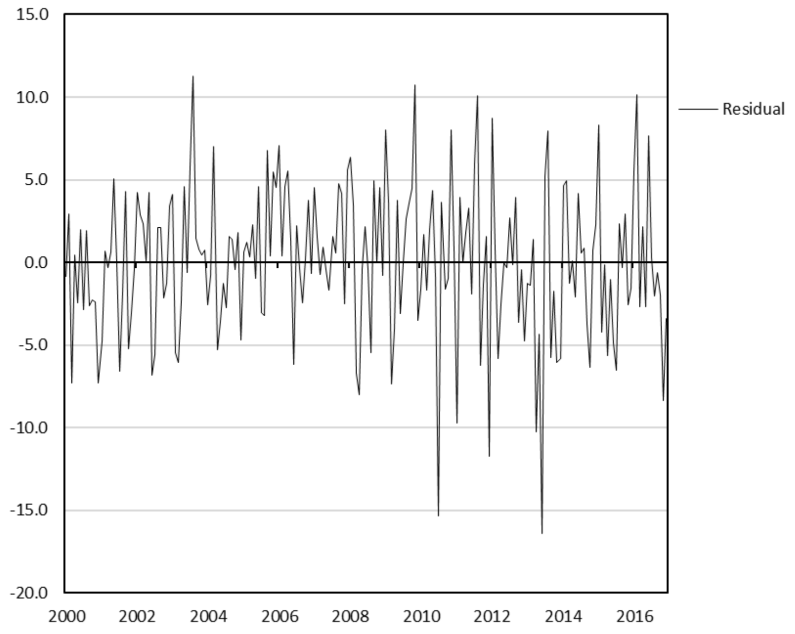


Figure 172 Residual time series plot: Model for H4e

Table 194

ADF test for stationarity in H4e model residual

Tau (Observed value)	-5.406
Tau (Critical value)	-3.402
p-value (one-tailed)	< .0001
alpha	.05

Source: Own research

Test interpretation:

H0: There is a unit root for the series.

Ha: There is no unit root for the series. The series is stationary.

As the computed p-value is lower than the significance level alpha=.05, one should reject the null hypothesis H0, and accept the alternative hypothesis Ha.

Table 195

KPSS test for stationarity in H4e residual

Eta (Observed value)	0.201
Eta (Critical value)	0.462
p-value (one-tailed)	.268
alpha	.05

Source: Own research

Test interpretation:

H0: The series is stationary.

Ha: The series is not stationary.

As the computed p-value is greater than the significance level alpha=.05, one cannot reject the null hypothesis H0.

Source: Own research

9.11 Additional plots and tables for model estimations for hypothesis 5

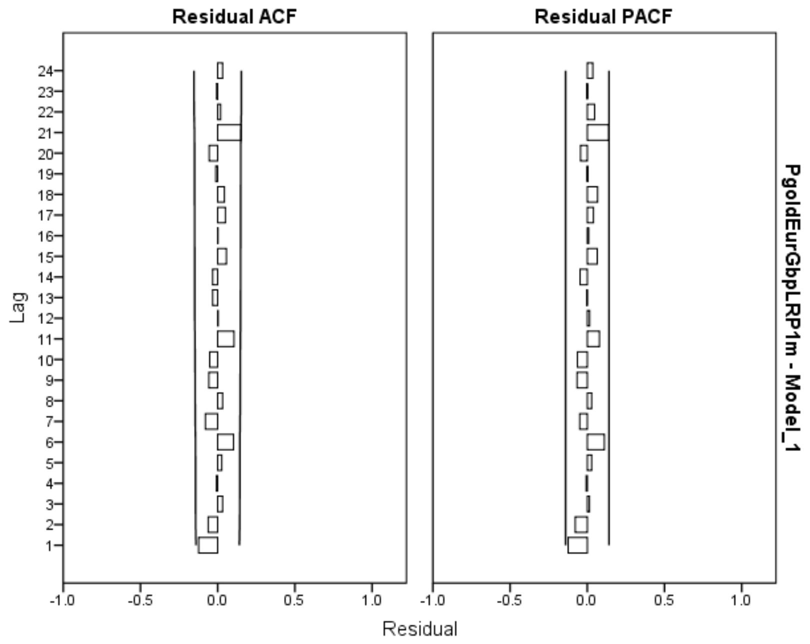


Figure 173 ACF for ARIMAX model estimation, with H4e stationarized data

Source: own research

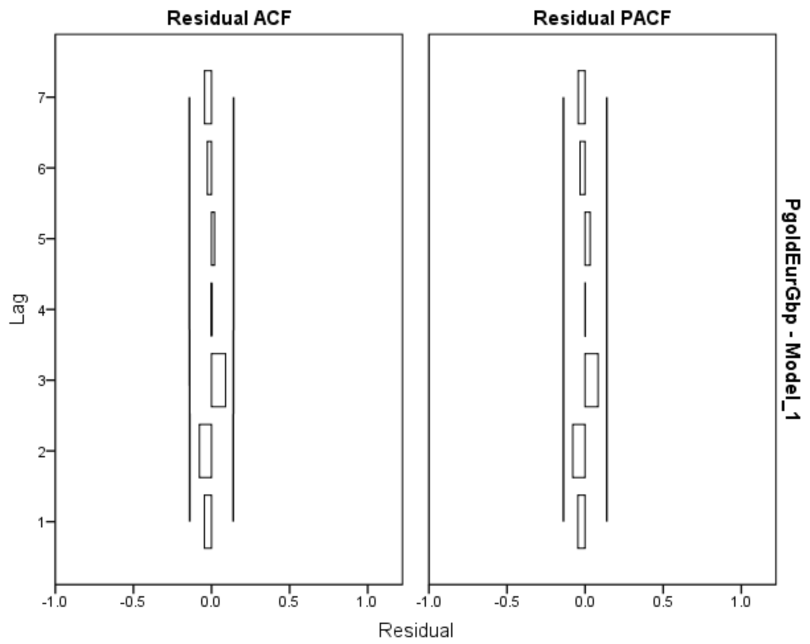


Figure 174 ACF for ARIMAX model estimation, with H4e stationarized

Source: own research

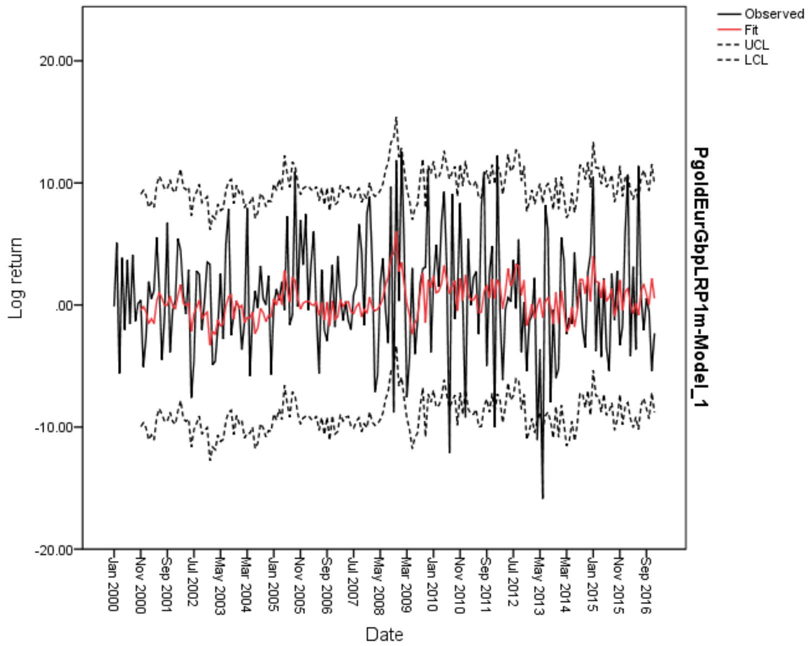


Figure 175 Fit for hypothesis 5, model 1 (using stationarized input data)

Source: own research

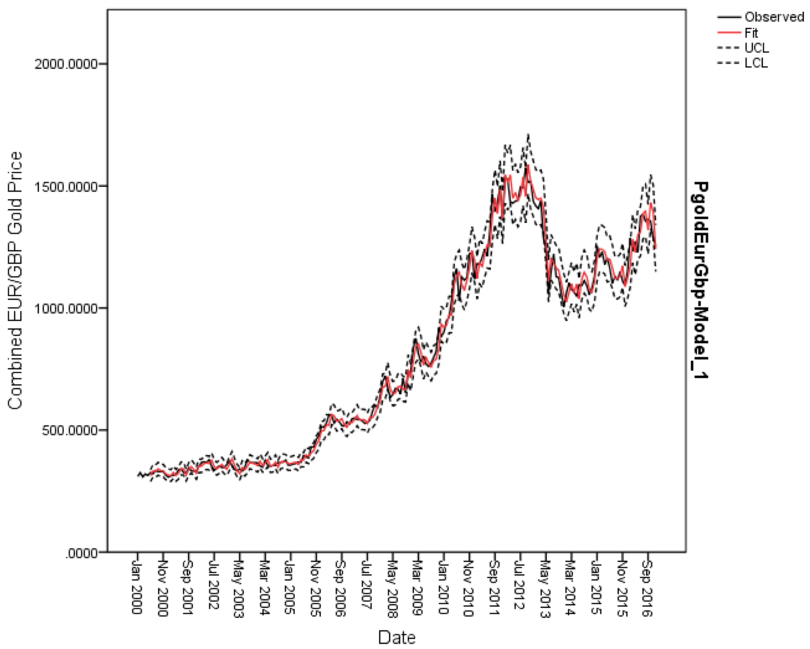


Figure 176 Fit for hypothesis 5, model 2 (using unstationarized input data)

Source: own research

Table 196

Outliers removed from dataset for estimating hypothesis 5, Model2

			Estimate	SE	t	Sig.
PgoldEurGbp-Model_1	Oct 2008	Additive	-0.161	0.029	-5.612	.000
	Aug 2010	Seasonal Additive	0.039	0.011	3.696	.000
	Dec 2011	Additive	-0.117	0.028	-4.216	.000
	Jun 2013	Additive	-0.117	0.028	-4.210	.000

Source: Own research

Table 197

Hypothesis 5, Model 2 ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	0.069	3	0.023	12.882	.000[b]
	Residual	0.348	196	0.002		
	Total	0.417	199			

a. Dependent Variable: PgoldEurGbp_L0_LR

b. Predictors: (Constant), IDXEurGbp_L0_LR, EPUeu_L0_LR, EPUeu_L4_LR

Source: Own research

9.12 Consistency matrix

Hypothesis	Description	Literature review	Data collection tool	Analysis
1	Determine whether the addition of EPUI Volatility to the multivariate regression model developed by Jones and Sackley (2016) described the relationship between EPU and gold spot prices, and thus the use of gold as an EPU safe haven asset, better than the original model	Jones and Sackley (2016) Brunetti, Büyükşahin, and Harris (2016) Diebold, Schorfheide, and Shin (2017)	Secondary data sourced from public sources	Multivariate linear regression
2	Determine whether estimating Jones and Sackley's (2016) model with its original set of variables against gold futures produces a better multivariate regression model, thus indicating that gold futures are a better safe haven against EPU	Jones and Sackley (2016) Bekiros, Boubake, Nguyen and Uddin (2017)	Secondary data sourced from public sources	Multivariate linear regression, and ARIMAX
3	Determine whether the addition of EPUI Volatility to the multivariate regression model estimated by Jones and Sackley (2016) describes the relationship between EPU and the price of gold futures as a dependent variable, and thus the use of gold as an EPU safe haven asset, better than the original model does by using the spot price of gold as a dependent variable	Jones and Sackley (2016) Brunetti, Büyükşahin, and Harris, (2016) Diebold, Schorfheide, and Shin, (2017) Bekiros, Boubake, Nguyen and Uddin (2017)	Secondary data sourced from public sources	Multivariate linear regression, and ARIMAX

Hypothesis	Description	Literature review	Data collection tool	Analysis
4	Pursuant to the avenues for further research in Jones and Sackley (2016), EPUI was modelled against gold spot prices in local currency, using multivariate regression, in Europe, China and Japan, which together constitute over 60% of the world's GDP (World Bank, 2017). These tests were performed to determine whether or not a statistically significant relationship existed between EPU in major economies outside the US and the price of gold	Jones and Sackley (2016) Liu et al. (2016)	Secondary data sourced from public sources	Multivariate linear regression
5	In an effort to develop a more robust understanding of the nature of the relationship between EPU and the price of gold, an Autoregressive Integrated Moving Average with Exogenous Variables Model (ARIMAX) (Andrews, Dean, Swain, & Cole, 2013; Ďurka & Silvia, 2012) was estimated using the best fitting set of variables from the previous four hypotheses (Andrews et al., 2013). This test was performed to determine whether or not a methodology incorporating autoregressive (AR) and moving average (MA) could produce a more statistically significant model, or one with better explanatory power, than those excluding these terms	Jones and Sackley (2016) Box & Jenkins (1968) Apergis (2015)	Secondary data sourced from public sources	ARIMAX

9.13 Ethical clearance letter

Gordon Institute of Business Science
University of Pretoria

07 September 2017

David Nightingale

Dear David,

Please be advised that your application for Ethical Clearance has been approved.

You are therefore allowed to continue collecting your data.

We wish you everything of the best for the rest of the project.

Kind Regards

GIBS MBA Research Ethical Clearance Committee

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